

**A multi-actor analysis approach in  
decision making**  
**A framework to complement ISA-95 guidelines within  
manufacturing companies**

**ENGINEERING and POLICY ANALYSIS MASTER THESIS**

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### Multi-actor presence in manufacturing activities

Today, almost all manufacturing companies work in an environment where the functions of different actors (i.e. departments) are intertwined and related with each other. This means that in order to achieve company's objectives, actors are dependent on the actions and/or information of the others. These general objectives (e.g. profit) are realized by decisions which are chosen after analyzing a certain set of information and options. Decisions are in everyday business and they are dependent *on the output* (information and/or activities) from the different actors of the manufacturing activities. However, as of now, decisions are sometimes not thought to be dependent *on the involvement* of these different actors. This proves to be an area for improvement of decision making: decisions should not be made without considering the differences in perceptions, interests and objectives of the different actors since these are often diverging between them and across functions. And since decisions are a matter of compromise that never allow the perfect achievement of the objectives of each actor, the *involvement* of all of them could be the missing factor to improve chances of effective decision making. An important reason why decisions are not effective - in the sense that they meet their intended purpose and are on time - is because of lack of support of the key actors, and failure in attending the interests and information from them.

Manufacturing companies are finding today the existence of dependency and coordination within their multi-disciplinary activities. This makes that decision making increases in complexity since more and more is connected and a decision affects a whole range of actors and activities. Due to this, support and a clear understanding of tasks and responsibilities are needed to be able to correctly implement decisions. Furthermore, cooperation among all these actors is crucial in order to achieve a common goal. For example, a new plan of action will need the support from the involved actors in order to increase the chances of this plan to be followed in time and with the intended resources and results.

### Thesis methodology of research

The goal of this thesis is defining a framework that can provide manufacturing companies with a decision making process that improves decision efficiency. The main research question was: *How and to what extent can a framework be provided that improves the decision making processes and practices for manufacturing companies when addressing their manufacturing activities which involve several actors?* In order to come up with this framework, a study had to be done to see exactly how to provide it and with which elements. Therefore, three research sub-questions were answered precisely to study the influence of 3 elements on decision making:

1. *What is the standard ISA-95 and how can the information from the standard and enterprise and control systems improve decision making?*
2. *What is a multi-actor analysis approach and why is such approach necessary to be considered to support decision making?*
3. *Which are the most fitting decision making processes, practices and techniques that acknowledge a multi-actor analysis approach and increase chances of support, collaboration and success in manufacturing activities?*

The research project was based upon 3 main areas: literature study (journals, books, policy documents, among others), interviews of personnel working in manufacturing companies (over 15 interviews from 9 persons in 7 companies), and on 3 empirical cases where the framework was

tested. The first two areas served as a basis to develop the framework, whereas the third area was to empirically assess and evaluate such framework.

### **Thesis elements of research**

The increased complexity to manage manufacturing activities, and therefore, to have efficient decisions as mentioned in previous lines, certainly is caused by the great amount of information and different actors involved. Manufacturing companies use a significant number of means to get their manufacturing activities up to date and going on an everyday business. These different means create a large set of information which may be contested. Since manufacturing activities - those processes that are involved in the transformation of raw material to end products like production, planning, quality assurance, maintenance, and so on – are complex activities, certain systems were needed in order to better handle this complexity. Therefore, enterprise and control systems were introduced to help companies address this issue by integrating information across the entire company (facilitating information flow) and managing manufacturing operations respectively. Thus, these systems should impact decision making as their output is information that decision makers analyze and use to come up with decisions. However, the correct management of these systems, and therefore of the information which impacts decision making, was difficult and expensive probably due to different terminology, computer systems and professional cultures that were present but not accounted for. Integration of these systems was necessary. An international standard for the integration of these systems, ISA-95, was developed to reduce the risks, costs and errors associated with such kind of integration. Hence, a look into this standard and into these enterprise and control systems was needed to know how much they could impact and influence the decision making, and if they could play a pivotal role in allowing for coordination and cooperation among actors.

It is found, after studying the standard itself and with the help of interviewing experts in this field that the relevance of the ISA-95 standard *for decision making* is in implementing an enterprise and control system solution and it is the output from these systems that help take decisions on manufacturing process. At some point, information from the standard itself can help with the decision making process in different ways, especially to help understand the dependencies and the relationships of functions and actors; to ensure a “common language”; to define a structure and responsibilities; and, via the system solution, to improve reliability and visibility of reports (improving process understanding) and, among others, as a checklist. Therefore, the information drawn from the guidelines of this standard and enterprise and control systems could very well be used and have an impact on decision making. However, because decision making does not only refer to technological issues, but also to people and organizational problems, the use and relevance of ISA-95 towards the scope of the research takes a backseat since the main issue refers to improving the decision making process for those activities involving trade-offs and different views from several actors - intangible, people and organizational problems - all which the ISA-95 does not attend. Therefore, the standard and the enterprise and control systems will serve as *input* providers within the proposed framework but will not be a focal point of the one. The proposed framework, along its steps, suggests on ways to include information from the standard to increase its relevance in decision making, and acknowledges that information from enterprise and control systems are a source of information to be considered in the decision making process. The first element of study in this thesis report, the standard ISA-95, showed an added value of the one - as to be considered by more companies around the world - by helping decision makers have a better reference on the structure of the company and improving the communication among the actors. Likewise, it is important in the decision making because it provides a system solution (formed by enterprise and control systems) which should be well done and reliable so these systems can provide accurate and on time information for decision makers.

The main idea of this thesis started from thinking that the correct involvement of key actors would provide the most complete and reliable set of information and the best chances of support in order to take the best possible decision and implementing it the best way afterwards. After all, companies' actors are not independent from each other. Therefore, a key element of the framework and hence, of the decision making process, was that of the actor involvement. Decision making processes in manufacturing companies should account for the several actors that are involved in creating information or output to come up with a right decision, and include the several actors that are responsible to implement the chosen decision. Manufacturing companies seem to acknowledge - some more than others- that in order to have a correct decision other actors should be addressed at some level. However, perhaps due to a lack of a standardized process to involve the different actors or due to a lack of knowledge in how effectively involve them, more than often decisions end up being taken without the right consideration of the key actors. Sometimes, companies know the importance of involving them and think they are correctly doing so but fail; other times, companies minimize the impact that a correct involvement of key actors can create towards achieving more efficient decisions, and decide based on other means such as intuition. Because information is contested and one cannot expect that all actors have the same point of view and perception of the same information, let alone think the same information has the same level of priority and importance, the need to account for the involvement of the actors is clear.

It is because of this that this thesis report introduces a multi-actor analysis approach in order to highlight the importance of the analysis of actors for an effective decision. A multi-actor analysis approach is the set of guidelines that allows for the study of characteristics – interests, objectives, resources, networks – of multiple actors. This is done by employing a multi-actor perspective and techniques that allow multi-actor analysis and multi-actor input giving value to the representation of several actors towards achieving efficient decisions. It is found in this research that such an approach is needed because, among others, it helps with the study and analysis of actor's characteristics and their perception, prioritization and own analysis of information. Therefore, facilitates the management of differences of these among the actors in order to strive for a decision that is, aside from being capable to reach desired objectives, well supported and best implemented.

The multi-actor approach framework for decision making makes use of the findings from the study elements in the thesis: ISA-95 standard, multi-actor analysis, and decision making. First of all, it gives space so that information from the ISA-95 standard and from enterprise and control systems is used. Secondly, it makes the multi-actor analysis approach an important element in the framework by including multi-actor analysis in all of its stages. Furthermore, the framework follows a specific decision making perspective and a specific decision making method that facilitate the inclusion of such approach. These are a political perspective and a mixed scanning method respectively. The former is that perspective which tries to come up with a decision through interaction and negotiation; the latter is a method that uses a mix of deep and shallow data evaluation, considering a broad range of facts and choices at first followed by a more detailed examination of a subset of facts and choices, fitting to current practices in manufacturing companies that have big amount of information to process (resulting in having incomplete information), have different number of actors involved in the process and have little time to make the decisions. Furthermore, this framework makes use of specific techniques – stakeholder analysis, nominal group technique, stepladder technique, qualitative CBA and what-if analysis - that are feasible, cheap, quick and not overly complex to be used.

### **Multi-actor analysis approach framework for decision making empirical research**

An empirical research was made within 3 companies: DSM, Manufactura e Integración, and Radiall; The first one situated in Netherlands and the other two situated in Mexico. This empirical

research consisted of using the proposed framework into a situational case – which previously was addressed by the company using other means - that needed a decision to be made and involved several actors. Interesting observations were made during and after this research. First, the framework is, in fact, usable within manufacturing companies. Second, it provides an added value to them, for example, showing factors more explicitly or generating knowledge on ones which were not considered previously. Third, it provides benefits to the companies implementing this framework such as reaching quicker decisions, minimizing risks of a wrong implementation, and minimizing risks of missing or untimely information. It is shown how following the proposed framework leads to Manufactura e Integración an increase in profit, and decrease in costs and time to do a certain project. However, there was a limitation in terms of empirical evaluation of the framework. Due to time constraints, 3 empirical cases were done, so actual benefits are certainly not proven for real cases. The practical research showed that a possible shortcoming of this framework was its elaborated process which would be hard to be followed if no previous knowledge or outside help was provided. Therefore, the researcher introduced a “leaner” framework with the intention to keep the added value and benefits of the original one, excluding those steps that after the empirical research showed little or no additional value for the decision making process. This leaner framework can be seen on the next page.

### **Observations from the empirical research**

The expectation of the researcher to provide a framework that, on paper, is usable and improves decision making is met. It provides with a decision making process which, even on a small sample, improves such process and improves the results of such decision when compared to the results and process of the same situation following other procedures and means. Upon further research, the framework has the potential to be catalogued as a smart practice regarding the relation cost-benefit it offers: it is simple and cheap to use yet can provide with greater benefits regarding taking decisions that are better studied, better supported, and better implemented which improves chances of better results. But this can only be claimed after more research has been done on this framework.

This thesis report has a high practical relevance. First, it suggests ways that the ISA-95 standard can become more relevant in decision making, offering more value for such standard. Second, it introduces what the researcher defines as a multi-actor analysis approach, which helps gain insight on those variables that were left out of consideration or thought unimportant but do have an important weight and influence on the decision outcome and on its correct implementation. Third, the framework suggests a more standardized procedure of decision making for manufacturing companies which is yet to be available on literature. Fourth, it is socially and ethically responsible by including a fixed step where the decision maker needs to acknowledge what is ethically and socially correct before looking at further options and steps. And fifth, it is relevant in that it is internationally applicable.

Likewise, there is a scientific relevance in this thesis report. Literature is scarce referring to multi-actor studies, and more scarce when referring to empirical research. Moreover, the available literature is quite inclined towards public policy analysis and not so in the private sector. This thesis is a first step in re-introducing this multi-actor field in the private, and more specifically, in the manufacturing industry sector. Thus, a scientific relevance exists first, in expanding the scope of multi-actor study and, second, introducing new elements that help add to the limited amount of research of this field. As an example, this paper introduces on new ways to value and evaluate options on a qualitative CBA, as well as introducing a new way to evaluate client satisfaction.

Specific situation that concerns one actor [e.g. client demands an urgent 30% increase in production rate]

Stage 1. The mapping of the company

- Step 1.** Define the decision making practice to follow [consensus, democratic, participatory, semi-autocratic]
- Step 2.** Multi-actor analysis with a *stakeholder analysis technique* based on situation.

Stage 2. The (multi-actor) definition of the problem.

- Step 1.** From a given situation, define the objective of applying the framework [e.g. reach the new production rate set by client fulfilling all requirements]
- Step 2.** Set means to reach defined objective with a *stepladder technique*
- Step 3.** Identify problems in the means to reach objective with a *stepladder technique*
- Step 4.** Select problem which is most critical and feasible to solve.
- Step 5.** Check for information completeness and decision relevance.

Stage 3. The (multi-actor) definition of the boundary conditions

- Step 1.** Define what is right [i.e. what is socially and ethically correct]
- Step 2.** Update multi-actor analysis with a *stakeholder analysis technique* based on defined problem
- Step 3.** Assess strategic behavior by comparing the two made stakeholder analysis
- Step 4.** Define criteria with a *nominal group technique*
- Step 5.** Define alternatives, scenario analysis and general plan of actions with a *what-if analysis*

Stage 4. The (multi-actor) decision making and decision implementation

- Step 1.** Make a decision with a *qualitative CBA*
- Step 2.** Reflect on scenario analysis findings for that chosen decision
- Step 3.** Manage winners and losers [e.g. hearing all “ (decision) loser’s” considerations and suggestions]
- Step 4.** State “implementation rules” [e.g. who needs to take actions]

Stage 5. The (multi-actor) decision evaluation and feedback

- Step 1.** Revise qualitative CBA findings
- Step 2.** State monitoring/preventive/corrective actions depending on the outcome and set “implementation rules” for these actions.



Further research for sure needs to be done on the framework itself. The one for sure is not finished; rather, this research was just a first step, a first idea and a first small test. More empirical research should be done in order to see if a quick-scan version of the process can be obtained without hurting its value and reach, and also to know if the leaner framework does keep all the added value and benefits from the original version. Moreover, more empirical research should be done to apply this framework into real cases, not “ex-post” cases as it was the case in this research and within a wider range of practical cases. This can help in analyzing and evaluating if the framework applies in distinct sectors of the manufacturing industry and if it is usable and feasible in manufacturing companies from different cultural backgrounds. Further research is yet needed, especially on letting the multi-actor field be known by students, graduates, managers and so on, so that this framework is easier to put into practice and has the expected results. A better understanding on the advantages of a multi-actor analysis approach and on the know-how of the techniques used will result in quicker benefits from using this framework, less mistakes by learning and, therefore, a better “maintenance” of the framework; meaning that companies themselves will be able to adjust this framework process depending on different situations and variables without hurting the added value of the one or having to rely on experts to do so. Thus, a deeper knowledge and understanding on the multi-actor field can increase the motivation to employ this framework process.

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## Acronyms

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ERP - Enterprise Resource Planning  
MES - Manufacturing Executive Systems  
MESA- Manufacturing Enterprise Solutions Association  
MEEIN - Mecatrónica e Integración  
OAGIS - Open Applications Group Integration Specification  
DANA - Dynamic actor network analysis  
MASAM - Multi-Issue Actor Strategy Analysis Model  
AHP - Analytic Hierarchy Process  
QSPM - Quantitative Strategic Planning Matrix  
PMI - Plus, minus, interesting  
OEE - Overall Equipment Efficiency  
MO&C - Manufacturing Operations and Control domains  
MOM - Manufacturing Operations Management  
NGT - Nominal Group Technique  
CBA - Cost-Benefit Analysis  
KPI - Key Performance Indicator

## Chapter One: Introduction

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In modern times, almost all firms work in an environment consisting of competing perceptions. Rarely can decisions be made without considering the differences in such perceptions, interests or objectives. This is mainly because, most of the times, these decisions help develop strategies or plans for the companies which need some level of support from the actors within, and sometimes even outside the organization: a department leader developing a new plan of actions needs the support of its personnel; a firm developing a new strategy might need the support of suppliers and clients as well as the various departments within the firm; a new investment project may also need the support from other external actor such as the government.

Why do many projects, strategies or modification decisions fail? Among various reasons, an important one could be because of lack of support of the key actors involved in those plans (de Bruijn & ten Heuvelhof, 2008). Half of strategic decisions fail (i.e. not implemented, only partially implemented or otherwise produced poor results) in large part because decision makers failed to attend to interests and information held by key actors (Nutt, 2002). Failure to attend to the information and concerns of actors is clearly a flaw that often leads to poor performance (Bryson, 2004). Within this paper, actor is referred as departments within a company, or by personnel representing those different departments.

Just as the world itself has become a web of connections, in which most of all places are interconnected with each other, new age manufacturing companies are finding the existence of dependency within their multi-disciplinary activities. Cooperation between different actors (i.e. departments) has taken a new level of importance in order to reach meaningful solutions to possible differences in perceptions, objectives, values and thinking. This complex environment arises from one where more and more is connected with each other: companies' processes are not independent from each other but have significant dependencies and interactions. In a general sense, companies have shifted from being mostly localized and department-specific to having, and needing, an approach relying more on networks. The consequence rests in an increase of cooperative links and networks between the actors involved in a given process. The ways activities are carried out have changed by extending the scope of them and the scope of involvement from exclusively inside a department to the inclusion of several other related departments. This has caused that interaction between different professional cultures and thinking becomes inevitable. Thus, a process that once was carried out exclusively by a single department is now faced with having to meaningfully cooperate with others to better reach positive results given a dependent nature of activities.

This overriding complexity called in for enterprise and control systems to help companies deal with the convoluted set of activities under the intense and fierce competitive manufacturing globalized market. The most prominent systems of this type are Enterprise Resource Planning (ERP) and Manufacturing Executive Systems (MES). An ERP is a system that integrates internal and external management information across the entire company by means of an integrated software application. The purpose of an ERP is to facilitate the flow of information between all business functions inside the boundaries of a company and manage connections with outside stakeholders (Bidgoli, 2004). Meanwhile, a MES system is one that manages manufacturing operations in a company. The goal of a MES is to improve productivity and reduce the total time to produce an order. MES and ERP systems are increasingly being integrated with each other. By integrating an MES with ERP software, a company can be proactive about ensuring the delivery of quality products in a timely, cost-effective manner.

Decisions are thought to be influenced by a high-level management system like the ERP, and a low-level control system as the MES. The ERP manages generic common functions such as receiving, inventory, invoicing, shipping, accounting, bill of material and manufacturing routing. The MES materializes the frontier between provisional plans and actual realizations. The MES is in charge of the detailed scheduling of activities in the manufacturing system, the launching of the orders, the response to random events, the adjustments of plans and the following-up of activities (Baina et al, 2005). MES are essential to automate the machines, production lines and the ERP systems. These systems link up these processes and are crucial for operations to go on without a break and achieve operational excellence (LOGICA.nl).

Because there was an overlap in functionality given a wide variety of these control systems, the Manufacturing Enterprise Solutions Association (MESA) introduced some structure by defining the scope of MES systems. This was needed as companies faced themselves with issues such as differences in terminology, methods and tools from one company to another and within the same company. This created time consuming and mistake prone activities to appear as manipulation of information was needed in order to convert, for example, one terminology set from a certain department to a terminology set that another department could effectively use. It is clear that the complex enterprise and control systems are almost unmanageable without standards supporting the efficient and effective process operation (Lukszo). Standards facilitate information and communication exchange and coordination, and only through this, do they contribute to efficient and effective process operations. Therefore, it was then that in the early 2000's, the ISA-95 standard was introduced to precisely develop an interface between enterprise and control systems and to ensure a consistent terminology that could provide consistent operation and information models. The standard along with the system solution it helps accommodate in manufacturing companies, provide information which can aid taking decisions since this information can give out an overview or status of different processes in real-time. However, this information can be viewed in different manner depending on the priorities and the background of each actor (i.e. department). This causes that there is a different perception on the meaning and value of each set of information, the priority and extent of it, and on the consequences and actions to be done due to this.

This research intends to focus on knowing how a multi-actor analysis approach may help improve current decision making processes for manufacturing activities by introducing a decision making process framework based on such approach. Manufacturing activities are referred as those processes that are involved in the transformation of raw material to end products like production, planning, quality assurance, maintenance, and so on. For a practical insight, collaboration with Accenture, DSM, Schott AG, Mecatrónica e Integración (MEEIN), Grupo Antolin and Radiall is made. The reader can find a description of these companies and the main findings from the interviews in Annex B, as well as in different sections of the paper named "Interview findings". By means of data drawn from interviews along with study of literature, the research will discover if and how decision making within manufacturing companies can be improved by the introduction of a multi-actor analysis approach.

The research will assess first, the relevance of ISA-95 guidelines into decision making in order to see how the latter could be improved by the former; second, if the current processes and practices in decision making are sufficient for the effective decision making concerning diverging interests and demands; and third, if decision making in manufacturing activities can be improved with a multi-actor analysis approach. In other words, is today's decision making enough to assure effective decisions considering the multi-perspective complexity of modern organizational environments, or might a framework that introduces a multi-actor analysis approach help improve these decision making activity?



## **Chapter Two:**

### **Research objectives and main description of the problem**

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**T**his chapter intends to facilitate in a clear way the main objectives of the research. It will also specify the research questions which will help the researcher reach the selected objectives, as well as the methodology the research will follow. Furthermore, it will give a deeper description of the perceived problem that made this research take place.

#### **2.1. Research Objectives**

The main objectives of this research are:

- First, to assess to what extent ISA-95 guidelines can help improve decision making.
- Second, to evaluate if the current processes in decision making are sufficient for the effective performance and decision making in everyday manufacturing activities. If this is not the case, then assess if the introduction of a multi-actor analysis approach might help improve these decision making processes.
- Third, to address the possible impact of the introduction of such approach and how it could improve the current practices.

The expectation of the researcher is to provide a framework that is usable, feasible and that it actually improves decision making process in the sense that decision making becomes less conflicting, more rapid and that the implementation of those decisions enjoy the support and understanding from all involved actors towards reaching desired objectives. It should be said that the main objective is to evaluate the practices in an internal organizational network.

#### **2.2. Deliverable and Problem Owner**

The result of this research project will consist of an evaluation and assessment of the impact an introduction of a multi-actor analysis approach have to current decision making processes regarding manufacturing activities, and how this could best accommodate information coming from enterprise and control systems and ISA-95 guidelines. It will also assess how this multi-actor analysis approach could support with perceived limitations of the current processes and practices. Based on these assessments, a framework will be delivered which can be used as guidance for manufacturing companies for their decision making processes. This framework will provide guiding principles to make it easier for end users companies to work and decide upon manufacturing processes under a complex, dependent, multi-actor environment.

The framework is intended to help end users companies on their decision making to have a process which can have a more complete set of information that is more reliable and on time, and which can promote better means to achieve a successful decision implementation. It will help them because, among different reasons, the framework will provide on guiding principles on improving the definition of their requirements and maximizing support from different actors involved.

#### **2.3. Problem Description**

The perceived problem is born due to initial perceptions recognized in the behavior and process of manufacturing companies regarding an important field: decision making. These assumptions are

fueled by past working experiences of the researcher as well as from limitations recognized in literature study. In simple terms, the problem is that manufacturing companies may not be taking the best decision making activities within their manufacturing processes due to a dismissal in the value of multi-actor integration in the decision making process. This dismissal may not be taken consciously but it may be done by following guidelines, such as the ones in ISA-95, which may not acknowledge multi-actor importance. Therefore, current decision making processes and practices may have a room for improvement.

Thus, an important perception for this research was that current decisions in manufacturing activities do not include views and opinions born from competing interests from different actors. In other words, that there is a mismatch between practical needs and factors that companies rely on within their decision making processes. A second perception was the need to introduce a multi-actor analysis approach due to a belief that the introduction of such approach will help improve decision efficiency by increasing chances of coordination, cooperation and support within and between departments by putting important weight to competing interests and diverse objectives and perceptions. A third perception was that decision makers (e.g. managers) overlook the importance of a multi-actor perspective for their decisions and that this undervalue translates into lack of support and failure to achieve a higher number of success in projects and plans. Finally, a fourth perception is that a research as this one, between the multi-actor field and the private manufacturing sector, is lacking as of today.

## 2.4. Research Questions

Research questions allow focusing attention on a specific problem. It is always a good idea to be clear about what is to be studied and why. Research questions help search literature more effectively, choose a methodological design and structure the written report. Having said this, the current section will provide the main research questions for the current project.

The fundamental goal addressed in this thesis is defining a framework that can provide manufacturing companies with a process that is based on a multi-actor analysis approach with the goal of improving decision efficiency. With decision efficiency, the researcher refers that the decision meets its intended purpose in the best possible manner with the least waste of time and resources, gathering the best support and understanding level from the involved actors. Thus, this main issue is reflected in the following main research question of this project:

- How and to what extent can a framework be provided that improves the decision making processes and practices for manufacturing companies when addressing their manufacturing activities which involve several actors?

In order to answer this general question, the research was divided into three parts and for each part a distinct research question, sub-questions as this thesis will identify them from now on, is answered.

I. Q1. What is the standard ISA-95 and how can the information from the standard and enterprise and control systems improve decision making?

Because the standard is used to create a (enterprise and control) system solution which provides information that is analyzed by decision makers, it could be that a change in the standard's guidelines could improve decision making altogether. Therefore, the ISA-95 standard is studied to find possible ways for the one to improve decision making. Now, what the ISA-95 standard tries to address may not be considering decision making processes at all: insight is needed on the main

objectives of the standard. Moreover, research should show if the information from the standard and from enterprise and control systems can improve decision making. Thus, the standard is included in the scope of this research to evaluate if it can provide with added value other than the implementation of system solutions for reaching better decisions.

In order to answer this question, the ISA-95 standard will be studied as well as published literature concerning this standard by recognized authors and insight from people with experience of implementing enterprise and control systems under this standard. Afterwards, the thesis will provide a view on how the information from the standard guidelines and from manufacturing and enterprise systems could be used in the framework and thus, help improve decision making.

II. Q2. What is a multi-actor analysis approach and why is such approach necessary to be considered to support decision making?

Currently, there is little literature concerning multi-actor processes, multi-actor analysis tools and techniques and there is no real definition on what a multi-actor analysis approach is. Furthermore, there is no real framework existing in current literature like the one this thesis tries to introduce. Thus, insight on multi-actor analysis techniques and processes is needed. Just like this, information on the strengths of such techniques and processes is valuable in order to know how they can be accommodated and used, and tackle the limitations drawn on this research for effective decision making processes and practices.

In order to answer this question, a review of the small volume of literature available addressing this topic will be used in order to come up with a definition of multi-actor analysis approach and how this approach will help with the overall objective of this research. This information will be complemented by findings and information drawn from interviews made to different international companies.

III. Q3. Which are the most fitting decision making processes, practices and techniques that acknowledge a multi-actor analysis approach and increase chances of support, collaboration and success in manufacturing activities?

There is a vast repertoire of decision making theories. But not all of these are fitting with the situation at hand. To be more specific on this question, insight on the most fitting decision making process, practices and techniques given manufacturing companies embedded in dependent network-like environments is needed.

Thus, in order to answer this question literature study will be consulted in order to come up with a list of practices and techniques that may best fit into this situation. Furthermore, just as with the previous questions, information from the different interviews will be used in order to provide with a more complete and reliable answer.

## **2.5. Research Methodology**

The research project is based upon 3 main areas: literature study, interviews of personnel working in manufacturing companies and that have experience in decision making processes, and on 3 empirical cases where the framework is used as means to diagnose a manufacturing situation. Practical insight, drawn from the information provided by interviews and from 3 empirical cases, will provide a better overview of the validity, extent and feasibility of the proposed framework.

Hence, this method is best suited to answer the research questions and to be able to provide a meaningful and more complete framework.

The style of this pragmatic research can be categorized as argumentative, client-advice, and as an interactive style. It is argumentative given that attention was denoted to debate and to prevent “dialogue of the deaf”. It is of a client-advice style since the process occurs in complex environments with different interests. Finally, it is of an interactive style since the actions themselves may have different views on the same problem. These styles are especially shown in the framework and on the empirical study.

The research was divided then in 3 parts:

#### ***Desk Research via Literature Review***

Literature review was done on three topics of utmost focus of this thesis: the ISA-95 standard, the multi-actor analysis approach and decision making processes and practices. The main cause of this methodology was to understand the fundamental reasoning of these theories and approaches so as to first, evaluate strengths and limitations; and second, find more linkages on how these topics could effectively support the decision making area. Journals, books, internet, policy documents, among others, were used for the theory study of this part of the research.

#### ***Practical Research via Interviews and Case Studies***

Practical research was made by working alongside different companies and gaining insight into information to learn, among other things, how decision making processes and practices are in the real world and what are yet the perceived windows for improvement in these processes. A synopsis of the interviewees and interviews can be found on Annex B. Furthermore, empirical study was made to put into practice the proposed framework with situations within manufacturing companies and evaluate if, and how, this framework helped and improved decision making when talking about decision efficiency and support. The reasoning of this methodology is to gain insight, on a much deeper nature and on different functions, from the actual people involved, and have information that may not be available in the literature, complementing findings from the desk research.

#### ***Framework development***

Finally, on the third part of the research, all information and findings was narrowed into a framework with the purpose of improving decision making processes by describing one which incorporates a multi-actor analysis approach into it. The data drawn will be validated by the literature study and by cross-referencing expert opinion and results from the interviews.

## **2.6. Structure of the research**

The research questions will be answered step by step in the following chapters:

**Chapter Three** will answer the first sub-question. It will introduce the concept of the ISA-95 standard, its functions and objectives. It will point out the benefits that such standard has made to the manufacturing companies as well as the shortcomings it has, among others, upon decision

making processes. The strengths and limitations of this standard will be presented upon two views: from literature study and from interviews from expert personnel from different companies. This will help to understand the reasoning of such standard and what exactly it tries to tackle in order to show if in fact, decision making is referred in it or not. It also provides on ways in which the information from ISA-95 and enterprise and control systems may facilitate the decision making processes. **Chapter Four** will answer the second sub-question. It will introduce the notion of a multi-actor analysis approach in order to see how it may support decision making processes. This will help mount the basis for the following chapter to find a link on how the strengths of a multi-actor analysis approach can complement the perceived needs of current decision making processes. **Chapter Five** will answer the final sub-question. It will introduce the decision making processes that occurs in manufacturing companies gathered from the interviews on the companies' personnel. Furthermore, thanks to research review, the most optimal decision making processes for the research situation will be pointed out. After having explained the different topics in the previous chapters, **Chapter Six** will then elaborate a framework based on a multi-actor analysis approach and the extent of how it improves decision making processes. Finally, in **Chapter Seven**, the conclusion from the three research sub-questions and main findings of the empirical research will be revisited and the main research question will be answered. Furthermore, limitations of this framework and future research suggestions will finish this chapter and the research paper.

Figure 1 shows how the different chapters will mend to produce a final framework. It shows as well which research questions will be answered under which chapters.

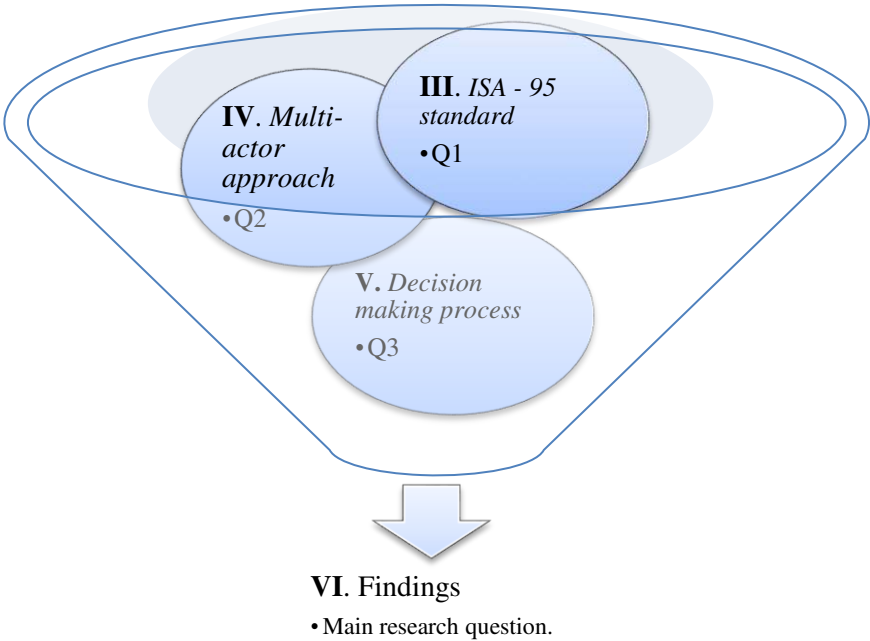


Figure 1. Overview of research steps to answer research questions.

One of the concepts analysed in this thesis is the ISA-95 standard. ISA-95 is the international standard for the integration of enterprise and control systems. In the introduction chapter, these two systems were introduced by the means of ERP and MES systems. It is not in the scope of this research paper to further elaborate on these types of systems but only to highlight the relevance of the standard onto these systems and therefore, on decision making in manufacturing companies. In this chapter, the functions and the objectives of this standard will be identified. Furthermore, strengths and limitations of the ISA-95 standard towards decision making processes and practices will be assessed. Therefore, this chapter answers the following question:

*Q1.* What is the standard ISA-95 and how can the information from the standard and enterprise and control systems improve decision making?

Hence, after reading this chapter, the reader will know how the standard can support decision making processes that are present in manufacturing activities. This chapter is based on the ISA-95 standard along with other available literature from recognized authors in the subject and input obtained from interviewees with experience in implementing, working or studying the standard. The goal of this chapter is first, to provide a basic explanation of the standard's main objectives and functions that may help those readers who are not familiar with it or to re-assess existing knowledge by readers familiarized with the topic; second, to identify aside from the strengths, limitations of the standard when referring to decision making activities. The expectation of the researcher is that this chapter will address the relevance of ISA-95 on decision making and how the information from this standard and enterprises and control systems may be used at decision making processes.

In section 3.1, the paper will explore why companies could be inclining more and more towards this standard and what are they trying to achieve by this. In section 3.2, the actual objectives of the standard will be identified. Section 3.3 presents the main findings from the interviews regarding the topics analysed in this chapter. Sections 3.4 and 3.5 will highlight the main strengths and weaknesses respectively of the standard towards the situation stressed so far in this report drawn from literature study and from inputs from interviews. In section 3.6, the paper concludes that the standard does not provide a real guideline for decision makers to improve their chances of support, approval and success in decisions of manufacturing activities because the scope of the standard does not include activities and procedures of management such as decision making. However, information drawn from the guidelines of this standard and enterprise and control systems could very well be used and have an impact on decision making.

### **3.1. ISA-95. The need of such standard**

One of a company's main goals has been to be able to integrate the operating units of a plant to be able to produce at minimum costs and therefore gain maximum profit. However, initial work for this goal failed because of a lack of unit coordination, dynamic response and market sensitivity (ISA-95 Part 1). To be able to overcome these factors of failure, the aid of overall design and operational standards was necessary.

Each production system around the world is organized differently and uses different types of business and control systems. There is no company that exactly uses the same terminology for activities, functions, and even departments. Moreover, the exchanged information within companies

varies from one to another. One firm for example, speaks of a batch, while other company speaks of a production run. To add complexity, within the same company, *professional cultures* vary from one department to another. As an example, the “spoken language” that the production department has is different from the terminology used in a logistics department. Professional culture is a patterned system of perceptions, meanings and beliefs about the organization which facilitates sense-making among a group of people sharing common experiences and activities, and guides individual behavior at work (Bloor, 2012). Professional culture contributes to the challenges of effective inter-professional teamwork. Insight into the educational, systemic and personal factors (i.e. characteristics of actors) which contribute to the culture of the professions can help improve inter-professional collaborative practice (Hall, 2005). These professional culture differences add complexity in any given process due to the need of the different actors to communicate with each other. This interconnectedness can be exemplified by the following: Logistics must provide information about which customer orders are received, which raw materials are to be ordered and what requirements do products must have. Production, then, will also need to give information to Logistics about, among others, which end products are completed and when are they completed, the amount of raw materials consumed during production and the exact quantities involved in this process.

It is true that the emergence of control and business systems has made information exchange become easier. However, the integration of these systems with each other and with the rest of the company’s activities such as accounting, planning, production, etc. as well as with the decision making between these different actors, has been one of the most difficult problems to solve because it does not only refer to technological issues, but also to people and organizational problems. Viewpoints of what is important differ and critical success factors are different. As addressed in Chapter One, the need of a standard to integrate the various processes with enterprise and control systems was needed. The lack of accepted standards for workflow management and missing standards for information exchange interfaces between ERP and MES applications made management and decision making to not be optimally implemented in practice (Gifford et al., 2006). Therefore, a ‘solution’ was the development of an international standard that could address this objective.

Enterprise and control systems are also needed in companies to comply with certain industry requirements. Therefore, ISA-95 is needed to maximize the performance of enterprise and control systems and to comply with requirements and regulations. Failing to comply with these could signify a company hampering its position in the market. The need for real time and reliable information, improved communication between actors, and improved management across functions that come from enterprise and control systems makes it important for the standardization of these systems to achieve such practical needs. ISA-95 looks to become the standard language in the integration of enterprise and control systems. Therefore, ISA-95 is quickly becoming the tool for stating requirements between departments and areas. Each of these has its specific terminology and is now able to use ISA-95 to translate between the areas through a common baseline. This means that special attention should be taken to ensure that best decision making processes and practice, can be achieved with the help of information coming from the standard and the enterprise and control systems. There are many different standards with similar objectives (e.g. Open Applications Group Integration Specification [OAGIS]) yet this paper will focus on the standard ISA-95. A reason behind this choice lies mainly in the fact that this paper tries to investigate decision making processes that occur within manufacturing companies. ISA-95 focuses precisely on integrating business and plant operations while OAGIS focuses on the entire data exchange problem domain, not just manufacturing functions and processes. Therefore, the ISA-95 standard made more sense in terms of scope and objectives of this research.

### 3.2. Objective of ISA-95

ISA-95 is a standard to develop an automated interface between enterprise and control systems. Therefore, it defines interfaces for example, between applications at the ERP and the MES levels, and between applications at the industrial control level and the MES level. Thus, it bridges the gap between control and business applications.

The goal of the ISA-95 standard is to reduce the risk, cost, and errors associated with implementing these interfaces. The standard must define information exchange that is robust, safe, and cost effective. The exchange mechanism must preserve the integrity of each system's information and control span (ISA-95 Part 3). Furthermore, the standard's objectives point towards providing consistent terminology, providing consistent information and operations models as to clarify how information is to be used. Thus, it can be seen that within its goals, decision making improvement or any management activities as for this matter, are not the real focus and concern of the standard.

ISA-95 was developed mainly because (Brandl, 2008):

- a) Integration of business systems to manufacturing systems was difficult and expensive. These integration projects typically took one or more years and had a low success rate. Possible reasons for this were the different terminology, computer systems, and professional cultures that were present but not fully accounted for.
- b) Effective manufacturing activities were difficult to explain and compare. It was impossible to compare operations at different plants and determine best practices. It was difficult to define requirements and solutions. MES solutions were not only difficult to compare, but it had no common definition.

So, the objectives of the standard yearn for the efficient development and carry-out of the manufacturing processes because it tries first to reduce risks and costs of implementation of enterprise and control systems to its activities and second, assure that the information provided by these implemented systems are safe and robust in order to minimize mistakes on the process and improve the efficient performance of manufacturing activities that use information from these systems. Even more, the standard looks to set guidelines for best practices.

### 3.3. Interview Findings on ISA-95 and MES/ERP knowledge

Just as the first paragraphs of this chapter mentioned, the researcher bases the information written in these sections with literature study and input from interviews. A main description of the interviewees and of the interviews can be found on Annex B. In this section, the findings from the interviews will be put together to facilitate the reader in separating the input from literature and from interviews. The careful reader can see that across the different sections, references to input from the interviewees are made. The researcher believes that having a clear separation will help the reader to have a better view and understand that the information comes from current events and "real" people and not only from books and publications. Table 3.1 presents the main finding from the interviewees regarding ISA-95 and enterprise and control systems.

Interviewee	Area of expertise	Need for the system	Strengths/Benefits	Limitations
Constantino Seixas (Accenture)	ISA-95 & MES	<i>On ISA-95:</i> Guideline and tool for analysis	<i>On ISA-95:</i> -Providing degree of freedom when	<i>On ISA-95:</i> -Not complete. No real cases.



		and an important reference. <i>On MES:</i> Having facts and information on real time.	implementing solutions. -Being able to evaluate MES systems. <i>On MES:</i> Help having reliable information to make decisions.	-Not all ideas and documents are included. -Does not tackle decision making <i>On MES:</i> Impossible to include all functionalities in one MES
Bianca Scholten (Accenture)	ISA-95 & MES	<i>On ISA-95:</i> -To define requirements and compare functionalities. To develop MES and ERP solutions. -It has become the standard language -Needing better communication among actors.	<i>On ISA-95:</i> -Helps actors on shop floor better understand the different functions. -Facilitates developing ERP and MES interfaces.  <i>On MES:</i> -Providing immediate information and on real time. -Improves communication -More efficient and less risk procedures	<i>On ISA-95:</i> -The standard is abstract. -Does not provide explanation on how to apply the standard. -Not everything is on scope
Alex van Delft (DSM)	ISA-95 & MES	Management of different areas	-Closing the loop -Support cooperation between actors and functions -Different areas showed improvement after implementation of system solutions.	-Incompleteness of the standard in shop-floor operations. -Improvement on MES is needed to have more accurate information
Arturo Armendáriz (Schott AG)	MES	-Manage inventory levels, production requirements and KPI reports. -Due to ISO requirements, a system to track production process is needed -Trustworthy information	-Visibility throughout the whole process -Easy gathering of information and report generation which facilitate decision making	-No real way of ensuring the information is 100% reliable -Results not seen immediately -Training on the use of MES can be expensive
Alejandro Treviño (MEEIN)	ERP	More order in the process.	Give correct information on the correct time to improve decision making	Human factor
Evaristo Uresti (Grupo Antolin)	ERP	Basis to make an informed decision on issues	Having an easier control of the plant	Human factor

Francisco Yepis (Radiall)	ERP	Help standardization in order to better understand the processes and improve them	Take the operating and administrative tasks towards standardization and improvement of processes.	Human factor
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**Table 3.1. Main findings of interviews regarding ISA-95, MES and ERP systems.**

### 3.4. Strengths of ISA-95 towards decision making

The ISA-95 brings numerous and important benefits to companies implementing systems with its guidelines. But the question is how does the standard support decision making within a multi-actor dependent and network-like environment? These benefits are drawn from literature and interview inputs.

#### a) Communication improvement.

First of all, the standard improves communication between all parties involved. After implementation of a system with ISA-95 guidelines, actors can understand what needs to be done. The support of ISA-95 enables companies to define in a better way their requirements regarding systems for their manufacturing activities. Just as the same way it is ideal that different actors are working together, it is ideal that different systems (e.g. MES and ERP) are also working together and ISA-95 facilitates this option (Scholten, 2012). This benefit allows establishing better system solutions which in turn will lead to more reliable and on-time information which lead to improved decision making.

#### b) Systems integration

A second benefit is obviously the ability to connect the control systems with the enterprise systems. The strength lies in providing data to the ERP from the MES and vice versa. When ERP and MES are not integrated, mistakes can be made and it can take a lot of time to update information that needs to be synchronized between ERP and the shop floor (Scholten, 2012). That is why ISA-95 was developed: to have standard interfaces and to make it much easier to exchange information between those two types of systems. This is also a benefit that indirectly influences decision making: by avoiding mistakes related to information, decision can be taken in a more reliable and quicker manner.

#### c) Benefits of implementing a system solution.

Another important strength of ISA-95 is the indirect benefits a correct system solution implementation delivers to a company. ISA-95 is not something that you implement but it is used to implement a system. Therefore, it gives out guidelines for that correct implementation in order to maximize benefits that these systems, like ERP and MES, can give. Therefore, the standard along these systems:

- **Help closing the loop.** As Mr. van Delft from DSM remarks, ISA-95 and MES systems support cooperation across levels because they help “closing the loop”. Mr. van Delft refers as “closing the loop” similar as ISA-95 defines integration: that information is brought back to that actor that first sent the information. For example, it closes the loop in production planning because the enterprise system gives the requirements to the operations where then it is executed; afterwards the results from these operations are brought back in order to see

the performance and be able to get better future production planning. This loop closing can be seen in other functions such as maintenance and finance. This allows to have a more complete set of information to help in the decision making process.

- **Help improve the generation of reports, the visibility of reports, and have correct and reliable information.** The manufacturing process beneficiates decision making by providing more trustworthy information than if no system was used at all (Armendáriz, 2012). This is important to highlight because this benefit influences directly the decision making process.
- **Allows taking decisions in real time.** MES, for example, provides information of the exact status of a production line and based on that, different actors with different functions can know about issues, quality mistakes, in order to take immediate actions. This is another important benefit that influences directly the decision making process.
- **Cost reduction.** For example, given that the exact status of the manufacturing activities can be observed in real time, it is faster to grasp mistakes and less expensive to correct them. It improves the portfolio management that tells you what to produce and at what cost, leading to cost reduction.
- **Supply chain optimization.** By being able to close different loops of different actors and by helping the users identify their needs more correctly and rapidly. Mr. van Delft states that after implementation of systems with ISA-95 guidelines, “production planning is better” leading to a supply chain optimization.
- **Helps having better control and overview of the company and its processes.** By taking the operating and administrative tasks towards standardization and improvement of processes, it helps actors understand better the different functions and helps upper level actors to view the status of the process and better detect mistakes. This of course, influences directly decision making.

From the previous benefits it is visible that, even if the main focus is not on decision making, the standard indirectly influences this process. It is more due to the systems that are implemented that decision making can be influenced by the communication improvement between actors, by the improvement of reports and information generation, and by allowing real-time decision making. Furthermore, after literature study, potential uses of ISA-95 that may help with information that beneficiates decision making – highlighting an added value for the standard- and which the proposed framework in Chapter 6 suggest to use, can be seen as follows:

- Using the hierarchical models (see Annex A) to define how a company is structured, when discussing departments and automation systems;
- Using the functional model (see Annex A) to determine which departments and systems are responsible for the functions of interest;
- Using the functional model to determine which information flows from one department to another department, and which information flows from one automation system to another automation system;
- Use the definition of functions and information flows as a checklist, making sure that nothing is forgotten;
- Using the definition of functions and information flows as a dictionary, making sure that everybody is talking about the same thing;

- Using the object models (see Annex A) to understand the relationship between different sorts of information;
- Producing reports of performance and costs, and evaluating constraints to capacity and quality. This information and analysis may be utilized to develop production and cost-based indicators.

More benefits of using this standard are obviously present yet these are out of scope of this project. Such benefits are, for example, overall lower project costs and time, faster and shorter learning curves due to standardization, lower cost integration services, consistent solutions across the industry. Additional benefits can be identified by different companies according to their way of working and their own structure and processes. The ISA-95 standard provides a general description of tasks to enable the integration of enterprise and control systems but it is up to each individual company as how to use these guidelines for their best advantage.

### **3.5. Limitations of ISA-95 towards decision making**

Just as the previous section did, this section will address limitations that the researcher finds in ISA-95 and in enterprise and control systems for effective decision making processes. So then, which are limitations of the standard towards decision making within a multi-actor dependent and network-like environment?

The standard's objectives, as already addressed go into a different direction other than decision making. However, the system solution along with the information that the standard and the enterprise and control systems provide, can influence greatly the decision process. So, perhaps it is unfair to state that not having decision making within their focus is a limitation of the standard. For now, it is best to state that the decision making is not within the scope of the standard yet information from the standard and its system solutions can have an influence in decision making. Therefore, the focus on limitations shifts towards those limitations of the information that the standard and the enterprise and control systems can provide and which can influence decision making. After revising literature and gathering information from the interviews, 4 main areas of opportunities were recognized. These are as follows:

#### **a) The abstract element of ISA-95**

Literature research signals that ISA-95 is not limited to just one specific industry but that various industries and sectors utilize this standard to implement enterprise and control system solutions. However, it is because of this, that the standard becomes abstract and implementations of these systems may not be optimal since the standard itself does not provide explanation on how to apply it (Scholten, 2012). This has an indirect effect on decision making: the standard is used to implement enterprise and control systems which in turn will provide information which will be used to make decisions. So if the implementation of the system is not correct in the first place due to the standard being abstract and not providing specific explanation, the information that these systems provide may not be reliable and decisions could very well be hurt.

#### **b) Information left out of scope**

An important limitation of the standard is that it leaves important information out of scope. Therefore, it risks correct implementation of system solutions since not all relevant information is considered within the standard. For example, Mr. van Delft realizes that the standard, although it is strong at production, maintenance, quality and inventory areas, lacks in supporting what is really happening on the plant process at the shop floor because it does not describe it. This has as a

consequence two things. First, the system solution may not be optimal since not all relevant information is considered for the implementation of such solution. Therefore, the solution could be inefficient and could provide output that is not reliable or complete for decision making efficiency. Second, that information that could be used to facilitate decision making such as the use of hierarchical or functional models for example, may not be complete or may be not present, resulting in not being able to benefit from the possible uses this type of information can provide to decision making and even more, resulting in being a cause of more time consuming and mistake prone decisions due to incomplete or missing information. Just as Mr. van Delft stated, an improvement on MES systems, and therefore on ISA-95 should be done in order to improve in allowing more accurate information to be given for decision making.

**c) Decision making is not considered as a consequence of the use of ISA-95**

According to the criteria list in ISA-95 (ANSI/ISA-95.00.01-2000), decision making across the different levels could very well be included within the functions or information flows of the standard. However, since decision making is not the real interest of the standard, the information and output of the standard and system solutions is not thought about towards decision making processes. Omission of information, perhaps due to the out of scope of the standard, can lead to the dismissal of crucial information. For example, the business plan is left out of scope and creates a hole in terms of decision making opportunities. The focus may not be on decision making per se, but it should be thought about how the output of this standard and systems could affect the manufacturing activities as to not leave out information.

The standard does not acknowledge the complete effect of the implementation of enterprise and control systems based on it. For example, the possibility of mismatches of what the systems indicates must be done to what in reality would work best. So far, ISA-95 only primarily focuses on the content to be exchanged, not the mechanism. Due to this, the standard ISA-95 informs about yet does not try to resolve integrating issues completely, specifically those issues that are born due to competing interests or perceptions.

**d) Participation and role of multiple actors not included**

Actors within a manufacturing company have an important role for the coordination and achievement of tasks, and furthermore, have a direct dependency with each other. Thus, cooperation is essential. However, even though this important element is acknowledged within the standard (e.g. refer to the functional model in part 1 of the ISA-95 standard), it takes into a limited account the participation of different actors. Special attention should be given to actor coordination, actor play and their influence on information and decision making as the standard itself acknowledges the importance of human involvement (ANSI/ISA-95.00.01-2000). As of now, the standard never evokes or refers to actors but only to activities.

Integration of enterprise and control systems is not exclusive to technical issues, but also incorporates organizational and human ones. Unfortunately, these two last factors, especially the human aspect, are not fully described within the ISA-95 scope. The human factor is recognized as a limitation in the using of enterprise and control systems since the information that is used to take on decisions is based on the input that users feed into the system or how they analyze the information. The limitation is more latent when considering that training personnel to correctly use enterprise and control systems and capacitate personnel to correctly analyze information from these systems is expensive. Therefore, companies not wanting to incur in such costs, may risk reliable information on their decision making.

The previous limitations of ISA-95 are not meant in the direction of disproving it. These limitations are written to showcase how decision making can be better supported if these limitations were taken into account when referring to the ways the information from the standard and the systems influence decision making.

### 3.6. Conclusions

The relevance of the ISA-95 standard within decision making is that the standard is used to implement an enterprise and control system solution and it is the output from these systems that help take decisions on manufacturing process. Furthermore, information from the standard itself can help with the decision making process. It was important then to understand about the standard's guidelines and what purpose it wants to achieve. Therefore, this chapter set out to answer the following research sub-question:

*What is the standard ISA-95 and how can the information from the standard and enterprise and control systems improve decision making?*

This chapter has highlighted ISA-95 as an international standard with the primary objective of integrating enterprise and control systems and with this, reducing the risk, cost, and errors associated with implementing these interfaces.

This chapter identified two main reasons of the need to develop and introduce ISA-95 along with some practical needs to adopting such standard along enterprise and control systems. The first was the change of paradigm in companies, which found themselves embedded within manufacturing processes that relied and included several different actors and whose functions were dependent with each other. This brought into light the existence of diverging professional cultures across actors. With the presence of different ways of doing, naming and encoding the same elements in same processes, it became complex to handle such processes without a "common way". Thus, a standard was needed in order to comply with these different professional cultures. Second, given that manufacturing processes became more complex, involved more actors and functions, involved more pieces and elements, enterprise and control systems were introduced to help manage them. And, in order to avoid higher complexity issues by having each company and actor working with their own system, a "common way" was also needed to introduce a certain standardization that governed practices and implementations for these systems in companies. Additionally, practical needs such as the necessity of having real time information, needing better communication among actors, needing better management of different areas and needing more reliable information were signaled by personnel within manufacturing companies as reasons to adopt the standard or enterprise and control systems.

The standard offers for sure numerous benefits, and limitations, to the companies that trust its guidelines. However, this chapter tried to focus on those benefits and limitations regarding the ability to have efficient decision making processes and practices that accounts for multi-actor, dependent, cooperative environments. The main benefits that ISA-95 and enterprise and control systems give as to support decision making under a multi-actor, dependent, cooperative, network-like environment are:

- a) Improving communication among actors and across levels,
- b) Allow systems integration,
- c) Setting guidelines that help implementing system solutions that can:
  - a. Allow integration within and across processes,

- b. Helping developing reports, allow visibility of information, and have correct and reliable information, and
- c. Allowing making decisions in real time.
- d) Reduce costs,
- e) Optimize supply chains, and
- f) Have better control and overview of the company and its processes.

The standard's objectives go into a different direction other than decision making. However, the system solution along with the information that the standard and the enterprise and control systems provide, can influence greatly the decision process. Therefore, the focus on limitations is on those limitations of the information that the standard and the enterprise and control systems can provide and which can influence decision making. After revising literature and gathering information from the interviews, 4 main areas of opportunities were recognized. These are as follows:

- a) ISA-95 is an abstract guideline,
- b) Information is left out of scope,
- c) Decision making is not considered as a consequence of the use of ISA-95 and,
- d) Participation and role of multiple actors is not included in the standard, including the human factor involved in the information input/output of enterprise and control systems

Therefore, it can be concluded that the standard guidelines do not support decision making in manufacturing companies since it is not within its focus and objectives: the goal of the standard is serving as an analytical tool that deals with information and stops when management activities, like decision making, starts. Yet, the relevance of the ISA-95 standard within decision making is that the standard is used to implement an enterprise and control system solution and it is the output from these systems that help take decisions on manufacturing process. By ensuring a correct implementation, the information these systems provide can be more accurate, strong and complete in order to facilitate better decisions. Furthermore, information from the standard itself can help with the decision making process in different ways, especially to help understand the dependencies and the relationships of functions and actors; to ensure a "common language"; to define a structure and responsibilities; to improve reliability and visibility of reports and therefore, process understanding; and, among others, as a checklist. Therefore, the information drawn from the guidelines of this standard and enterprise and control systems could very well be used and have an impact on decision making.

However, because decision making does not only refer to technological issues, but also to people and organizational problems; viewpoints of what is important differ. It is due to these that the use of ISA-95 towards the scope of the research loses a step, since the main issue refers to improving the decision making process for those activities involving different views from several actors: intangible, people and organizational problems, all which the ISA-95 does not attend. The next chapter will introduce the notion of a multi-actor analysis approach to set the initial point for the framework proposed in this thesis yet the careful reader will notice that the value of ISA-95 diminishes and plays a small role from here onwards. Yet, it was important to know how the standard can be of more value towards decision making.

All throughout the previous pages, the reader has come about numerous references to a multi-actor dependent and cooperative environment. In the introduction it was argued how companies have shifted from being mostly localized and department-specific to having, and needing, an approach relying more on networks. A network is defined as a number of actors with different goals and interests and different resources who depend on each other for the realization of their goals (de Bruijn & ten Heuvelhof, 2008). Based on this definition, it is clear that manufacturing companies are indeed embedded within network workplaces because different actors (i.e. departments) have different demands and different resources, yet they all depend on each other to reach theirs and a common goal. When having a network-like structure, actors are in a certain need to receive support from other actors; in this case, actors are in need to work together to reach certain objectives, or actors are in the need of support to facilitate approval of decisions on plans of action. The first notion highlights the sense of dependency among actors and across functions that occur in manufacturing companies while the latter highlights the aspect of cooperation. In this chapter, the introduction of a multi-actor analysis approach will be made along its definition and the need to include this for decision making. Therefore, this chapter answers the following question:

*Q2. What is a multi-actor analysis approach and why is such approach necessary to be considered to support decision making?*

After reading this chapter, the reader will know what the researcher means by a multi-actor analysis approach and will start noticing on how its strengths can benefit in situations where conflicting interests are in place. This chapter is heavily based on literature study and some important inputs from interviews. The goal of this chapter is first, to provide a definition on what the researcher refers to as multi-actor analysis approach; second to introduce the need for this approach to improve decisions within manufacturing; and third, identify those strengths that can help reach for better decisions, improved efficiency and support of the decision's implementations. The expectation of the researcher is that this chapter will continue building the notion on why a multi-actor analysis approach might help support these situations.

In section 4.1, the paper will explore why companies can find themselves in the need to include the multi-actor analysis approach, and therefore, will define what a multi-actor analysis approach is. Section 4.2 will point out the benefits of this approach towards improving decision making under the situations stressed numerous times in this paper. Section 4.3 will give a short description of multi-actor methods that are most fitting to be utilized in the proposed framework. Finally, section 4.4 concludes that indeed, the relevance of a multi-actor analysis approach is an important one and one that can boost the improvement and efficiency of decision making towards support and cooperation on decisions for plans of action and manufacturing activities.

#### **4.1. A multi-actor analysis approach definition and need.**

Being able to see the other person's point of view is one of Henry Ford's advices towards being successful in business. "If there is any one secret of success, it lies in the ability to get the other person's point of view and see things from that person's angle as well as from your own"(Carnegie, 1936).

If companies, in practice, have shifted in recent times towards a network-like environment, why is it that the value of the multi-actor field is still light-weighted in their decision making processes?



First, it is because of the lack of knowledge on the suitability of actor techniques for decision making processes. This can be derived because basically literature on actor techniques, its selection and benefits is quite limited (van der Lei, 2009). Thus, decision makers will turn to those practices that have been proved and thought successful over the years, even though the characteristics for their employment are not matching current needs of manufacturing activities. Second, decision makers may not be fully convinced of incorporating multi-actor ideas since their own companies may have a hierarchical structure and hence, don't see a fit. Formal structures of companies are usually a hierarchical one (de Bruijn & ten Heuvelhof, 2008), and even if in practice it is not like this, a hierarchical process may be preferred and used: decision makers may feel that their decision-making process should take place in a manner that matches that company's structure. Hence, a resistance to change may exist. Finally, the ego of decision makers can be present: decision makers may feel that they lose the power and authority by handing the responsibility of coming down with a decision to other actors, feeling they are downgrading their value in the company. Thus, decision makers may safeguard their place by "buying in" the thoughts that unilateral dependencies, unilateral decisions and openness to hierarchical signals in decision making provide stability. However, the non-inclusion of multi-actor notions within a decision making process can hamper the effectiveness, reach and support of such decision outcome.

What is a multi-actor analysis approach? Approach in this report refers to a structured set of guidelines to assist people in undertaking individual or group processes. A multi-actor analysis approach for decision making refers then, to a set of guidelines that allows for the study of relevant characteristics of multiple actors. This is done by employing a multi-actor perspective and techniques that allow multi-actor analysis and multi-actor input giving value to the representation of several actors towards achieving efficient decisions. A multi-actor analysis approach will help with decisions that should focus on achieving support and cooperation by the involved actors. Characteristics of actors are for example, relationships, perceptions, objectives and interests.

A multi-actor analysis approach definition has been introduced. Now, the report turns to showing the need of such approach in manufacturing companies with a network-like structure. Cooperation is essential for the firm's success because it provides a way to achieve cheaper, faster and more effectively its goals. It is important as to gain support and head on the same direction. It is essential in order to reach potential solutions or agreements over differences in perceptions, objectives and interests. Within a working environment, these differences also include discrepancies in way of working and thinking: decision-makers with conflicting goals bargain among themselves to produce decisions (Cyert and March, 1963). In a practical realm, and as Mr. Seixas points out, there is the inevitable presence of several perspectives on data that is produced by MES for example. A multi-actor analysis approach need is born due to the complexity that arises from the diversity in problem perceptions among the actors involved (Rosenhead, 1989). This diversity comes from different interests and perceptions of reality of the actors. Actor's interests are affected by their values and their role within the company which can change dramatically among actors. Different actors have different perspectives on the same business giving in to the inevitable presence of conflict, negotiation and deadlock situations that could hamper a decision making process (Seixas, 2012). Furthermore, decisions today are not based exclusively on facts but on individual interests so the need to manage these differences is an important one.

The importance of multi-actor inclusion is shown by other authors as well: the effectiveness of solutions depends on the access to the available knowledge that can be improved with the inclusion of multiple actors (Dunn, 2008). Key actors must be satisfied, at least minimally, if not companies will fail (Friedman, 2000). Actors are referred as departments within a company, or by personnel representing those different departments and that can be seen to play a stakeholder position. This definition of actor includes how literature study defines actors as. In literature, actors are those who:

will be affected or will affect the company's strategy (Nutt and Backoff 1992); can place a claim on the company's attention, resources, or output, or is affected by that output (Bryson, 1995); have power to respond to, negotiate with, and change the strategic plan of the company (Eden and Ackermann, 1998) or; depend on the company to fulfil their own goals and on whom, in turn, the company depends on (Johnson and Scholes, 2002).

Implementation of plans or strategies is complicated by the fact that it involves multiple actors (Hermans, 2010); they involve different members from different departments (Pressman and Wildavsky, 1984). Despite having the same common goal, actors have individual targets and objectives and thus, have to make their own choices as how to assess, interpret and implement the information received. If certain information makes less sense from their point of view, it is more likely that this information will be neglected or minimized, even though they may affect other actors. Thus, intended strategies do not always get realized, but rather, the interaction and conflict between decision-makers often leads to unrealized strategies (Minzberg, 1978). The organizational stakeholders generally recognize the importance of including a wide range of actors in implementation efforts since individuals at each organizational level have unique and critical roles to play in implementation (Kirchner et al., 2012). Yet, this recognition is yet to be uniformly seen in decision making within manufacturing activities. Moreover, actors within a company have biases in how they process information and work within a comfort zone under certain kind of settings. Those biases are further influenced by organizational experience, both at functional and cultural levels. At the functional level, for example, production and quality people tend to differ in assumptions regarding on what is "a good product". At the cultural level, there is often a set of values that establish "how things are done here". Because this values can be powerful, it may be difficult to recognize the weaknesses in own perceptions and advantages in opposing perspectives. It is common to see these various perspectives as competing positions in which one must win over the other (Quinn, 1991). Thus, these biases can have adverse effects on decision outcomes and their implementations.

Furthermore and as already expressed in this paper, in today's society, there are hardly any pure hierarchical organizations. Even though the formal structure of organizations is usually a hierarchical one, the reality points to a network-like behavior. Not only the internal structure of an organization may show networks characteristics, but also companies are part of a network depending on support by and relationships with external parties. Because of this, a process approach is needed in which the process of interaction between the actors is highlighted given the unstructured nature of decision making in networks (de Bruijn and ten Heuvelhof, 2008). A multi-actor analysis approach is needed to help manage the real practical structure that is present in today's businesses in which several actors are included.

Due to the potential presence of strategic behavior and trade-offs in information processing and decision-making, negotiation aspects are important. Actors within network-like environments may be inclined to behave strategically: they behave pursuing their position in the network and not so much determined by his opinions. The need to manage strategic behavior and trade-offs is present and a multi-actor analysis approach helps identifying perceived interests, alternatives, values and perceptions, and efforts to change; all of which are significant for negotiation (Sebenius, 1992). A multi-actor analysis approach acknowledges these elements in the decision making process and will help by giving room to trade-offs and negotiation between actors if needed. Numerous problems in manufacturing companies can be characterized as multi-actor problems, which are characterized themselves by multiple actors with their own perceptions and interests of that specific problem. This results in multiple perspectives, incommensurable and/or conflicting interests, and important intangibles (Rosenhead and Mingers 2001). As a consequence, actor analysis techniques should be used to analyze and understand these types of multi-actor problems (van der Lei, 2009). The main

characteristic of a multi-actor analysis approach is that this approach focuses on the analysis of the characteristics of multiple actors. It is now recognized that views on a specific problem differ and that decision making power is often spread amongst multiple actors (van de Riet, 2003). These different views make it difficult to make a decision or find a solution, evoking once again to the complex production and management environment. These complex situations can be exemplified in the next sub-section where different cases from different companies show situation where a multi-actor analysis approach could help overcome limitations or mistakes.

#### **4.1.1 The reality: examples where a multi-actor analysis approach would fit**

##### **- 1<sup>st</sup> case**

BIC is a multinational company best known for manufacturing products such as lighters, magnets, ballpoint pens and shaving razors products. Among the different plants that BIC has throughout the world, there is one located in Ramos Arizpe, Mexico. It is in this plant where the researcher worked for a year and a half. This plant was in charge of packaging shaving razor products that came from Mexico City and from Athens, Greece and then export them to the US and also to other points within Mexico for their consumption. It clearly involved a process with several actors and a great deal of information in the mix. However, the decision making processes did not fully recognize a multi-actor analysis approach and the production process suffered due to this.

Production, Planning, Quality, Maintenance and Warehouse departments were closely linked with the process given their respective functions. They were dependent on each other in order to provide quality products on time. However, there was a lack of recognition on this and each department strove as to achieve their own objectives, even if it meant putting in bad positions other actors, and therefore, the overall welfare of the plant. Just to give an example, Production Department was highly pressured to meet production rates and, in order to do this, machinery had to be in good state. However, Production did not want to allow Maintenance Department to schedule for preventive maintenance of the equipment because it took time off from the production process (even if this could very well be planned before with the help of the Planning Department). Maintenance's interest of securing optimal machinery state was in direct conflict with Production's interest of achieving a certain production rate. The results at first were high production rates given no stoppage on the production process. However, and logically due to lack of maintenance, there was the need to have corrective maintenance (which takes longer time than preventive maintenance) to repair failures in the machines. This meant that the production rates went considerably low, that the machines were not in their optimal state and then that there were discussions about lowering quality standards in order to have an OK on products in order to comply with the production rates.

It is clear the importance of considering different actors' needs, interests and perceptions. It is in the researcher's opinion that if a multi-actor analysis approach was taken, a great number of conflicts like this would have been able to be managed in a much more effective manner. If Maintenance Department would have expressed their concerns about the machinery state and its consequences, Production Department would have stated the need of reaching certain production rate, Quality Department push to respect the standards, and Planning Department voice on planning targets, a trade-off perhaps could have been achieved via a multi-actor analysis approach. As an example of a trade-off, Planning Department could have deviated from its planning just to include a preventive maintenance in order for Production to reach its desired production rate with the specified quality.

##### **- 2<sup>nd</sup> case**

Schott AG is a German manufacturer of high-quality industrial glass products best known for manufacturing glass component of lenses. Among the different plants that Schott AG has throughout the world, there is one located in Mainz, Germany. It is in this plant where Mr. Armendáriz works. A simple example that Mr. Armendáriz shares about conflicts between actors with different demands can be actually seen in many more manufacturing companies. Mr. Armendáriz explains how different objectives of departments can create conflicting situations. In this sense, he refers to how Purchasing, Quality and Production come across such situations of distress. Again, it is stressed that the overall objective in this sense is the welfare of the company: maximizing its profit. In order to achieve this, each actor plays a significant and specific role according to their functions. It is believed that if each actor realizes the best possible way their functions, the overall objective will be achieved. However, there are times that the functions of an actor overlap with the objectives of another. This means that in order for an actor to effectively do their functions and contribute to the overall objective, it will at some level affect the performance or objectives of another actor and vice versa. Furthermore, actors are evaluated by the performance of these functions so a tension is created because if an actor is not performing well, it may lead to negative consequences for that specific actor. The irony is that these negative consequences may be the effect of another actor trying to achieve the overall objective of the company!

In this case, Purchasing Department has an objective of cost reduction. It can achieve this by, among others, incurring in the purchase of low cost materials. This way, they have materials so that the production does not stop and contribute to maximizing profit of the company by reducing the costs of materials that are used. However, it comes to be true on certain occasions that low cost materials come with not the best quality. On the other hand, Production Department wants to comply with a production rate. If it does not have materials, then production stops and their objective, and performance, suffers. The dilemma in Production is that it has a secondary objective, along Quality Department, of zero defect policy. This objective indicates that products that are not complying with the quality standards set by the company should not be allowed. If Purchasing Department keeps on feeding production with low cost materials, the quality of components (and therefore, the objective of zero defect policy) can be in jeopardy. If this happens, then Quality Department is affected in its performance and Production does not perform well neither because they will not be achieving a production rate (since a percentage of that production will be NOK). Therefore, the overall objective will certainly suffer because of lower production than expected and potential distrust in clients due to non-compliant products if it were to happen. The only actor benefiting in this sense is Purchasing Department, but at the cost of other actor's and the company's performance and objectives.

With this example, it can be seen that opportunity for strategic behavior can be present. For example, in order to achieve its objective, Quality Department can incur in stricter quality norms than stated and the process of selection of Pass/Fail material can be exposed to the subjectivity of this actor. Then, Quality may improve its performance at the expense of the Purchasing Department's objective. It is quite evident the existence of a network-like structure, the dependency between actors and the need of cooperation. It is because of this that a method that can comply with these characteristics of environment is needed. In this sense, a multi-actor analysis approach fits nicely in order to support decision making processes among actors with different demands.

### - 3<sup>rd</sup> Case

“Mecatrónica e Integración” (from now on referred as MEEIN) is a Mexican based company that is involved with automation projects for the different industries in their area. Their first market is the automotive industry since it is the one most present and most important. MEEIN offers different kinds of automation solutions depending on the specifications that the client asks. These solutions

are the design, manufacture and integration of automated machines. It is in this company that Mr. Treviño works as a Project Manager. Mr. Treviño acknowledges the fact that within the projects, more than enough they come upon situations which present themselves with conflicts between the different actors involved. He gives an interesting example:

A machine was produced and developed in their plant in Mexico; Production Department viewed this project as completed and successful since it was on time and the machine was working. However, Quality Department did not agree on this because for them, the machine needed to be improved in order to meet with all the specifications and to prevent damages later on. Quality wanted to assure the safeguard and lasting operations of this machine. Naturally, a conflicting situation arose since Production wanted to move on to the next project which also had a close deadline yet Quality, following their own objectives, wanted to assure the quality itself on the product. No agreement was made possible until the client itself was involved. After some time and after discussions between the 3 actors in this case, a decision was made of delivering the machine and working on improvement on the site of the client. Of course this was not the optimal situation nor was it the desired situation because the time was not totally respected at the end, the quality was not the optimal and a faster decision within the company was not able to be done which affected the perception of the client towards this company.

It can be seen with this example that conflicting situation are in daily processes and occur at different levels and involving different actors. A multi-actor analysis approach can certainly benefit to help reduce time in the decision process and actually help reach a decision that is acceptable and right to all involved actors as will be shown on the case study of MEEIN in chapter 6.

#### - 4<sup>th</sup> Case

Grupo Antolin is a Spanish global automotive supplier. It operates in 25 countries with 90+ plants. Among these plants, one is located in Saltillo, Mexico. It is here where the researcher was a 6-month intern and where Mr. Uresti works at. The plant in Saltillo is a production plant, producing different automotive parts for different automotive brands. Mr. Uresti, as a Process Engineer and with Production expertise background, draws a simple case example that provides insight into the existence of conflicting situations among different actors.

Within their manufacturing process, they are involved in plastic injection processes where raw material is transformed, through the use of dies, to solidified parts that later on will be part of an assembly process. At one point in time, one of these dies was damaged. Depending on the damage of the die, the process needs to stop. It is important to mention that a slight damage in the die affects the whole lot of products that goes through this process and through this die. This is because a slight damage, be it a slight tear for example, is reflected in the product: every product will come out with the damage that the die has. This damage was critical because the production had been stalled and at that point, Grupo Antolin was 1 day from stopping their direct client and 2 days from stopping the process of their end client. This is highly negative since stopping production lines is excessively costly and not even referring to the trust issues that a failure of commitment represents. Therefore, the pressure to produce and meet with the production requirements was high but at the same time, the dilemma of producing with a visible damage on the products was present. The production manager wanted to keep on working with the damaged die but the quality manager wanted to remove the die, repair it, and then start process again. The time to repair the die was of 1 day, so if the latter choice was selected, the clients' processes would be stopped. It is clear how opposing interests were present and how both actors had valid points and were looking for not only their own interests, but for the overall objective of the company. But even this did not help to ease the conflict

and find an easy solution; the client here was needed to help take a decision because the actors themselves were unable to reach an agreement.

It is shown in this example how, even if the actors are not behaving strategically and are honestly pursuing for the overall objective, their nature of business can put them in opposing positions and demands. It is here where a multi-actor analysis approach within an established framework can help them with looking at trade-offs and different courses of actions to reach a decision that looks for the best and for what is right while being acceptable to the actors involved and perhaps show in less time the need to involve external parties like the client in this case. This last notion could be done by addressing missing information and who is in hold and can provide with such information. This will be shown in the empirical cases in Chapter 6.

#### 4.1.2. Interview findings on know-how of the multi-actor field

This section provides a simple overview on the different interviewees' knowledge and practical use perception of a multi-actor analysis approach. They were asked if they were familiarized (i.e. had prior knowledge on the multi-actor field, multi-actor theory and multi-actor analysis techniques); if in their companies, multiple actors are involved in the decision making process and if so, if this is a standard process or is an improvised procedure. Table 4.1 provides this overview.

	<b>Are you familiarized with the multi-actor field of study?</b>	<b>Are multiple actors involved in the decision making process?</b>	<b>How many actors are involved?</b>	<b>Is this involvement a standard procedure or more of an improvised situation?</b>
<b>Alex van Delft (DSM)</b>	Yes	Yes	Depending on the situation. Sales and Operation Planning meetings involve 5 to 6 actors for example. Each situation has a specific responsible actor and specific functions for each actor.	Standard procedure
<b>Evaristo Uresti (Grupo Antolin)</b>	No	Yes	Depending on the situation the actors that are thought should deal with the situation are involved. It keeps with a hierarchical structure, involving each time a member from a higher level.	It depends on the situation how the decision is made.
<b>Alejandro Treviño (MEEIN)</b>	No	Yes	Referring to the common conflicts between design and machining, the actors that are included are the project manager, designer and a technician. Normally, 3 actors are involved and the highest level actor has the final say.	It depends on the situation who to involve and how to take the decision.
<b>Arturo Armendariz (Schott AG)</b>	Yes	Yes	It includes several people. Talking about the Materials Revision Board, Quality would be the responsible one.	Standard procedure
<b>Constantino</b>	No	Yes	An "Intelligence Operations	Standard procedure

<b>Seixas (Accenture)</b>			Center” includes several actors that follow governance rules respecting hierarchy.	
<b>Francisco Yepis (Radiall)</b>	Yes	Yes	It depends on the situation but when facing problems, contention meetings are held where the involved actors are present.	Standard procedure

**Table 4.1. Overview of the knowledge on the multi-actor field and how multiple actors are currently involved in the decision making process.**

With the information from table 4.1, it is shown how, one way or another, multiple actors are always involved in decision making processes. DSM, Radiall and Schott AG, all present employees that are familiarized with the multi-actor concept and therefore, acknowledge the importance of involving several actors in the decision making process and it is due to this perhaps that they do have standard procedures. On the other hand, Grupo Antolin and MEEIN, represented by Mr. Uresti and Mr. Treviño respectively, point out the lack of knowledge in the multi-actor field. And even though they acknowledge that in decisions, several actors are indeed included because it helps the process, they do not follow any standard procedure that can guide them into showing who should be involved, how to manage the decision making process among several actors, who is responsible for decisions, among other things. They partially involve actors depending on what the group feels is needed but more based on feeling and intuition instead of based on procedures. Mr. Seixas, from Accenture states that he too, is not familiarized with the multi-actor field of study yet in their decision making processes, a standard procedure is used that involves the different involved actors. In short, it can be seen that they all employ the insight from different actors in their decision making processes: be it on a small or higher scale, the importance of involving other persons in the decision-making process is present. But, the value of this involvement on the results and process is a different story given the amount of knowledge they have on this field.

## 4.2 Strengths of a multi-actor analysis approach

How will companies benefit of employing such approach in their decision making processes and practices?

### a) **Better understanding and management of multiple actor’s characteristics.**

A multi-actor analysis approach as its definition suggests, will help to better understand characteristics of multiple actors in a network. A multi-actor analysis approach is important because of the increasingly interconnected nature of business. Many individuals are involved or affected or have some partial responsibility to act. Figuring out what the problem is and what solutions might work are actually part of the problem, and taking actors into account is a crucial aspect of problem solving (Bryson and Crosby, 1992). Using a multi-actor analysis approach will help in showing interdependencies, making the blockage and problems of joint action visible and show that, in many cases, unilateral actions will not lead to satisfactory outcomes (van Bueren et al. 2003). This certainly helps with putting out in the clear that an approach that incorporates distinct inputs will provide better chances of satisfactory decision outcomes than keeping outcomes tied to the characteristics of a single actor. A multi-actor analysis approach can help dealing with the complexity of situations expressed in this research because it offers a trustworthy analysis, it comes up with an analysis that accounts for interests of all actors and takes a multi-perspective focus. Based on current manufacturing activities, it is hard for the researcher to imagine effective management without the use of a multi-actor analysis approach.

### **b) Improvement in quality of decision solutions and implementations**

A multi-actor analysis approach will help in providing a better quality in potential solutions, or means to solutions, because it will improve the chances of support, improve the chances of minimizing the risk of overlooking certain threats, and improve the chances of detecting opportunities by having better insight from a more complete set of knowledge and ideas. Diverse points are shared, examined and evaluated and if a solution is reached, it will be done after a sound evaluation of different angles. Because of this, a multi-actor analysis approach will help in minimizing the effect of biases, both functional and cultural in decision making. Furthermore, including actors in the process and consulting with them on decisions will build up morale within the organization. Actors are more likely to carry out procedures and plans of action if they have a role developing them. They are also more likely to increase loyalty towards the company. This certainly helps when implementing the decisions; thus, increasing chances of a more efficient decision making.

### **c) More reliable and complete information**

A specific and structured multi-actor analysis approach, can offer a model to guide observations and discussions. This can help to identify anomalies or deviations in collected data by comparing the observed process with the expectations drawn from the analysis. As Mr. Armendáriz states, even if the use of enterprise and control systems contribute to have more trustworthy data, it is not 100% percent reliable and mistakes are bound to happen. There is no way with current practices to ensure this reliability of correct information without employing a great amount of time and/or resources. Following a multi actor approach, this gap between current, not perfect reliability and total reliability can be reduced even more by allowing multiple actors to see the information provided by different sources, such as enterprise and control systems, and minimize the risk of overlooking data or the risk of interpreting it and using it inefficiently or wrong. Furthermore, it can provide a view that enables learning more about the presence of hidden agendas. The use of a multi-actor analysis approach may help identify some of the factors and processes that were previously out of loop. Using a multi-actor analysis approach can explain aspects that were previously unsaid and ambiguous and it enables actors to express their concerns and interests better (Hermans and Thissen, 2009).

### **d) Giving each actor an important place in the process.**

A multi-actor analysis approach starts from the idea that each actor has its own legitimate interests. These interests are respected and included in the process of decision making; the approach is aimed at cooperation and to moderate strategic behavior of the actors involved. The goal is to reach a decision that is pluralistic, with sufficient support and that reflects the different perceptions of reality of the actors. People feel more valued when included in decision -making processes. Feeling empowered is an essential factor in job satisfaction for most workers (Dopson et al., 2011). Attention to actors is important throughout the strategic management process because 'success' for companies partially depends on satisfying key actors according to their definition of what is valuable (Bryson, 1995) in order to, among others, create support for decisions and to improve the working environment. Then, because attention to actors is important, a multi-actor analysis approach becomes important. If the actors can help companies better fulfill their purposes, then there is much to involve them. A multi-actor analysis approach should be used because it acknowledges actors can make important contributions to creating value through their impact on their functions to the strategic management. Strategic management processes that use a reasonable



number of competently done actor analyses are more likely to be successful (e.g. meet mandates, fulfill missions and create value) than those that do not (Bryson, 2004).

#### e) Smart practice

Given Nutt's evidence (2002), expressed in the introduction chapter and how relatively simple and cheap this methodology is, undertaking a multi-actor analysis approach certainly would appear to be a clear candidate for what Bardach (1998) calls a "smart practice". A smart practice because "it involves taking advantage of some opportunity for creating value on the cheap" (Bardach, 1998). It is a smart practice because it is generally easy to understand and is not time and resource intensive (especially when weighing them against the costs of potential failure).

### 4.3. Multi-actor techniques

Employing a multi-actor analysis approach for decision making is not only limited to the acknowledgment of the involvement of actors in the process of decision making. It is logical that the approach makes use of certain techniques as to use the approach's strengths and to ensure a process that minimizes the risk of overlooking key information and key actors. Therefore, multi-actor techniques will be introduced in this section. An actor analysis technique allows for the study of the characteristics of multiple actors. Actor analysis techniques have been developed more significantly over the past years to help better understand the characteristics of multiple actors in decision making situations. This is logical given that since some years ago, the paradigm was one of hierarchical, non-actor processes. Essentially, an actor analysis technique should match the needs and constraints that arise from the situation at hand. For example, decision making activities that are aimed at problem analysis should be better supported by a technique which focuses on perceptions. If resources are distributed over various actors in the network, a focus on resources becomes more interesting. In response to the challenges that a multi-actor process poses, authors have come up with a variety of techniques (Mayer et al., 2004). A first list of multi-actor techniques which could be considered for a multi-actor analysis approach, and based on the findings of Hermans and Thissen (2009) and Bendahan et al (2003), is presented. This list will be further cut down when using the proposed framework in Chapter 6. These techniques are:

- Social network analysis (Kenis and Schneider, 1991; Scott, 2000)
- Configuration analysis (Termeer, 1993)
- Dynamic actor network analysis (DANA) (Bots et al,2000)
- Multi-attribute assessment (Ananda, 2007)
- Stakeholder analysis (Freeman, 1984; Bryson, 2004)
- Analysis of options (Howard, 1971)
- Meta-game analysis (Howard, 1971; Fraser and Hipel, 1984)
- Graph model for conflict resolution (Fang et al, 1993, Kilgour)
- Drama theory and confrontation analysis (Bennett et al, 2001, Howard, 1994)
- Transactional process models (Coleman, 1990)
- Dynamic access models (Stokman and Zeggelink, 1996)
- Causal maps comparison (Jenkins, 1994)
- Allas model (Allas and Georgiades, 2001)
- Multi-Issue Actor Strategy Analysis Model (MASAM) (Bendahan 2002)

It is not within the scope of this research to explain each of these methods in an extended manner but to first, show the reader a list of techniques which could fit best to the situation this paper addresses, and second, to delineate specific techniques to be used at different stages of the

framework in order to improve decision making. If the reader is interested, Hermans and Thissen (2009) provide a nice description of most of these techniques. Table c.2 on Annex C shows a short description of them nevertheless. In this chapter then, a list of possible multi-actor techniques which could be used with the framework that this paper proposes is mentioned. It is in chapter 6, that the researcher suggests the use of specific techniques to guide the decision maker in a clearer way. The previous list shows techniques that were chosen because they can help in situations of multi-actor dependency and interconnection. These techniques are thought to have characteristics that make them be considered to be used within the proposed framework of chapter 6. Other interesting techniques such as Q-methodology (McKeown and Thomas, 1988) were not included in the list because the technique is not appropriate for a general manufacturing decision making process. In this case, Q-methodology is not applicable since it needs samples of statements as a necessary input for the technique, and it is not practical to get a significant amount of samples within a company that does not hurt the company's process, the decision making process nor the method's results. The specific techniques that are suggested to be used in the proposed framework are the ones that the researcher believes are the less time consuming, most feasible to be used, and which best allow for multiple actor intervention under different situations. Moreover, the sources of information for input, information that is assumed to exist, and the necessary information to work with these suggested techniques are feasible to obtain and at the disposal within manufacturing companies. This is why not all of the techniques presented in Table c.2 are suggested to be used in the proposed framework. They could be used but the researcher believes that the suggested techniques offer quality results and offer the means to achieve decision efficiency while accounting for the time and resource restrictions that can be present in manufacturing companies.

Several authors have classified these different techniques into different categories and these findings are on what the researcher based himself onto provide a classification of his own. The researcher identifies two main commonalities in classification of multi-actor techniques from the different authors: techniques for relationships and networks, and techniques for perceptions, objectives and resources. The first type of techniques, for relationships and networks, is found in the work of Hermans (2005), van der Lei (2009), and Rosenhead (1989). The second type of techniques can be found in the work of van der Lei (2009), Hermans (2005) and Enserink and Mayer (2002).

The multi-actor analysis techniques employed in the framework should offer a way to increase the reach, support and effectiveness of decisions. They should then focus on minimizing information gaps and including with greater weight the participation and role of multiple actors as to look for the benefits already stated in this chapter. They should be able to include a multi-actor characteristics study, should be able to be used under different decision making practices (these practices will be introduced in the next chapter) and be used under situation of conflict and trade-offs within manufacturing activities as seen on the separate cases in section 4.1.1 of this chapter. Therefore, the researcher proposes to classify the techniques based on what information they give to the decision makers in order to help the decision making process. A distinction into two levels and 3 choices of groups is made. These distinctions will be explained in the next sections. As seen and explained in table c.1, the techniques are aimed with a primary objective but also have secondary ones that are filled: this is why several techniques may be classified under different types. It is not the intention of this paper to mention all available techniques for each categorization nor a deep explanation for the ones depicted within this paper, but to provide a guideline into possible selection of techniques and how it could help in the decision making process.

### **4.3.1. Techniques of multi-actor decision making process**

All techniques that are mentioned in this research go through a first filter of classification depending on the decision making practice that will be used (these decision making practices will be introduced in the next chapter). For example, decision making in manufacturing activities is characterized by conflicting situations that will make use of trade-offs or autocratic resolutions for a decision outcome. Techniques of multi-actor decision making process are then, closely linked to decision making practices and decision making techniques. Basically, the intention to classify the techniques on this first level is to narrow the selection of techniques depending on the way that decision making is done in the company. After making such distinction, the techniques are classified on a second level, based on their purpose of analysis and which will be explained in sections 4.3.2 and 4.3.3. Thus, these techniques can have, or not, a primary objective of studying perceptions or relationships and at the same time being classified according to the decision making practice. So then, the decision maker can have the option of choosing the most fitting technique depending on both, the purpose of analysis (e.g. relationships or perceptions) and the decision making practice.

Based on the decision making practices occurring in different manufacturing companies, the researcher finds that the decision making processes can be either top-down or bottom-up. With the former, decisions are the responsibility of one actor due to a hierarchical status or any other resource it has hold of and that allows to have that final say in the process. Bottom-up decision making process methods model the outcome of a decision acknowledging, in more or less sense, the input from the various other involved actors. Examples of techniques for decision making bottom-up process are analysis of options, meta-game analysis and drama theory. On the other hand, techniques for decision making top-down processes rely on decision making techniques such as grid analysis, paired comparison analysis, and Pareto analysis. These techniques utilize various factors, possibly including input from different actors, but the decision is primarily the responsibility of a single actor. So, for example, if the way decisions are made is the main responsibility of one actor, techniques situated under the top-down classification should be taken into account. This distinction is made in order to maximize the profit of utilizing each technique based on the characteristics of that technique within a way of decision making. In other words, employing a technique that allows the input and involvement of various actors (also for the decision outcome and implementation) makes better sense within a process that exactly looks for that.

### **4.3.2. Dependency multi-actor techniques**

After the first level classification, the techniques are classified according to their purpose of analysis. This purpose of analysis can be of finding links of work-networks, or of detecting individual objectives and interests of each involved actor. In this section then, the former will be explained. It has been already stated that actors within a manufacturing company are linked with each other forming a network. A characteristic of a network is that it creates dependencies among the different actors, thus, in this sub-section the attention will be on those techniques that help to find links of work networks, calling these: dependency multi-actor techniques.

The main benefit of techniques in this category is that they can provide with vital information on how the relationships between actors can influence their behavior and hence, facilitate or block support in decision making processes. These relationships can be seen through the lens of work-networks which will allow finding dependencies on working processes. Work networks are dictated by the company's process and can hardly ever be changed. It is useful and wise to know how each actor connects with each other, and to see who is dependent to whom in order to make it clear, for example, which information is important for each actor, by whom it needs to be provided and to whom that information needs to be sent. Within this same example, there are situation in which

actors have valuable information that “stays floating in the shop floor” because that actor does not see a value on it even if for another actor it would be extremely useful. Therefore, techniques that facilitate in finding and highlighting this important elements of each actor, could contribute in getting the most complete set of information in order to reach a better decision outcome. Moreover, highlighting the dependencies between actors could improve the sense of accountability because each actor then would know who has to give or do what, who has to receive what, at which times and conditions. This could minimize situations in which the overall performance gets hampered because some actors did not know they were supposed to do certain activities. The dependency multi-actor techniques then, study the relationships between the actors. Social network analysis, configuration analysis and stakeholder analysis are methods that fall in this group of methods.

### **4.3.3. Intangible multi-actor techniques**

Decision making is heavily influenced by the objectives, perceptions and resources of the involved actors in the process; elements which cannot be seen or touched yet influenced: “intangible” elements. As it has been commented throughout this paper, within a multi-actor environment, it is true that conflicts arise due precisely to differences of these actor’s characteristics. Intangible multi-actor techniques will focus on the actor themselves, on the actor characteristics.

The objective of these techniques are putting into the open the individual actor characteristics for each actor involved in the decision making process. Furthermore, to provide with information of the reach and influence each actor has based on their respective resources. It is important to have an insight into these elements since they largely determine the actor’s stand and influence they can use to realize their interests. Resources may be for example, authority or knowledge. These techniques should help in providing with an analysis of common grounds so to identify potential disruptions, and support and blockage points. This will very well help in facilitating support, agreements and trade-offs in a given decision making process. Moreover, the techniques can signal who are those actors who are critical within a process as to help establish conditions for their involvement in the process of decision making process and practices. DANA and multi-attribute assessment are examples of intangible multi-actor techniques.

## **4.4. Conclusions**

Due to a lack of research on the multi-actor field as compared with other proven approaches, the one has not yet been used and put under the spotlight as it would be expected to, given the environment in which today’s manufacturing companies and their activities are embedded in. This chapter therefore set out to answer the following sub-question:

*What is a multi-actor analysis approach and why is such approach necessary to be considered to support decision making?*

In this chapter the definition of a multi-actor analysis approach was made. A multi-actor analysis approach is a set of guidelines or activities that allows for the study of relevant characteristics of multiple actors. This is done by employing a multi-actor perspective with the inclusion of multi-actor analysis techniques that incorporate the value and multi-actor representation towards achieving efficient decisions. The main characteristic of a multi-actor analysis approach is that this approach focuses on the analysis of the characteristics of multiple actors. This approach has not been considered widely within companies because of 3 main reasons: lack of proven use; resistance to change, and wrong perception on fitness of this approach to different kinds of company structures; and sense of downgrading value of decision makers as compared to unilateral decisions.

However, it has been noted that the inclusion of multi-actor notions within a decision making process can help improve the effectiveness, reach and support of such decision outcome.

A multi-actor analysis approach is needed within manufacturing activities because first of all, these activities are within a network which suggests dependency and cooperative needs. A need is present also because of the complexity that arises from the diversity in problem perceptions among the actors involved. Not only perceptions, but differences in interests, objectives, resources, and targets are present. Therefore, there is a need to manage complexity arising from these differences which lead to conflict and deadlock situations. Furthermore, the inclusion of several actors is crucial in order to ensure decision support and viability. A multi-actor analysis approach can help offset and minimize the functional and cultural biases present across the workplace. Moreover, it supports decision making due to the negotiations that are needed to reach decisions embedded in conflicting interests and points of view in a given situation. Multi-actor analysis approach can help in detecting the potential presence of strategic behavior and set common grounds for making trade-offs in information processing and decision-making. This approach is needed also to manage the problems of strategic and cognitive uncertainty because it can help coming up with a more complete set of information. This increase in available knowledge allows for more effective solutions and therefore, along with the cooperation this approach yearns to obtain among actors, improves the chances of better implementation of decisions and strategies. Finally, the way manufacturing activities really work and are structured (in which several actors are involved) calls for an approach that can manage this network structure that occurs in reality.

This chapter provided with some practical cases as examples of manufacturing activities and decision making being met with the challenges that a multi-actor, dependent and cooperative environment presents with. These cases were provided by different companies throughout the world; cases from Mexico and Germany state that this phenomenon occurs all around the globe, hence, the significance of this research. The main findings from these cases are as follows: The first case showed that actors are sometimes pursuing first their own objectives rather than the company's. The second case provided an environment where overlapping interests created an opportunity for strategic behavior. The third case showed situations of conflicting perceptions in which a failure in reaching a decision on time caused the involvement of the client and negative effects. Finally, the fourth case showed how even if the actors are willingly pursuing the company's objectives, their functions may in fact stall the reaching of that objective. These cases showed that these situations are not happening only at one company but are quite common giving a strong practical relevance to the proposed framework of Chapter 6. After reading the cases, the reader can see that indeed a multi-actor analysis approach can benefit companies in their decision making processes to improve their welfare. This because a multi-actor analysis approach will improve support and cooperation with decision outcomes and can help companies reach agreements that are acceptable and right in an efficient time-frame, and show in less time that other actors, like the client, should be included in the process of decision-making. The other benefits that are written throughout this chapter clearly can help put with the situations presented in these cases.

The chapter also showed important insight from people in different companies. They mention how companies certainly use, on an improvised way or through standard procedures, multi-actor information on their decision processes. Some companies do not have yet the knowledge on the multi-actor field of study so in practice what occurs is that they do not fully take advantage of this and their decisions may not be as effective as they would desire. This shows again the practical relevance of including a multi-actor analysis approach in the decision making process: such decision making can be improved when following guidelines that fit best with the actual nature of dependency, cooperation and linkages found in today's manufacturing activities. Furthermore, companies will benefit by using a standard way of involving actors and not on ways that rely on

intuition and feelings like in some companies do. Referring to benefits a multi-actor analysis approach can bring to the table, several benefits were found. The main benefits that a multi-actor analysis approach provides are:

- Better understanding of characteristics of multiple actors in a network,
- Improvement in quality of decision solutions and implementations,
- More reliable and complete information,
- Giving each actor an important place in the decision making process,
- Providing with techniques that are simple and cheap.

A first set of techniques, referred as multi-actor techniques, were introduced in this chapter and could be used at different stages of the framework. This list will be completed with decision making techniques which will be introduced in the next chapter. Later on, in chapter 6, specific techniques that are ought to be the best fit for the framework purposes based, among other, on feasibility of use and time consumption will be identified. Moreover, a special contribution on this chapter is a classification for the techniques to be used in the framework later introduced in this paper.

It can be concluded that indeed a multi-actor analysis approach is needed and could provide important benefits to decision makers. A multi-actor analysis approach can benefit situations that are present in daily basis on manufacturing activities. Therefore, referring to theoretical and practical information, multi-actor analysis approach's strengths can support decision making processes and is a valuable option if, and when, analyzing and using information coming from different sources such as enterprise and control systems and from the ISA-95 standard itself. Furthermore, a multi-actor analysis approach is beneficial since it includes the utilization of techniques which can put into practice the benefits that are stated throughout the chapter, for example, showing how different actors may hamper or increase chances of success of a decision with their resources based on their different demands and functions.

## Chapter Five: Decision making process and practices

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**D**ecision making is everyday business. Decisions are usually a part of, or are connected to, other decisions forming a chain. It can be either taken consciously or unconsciously and be taken to either avoid problems, or to solve them. Because a problem is the perceived gap between an observed and a desired condition, a problem is not the same to everyone; hence, the link between decision making and applying a multi-actor analysis approach to its process is present. This chapter will introduce the terms of decision making process, decision making practices and additional terms that he finds are integral part of the process such as decision making perspectives, techniques and methods. Thus, this chapter answers the following question:

*Q3. Which are the most fitting decision making processes, practices and techniques that acknowledge a multi-actor analysis approach and increase chances of support, collaboration and success in manufacturing activities?*

After reading this chapter, the reader will know what the researcher refers to and differentiate when talking about decision making processes, practices, perspectives, techniques and methods. Moreover, the reader will comprehend which of these may be complemented best by the use of a multi-actor analysis approach; all with a purpose of improving the decisions for manufacturing activities. This chapter, as the previous one, is based on literature study and input from interviews. The goal of this chapter then is first, to provide a clear demarcation of all the terms involving decision making; second, provide an overlook of some examples of these previous terms and help see why or why not they could help in a multi-actor analysis approach; and third, enlist which of these terms best support a multi-actor analysis approach for the situations of this research.

Section 5.1 gives information about the findings from interviews. In section 5.2, the chapter will introduce a specific decision-making process. Section 5.3 will introduce decision making perspectives. Section 5.4 and 5.5 will focus on the methods and techniques respectively, while section 5.6 will introduce decision making practices. Finally, section 5.7 concludes that the suggested techniques, methods and practices of decision making offer the best chances of support and cooperation and best options for effective decisions when several actors are included and when the need of cooperation is present as well as a dependent nature among actors and functions. This is because the suggested elements all take into account actor's characteristics which in turn, facilitate the inclusion of a multi-actor analysis approach which fits with the nature of the manufacturing activities and maximize the advantages and strengths this approach offers to the decision making.

### 5.1. Interview findings on decision making

Table 5.1 presents the overall findings of the interviews regarding decision making. In this table, the decision making practice that interviewees perceive are followed in their companies are written in the first column. The practice that would fit best with the cultural context of each company according to Hofstede is written in the second column. With this, the reader can see if the practice matches the theory in this sense. It is seen that all companies match at some level the cultural context of their location. On the third column, the table shows the answer that interviewees gave regarding the main objectives of taking decisions in manufacturing activities. The common trend is that the main objectives are of choosing among options and perhaps looking for the best future options. The fourth column shows how enterprise and control systems influence the decision making according to the interviewee's expertise, knowledge and functions. Finally, the fifth column

shows what do the interviewees believe is needed to improve decision making. It is clear how involving more actors is a perception the interviewees all have to improve decision making.

	<b>Decision making practice</b>	<b>Practice most fitting with Hofstede's theoretical findings</b>	<b>Objectives of decisions</b>	<b>How enterprise and control systems influence decision making</b>	<b>What is needed for better decisions?</b>
<b>Alex van Delft (DSM)</b>	Mix of consensus and participatory. In urgent matters, semi-autocratic practices are followed.	Consensus or democratic given individualistic and small power distance features.	Choose among options and see the best option for the future	Provide information so that a decision can be made. Improvement on these systems must be made to have better information.	Involvement of other actors is crucial. A good follow-up and clear description of responsibilities and actions.
<b>Evaristo Uresti (Grupo Antolin)</b>	Participatory or semi-autocratic. Involve other actors but always following the hierarchical structure of the company.	Participatory or semi-autocratic given collectivistic and large power distance features.	Overcoming conflicts and making choices.	Decisions are based on the information of the system.	More involvement of other actors and improvement of knowledge of the situation.
<b>Alejandro Treviño (MEEIN)</b>	Participatory or semi-autocratic. Involve other actors but always following the hierarchical structure of the company.	Participatory or semi-autocratic given collectivistic and large power distance features.	Find a solution to a problem. Aim a projection, visualize effects of a decision.	Give correct information on correct time to make better decisions.	Flexibility on rules. More reliability on actors, involve them more and have a better analysis of them. Better communication between actors.
<b>Miguel Ángel Reina (MEEIN)</b>	Semi-autocratic. Hierarchy should be followed but other actors can give their impressions.	Participatory or semi-autocratic given collectivistic and large power distance features.	Not discussed in interviews.	Generate and take information to and from the system.	More involvement of other actors. That everyone follows the same path.
<b>Rafael Lara (MEEIN)</b>	Semi-autocratic. Hierarchy should be followed but other actors can give their impressions. If it is a minor decision then it	Participatory or semi-autocratic given collectivistic and large power distance features.	Decide on a problem.	Not discussed in interviews.	More expertise on the actors involved in the problem. Complementation from other actors.



	can be done quickly and unilaterally.				
<b>Arturo Armendariz (Schott AG)</b>	A mixture between participatory and consensus. Rarely decisions are taken by one person without input from other actors.	Participatory given slight individualistic and small power distance features.	Choose among options and learn about future possibilities. Project future events.	Provide key information indicators.	A standard procedure. Improvement on knowledge and use of techniques. Experience in handling information from the system.
<b>Constantino Seixas (Accenture)</b>	Participatory or semi-autocratic. Involve other actors yet make decisions with governance rules	Participatory or semi-autocratic given collectivistic and large power distance features.	Not discussed in interviews	Help give information and bring facts to decision room.	Not discussed in interviews.
<b>Francisco Yepis (Radiall)</b>	A mix of democratic and participatory practice appears to be present due to the responsibility of the decision to one actor and the high involvement of the rest of the actors.	Participatory or semi-autocratic given collectivistic and large power distance features.	Help improve situations by improving goals such as quality, cost and delivery	Help in achieving standardization in processes to facilitate decision making	Better data, better talent, and more respect and space for perceptions, ideas and discussions from other actors.

Table 5.1. Overview of the findings about decision making.

## 5.2. Decision making process

Decision making process in this paper is defined as the iterative and analytic process that results in the selection of a course of action (i.e. a decision) from alternative options. Decision making occurs at all levels of a company and can be of an individual nature (e.g. which task should a specific actor perform first within their tasks?) or of a collective one (e.g. who should be involved in this process?). However, companies follow a certain organizational structure and it is because of this that certain decisions are more important than others, that certain decisions involve different actors and the responsibility and priorities of the decisions differ. All decisions are a matter of compromise. The decision that is selected never allows a perfect achievement of objectives of all those involved. It is just the best solution that is available under those specific circumstances (Simon, 1947). The compromise makes it necessary to find a common denominator amongst all actors. It can be said that this common denominator, although general and broad, is the welfare of the company. Moreover, every decision is a risk taking judgment. Eventually, no decision is free from values, no matter how factual it may seem. Values manifest themselves in proposals for decisions. Furthermore, information is not neutral (Simon, 1947). This is why a political process perspective (which will be explained in following sections) is important and matches a company's

dependent, cooperative nature. Rather than simple problem solving, different views are transformed into decisions through conflict and compromise in addition to the analysis, adapting itself to cooperative and competitive patterns. Therefore, weighing different values and interests is important.

Furthermore, within everyday processes, patterns can be seen to be always present which can influence, for the better or for the worse, a decision-making process. A cooperative pattern lies when actors prefer the same set of consequences. In a competitive pattern, the preferred outcome of one actor is not the optimal for another one. Cooperation exists when the actors share a common goal and coordination. Cooperation will usually be ineffective in the absence of coordination and coordination is achieved when the common grounds are understood to pull towards a same direction. Companies are systems of cooperative behavior: their members are expected to orient their behavior towards certain “company’s objectives” (Simon, 1947). However, situations of trade-off and conflict may occur given individual objectives that are, at the same time, pursuing those “company’s objectives” yet are in conflict with other actor’s objectives. This was seen in section 4.1.1.

The understanding and analysis of actors’ characteristics is fundamental for effective decision making since, for example, the objectives of each actor are the standard by which possible actions are evaluated against. Thus, objectives, goals, and so on, must be available to the decision makers and explicitly formulated. Decision makers should account for 4 dimensions (March, 1994); these dimensions serving as a guideline in the proposed framework to assess the completeness of the different stages. The 4 dimensions are:

- 1) Knowledge: *What is the information decision makers have about the situation and about other actors?*
  - 1a) *Which information is available right now?*
  - 1b) *Which information is needed to be known?*
- 2) Actors: *What are the characteristics of other actors?*
- 3) Preferences: *What are the preferences by which alternatives and consequences are evaluated against?*
- 4) Decision rule: *What is the decision rule by which decision makers choose an outcome?* In this paper, this can be referred as decision making practice.

Based on these previous dimensions, the reader can see how a multi-actor analysis approach is fundamental for decision makers because the use of this approach gives answer to all of these dimensions as it will be shown in chapter 6. However, decision making in manufacturing companies puts aside often enough, the importance of including actor’s characteristics. This is due, perhaps, to lack of knowledge in the benefits the study of actor characteristics has or to the unwillingness of decision makers to change their approaches in the decision making process as seen in the previous chapter. Hence, if this approach is put aside, the ability to account for the previous dimensions diminishes and decision making will be at risk of incomplete information or support.

The first key to success and power for succeeding in management in manufacturing companies is problem solving and decision making (Cohen and Cohen, 1984). Companies adapt their decision making to what they have and to what they think fits the best because there is actually no guideline stating otherwise. So then, it is true that different companies employ different methods, techniques and practices to reach decisions. To address this issue, the following series of steps is suggested based on Drucker, (2006) and which include the dimensions that March (1994) suggested for decision makers to account for. It is based on Drucker because the researcher feels these steps provide a complete set of information and means towards achieving the desired goals of multi-actor

analysis approach and decision efficiency through problem and actor analysis, support and cooperation achievement and appropriate implementation. The proposed framework heavily relies on this decision making process as to set a standard way of reaching a decision that includes a multi-actor analysis approach:

1. The classification of the situation.
2. The definition of the problem.
3. The definition of the boundary conditions.
4. The decision making and the decision implementation.
5. The decision evaluation and feedback.

These steps will be used in the proposed framework. Therefore, a deep explanation of each step will be made in Chapter 6 when introducing the one. For now, the purpose was to state the decision making process which the framework is based on and give the reasoning to choose such steps.

### **5.3. Decision making perspectives**

A perspective is the choice of a context (i.e. a way of regarding situations and facts) from which to categorize experience forming then a coherent value system. Following this definition, there are 2 perspectives for decision making that the researcher found after literature study.

The first is an analytical or rational one, which looks to come up with a decision through scientific analysis and goal-oriented actions. However, this type of perspective does not acknowledge a multi-actor environment and it assumes a single decision maker, complete information and univocal preference structure. Of course this perspective presents question marks since in reality there is a divided and disputed power of decision along with the presence of uncertainty and information problems. Complete information is for sure not realistically possible within a time constraint.

Thus, a second perspective comes into play: a “political” perspective, which tries to come up with a decision through interaction and negotiation. Management might formally be responsible for decision making but in practice there is a multi-actor setting behind that responsibility. Therefore, a multi-actor analysis approach will be best supported by a political perspective and vice versa. The political perspective gives space for negotiation and trade-offs, does not solely focus on a unilateral decision maker, and does not assume complete nor perfect information but rather the opposite: that the information is contested which acknowledges a need for interaction, cooperation and trade-offs of different actors to come up with a decision. Therefore, when using the proposed framework, one must rely on this political perspective to give room to the trade-offs, that are bound to happen, to improve chances of reaching a decision that is acceptable and efficient to all actors.

### **5.4. Decision making methods for “political” processes**

Decision making process is both a political process, with conflicts of value, and a social process, with multiple actors (Lindblom, 1959). There are several methods for decision making for political processes in literature. However, not all of them apply to the situation stated in this paper. For example, the method of successive limited comparisons by Lindblom, fails by neglecting possible outcomes, alternatives and affected values, all of which are important for an effective decision making under a multi-actor situation and limiting the analysis drastically.

An interesting method for decision making is that from Etzioni (1989). This method is called “humble decision making” or “mixed scanning”. This method is the one that the researcher suggests

to adopt to go along with the proposed framework process. This method contrasts with two prevailing methods of decision making: rationalism and incrementalism. The rationalist method is often impossible to follow since it requires a full evaluation of the relevant information and alternatives. It is not feasible given that it requires the collection of an enormous amount of facts and knowledge of consequences far ahead in time. On the other hand, incrementalism can lead to actions without direction because of its not so clear goals. It is highly conservative and puts emphasis on short-term goals while overlooking long-term ones by suggesting to depart from a point that accepts this as the most common reality (Hermans, 2012). The mixed scanning method, on the other hand, fits to current practices within manufacturing companies that have big amount of information to process (resulting in having incomplete information), have different number of actors involved in the process and have little time to make the decisions. Mixed scanning uses a mix of deep and shallow data evaluation: it can consider a broad range of facts and choices at first followed by a more detailed examination of a subset of facts and choices. This method fits with the decision making process depicted in section 5.2, for example, in the 2<sup>nd</sup> and 3<sup>rd</sup> step. For the second step, a broad examination of the situation is done in order to come up with a narrower problem recognition and definition. On the third step, first the decision-makers can establish what is “right” and then narrow the study through its boundary conditions including what is acceptable to the actors involved. Mixed scanning is an adaptive method that acknowledges the inability to know more than what is needed to make a genuinely rational decision (Etzioni, 1989), recognizing company’s current way of business.

## 5.5. Decision making techniques

“A technique is a specific activity that has a clear and well-defined purpose within the context of a methodology (Mingers and Brocklesby, 1997 p. 491)”. Due to the multi-actor setting described in this paper, these techniques must be ideally used to be complemented by a multi-actor analysis approach and support political decision making processes and mixed scanning method. Decision making techniques can be categorized depending on what is their goal. Therefore, decision making techniques can be techniques to: choose between options, decide where to go ahead, support certain areas of business (e.g. financial decisions), improving decision making, etc. Naturally, one must choose those techniques that fit best the environment and structure of its company and processes. In this sense, this research focuses on those techniques which have as a goal choosing between options and deciding on future options rather than, for example, financial decisions. This is because the first two fit best with decisions that ought to be taken in manufacturing activities: situations of conflicting demands across functions and between actors are more prominent to need the support of techniques that can help with choosing between different alternatives; and decisions which can help with deciding on future steps among different actors based on problem and actor characteristics. These notions are validated by Mr. Treviño and Mr. Uresti who state that most of the decisions are to solve problems based on finding the best choice among a set of possible ones and to find the most attractive course of future events on a given situation. They point out that basically these two are the main reasons of why decisions are taken within manufacturing activities.

It can be seen that the following list of techniques is a continuation of the categorization portrayed in the previous chapter. Table c.1 in Annex C will provide a better overview of these different categories and techniques that apply the best to each of them. Furthermore, in chapter 6, specific decision making techniques are suggested to be used in the framework out of the list below due to their feasibility and practicability in the manufacturing context and environment. After literature study, the most interesting techniques to the researcher that enable choosing between options, assessing future steps and that fit a multi-actor analysis approach are the following. Again, this were

chosen because they all can be used with the information and resources that are available in manufacturing companies while abiding for resource and time constraints.

- Grid analysis (Kepner & Tregoe, 1965)
- Paired comparison analysis (Cohen, 1967)
- Analytic Hierarchy Process (AHP) (Saaty, 2008)
- Decision trees (Yuan and Shaw, 1995)
- Quantitative Strategic Planning Matrix (QSPM) (Mangold, 2009)
- The Future's wheel (Glenn, 2009)
- Go/No Go Decisions
- Risk Analysis (Hillson & Murray-Webster, 2007)
- Plus, minus, interesting (PMI) (de Bono, 1992)
- What-if analysis
- Change impact analysis (Bohner & Arnold, 1996)
- Qualitative Cost-Benefit analysis

There are other techniques that are useful within a company yet do not seem to fit the most with a multi-actor analysis approach since their characteristics and objectives are directed into enabling the evaluation of future options but based on other factors other than actor's characteristics . This decision making techniques are most used by upper management personnel and do not fully acknowledge multi-actor characteristics as the previous set of techniques could do. Such techniques are for example, Financial Cost/Benefit Analysis, Net Present Value, Cash Flow Forecasting, among others. Furthermore, within the framework presented in Chapter 6, 4 additional techniques are presented. These are: multi-voting decision making, nominal group technique (VandeVen et al., 1974), stepladder technique (Orpen, 1995) and six thinking hats (de Bono, 1985). The first three will help facilitate group decision making while the last one will facilitate decision making if there should be a stall in the process.

It is not within the scope of this research to explain each of these techniques in an extended manner. Table c.3 shows a short description of the techniques that enable choosing between options, while Table c.4 shows a description of techniques that assesses future steps. Table c.5 presents the additional set of techniques. The previous tables show the techniques of decision making that could fit appropriately with a multi-actor analysis approach since characteristics of several actors and several options can be taken into account. Having defined and identified the appropriate perspective, method and techniques of decision making that best suit the situation of this research, the following section will introduce some decision making practices that actually occur within companies.

## **5.6. Decision making practices**

Decision making practices refer in this paper as to those ways that facilitate coming up with a decision between involved actors after using selected techniques and following selected perspectives, process and method. In other words, how the decision makers choose an outcome. In this case, the decision making practices that will be introduced all support a multi-actor analysis approach. Common ways to reach a decision in companies (i.e. decision making practices) are not standardized and have to be made according to each individual ways of working. Some of them work really well but others may have room for improvement. The fact is that there is no baseline to compare these practices with.

Decision making practices that are heavily being used in companies yet do not fit at their best with the situation of this research are intuitive decision making and autocratic decision making. The solely use of these practices, in their “purenness”, will not support on a multi-actor analysis approach. The first one, intuitive decision making, is signaled as difficult for companies. It is rather quick but does not satisfy company needs of reliable information. Also, the process does not include the analysis of alternatives; this means that if a better solution exists, it will never be discovered. Furthermore, intuitive decision making does little to mitigate the effects of biases and strategic behavior. Moreover, by using this practice, decision makers can be subject to significant errors in the course of decision making because of the presence of flawed information, emotional biases, insufficient identification of alternatives, prejudices, lack of openness, and inappropriate application (Matzler et al, 2007). However, intuition is always present in decision making: 90% of critical decisions are made using intuition (Klein, 2004). If only a bit true, this suggests that the decision making practices should account for intuitive behavior and the disadvantages presented in this paragraph. When intuitive decision making overrides the processes, the decisions can be far from efficient and positive. The second decision making practice that is widely used in companies is the autocratic decision making type. As its name suggests, an autocratic practice is when the leader maintains control and univocal power of the decision. Therefore, it is this leader who is responsible for the good or bad of the outcome. This actor does not receive input from other actors but decides based on his own experiences/ideas/knowledge/perception of the situation. While it holds true that this decision making practices provides fast decisions, the disadvantages are more numerous. These can include low morale from the rest of the actors that must carry out the decision, especially if they feel affected by it and have not been included in the decision making process. The risk of losing credibility is present if the results are not desirable and other actors feel a better job could have been done. Moreover, a mix with intuitive practices can result in catastrophic resolutions. It is best if this kind of practice be left for emergency situations only, and adapted to include a multi-actor analysis approach, as this practice may weaken support within a multi-actor environment by, for example, growing resentment towards the decision maker for not involving the rest of the affected and critical actors.

Therefore, autocratic and intuitive decision making practices could be improved by using a multi-actor analysis approach but then again, they would not be autocratic nor intuitive practices at the end but other practices, which will be identified in following sections. These two decision making practices are not seen by the researcher as practices that could be used to support a multi-actor analysis approach and that could go along with the selected decision making techniques, method and perspective suggested in previous sections. This is because the nature of the autocratic practice dismisses the idea of incorporating input from other actors which is a major feature of a multi-actor analysis approach and the techniques suggested. For the intuitive practice is different; intuition will be present but it is with a multi-actor analysis approach and the suggested techniques that the negative effects of this practice can be minimized. Therefore, it is in the thought of the researcher that a pure intuitive decision making practice is not beneficial to support decision making in manufacturing activities within a dependent and cooperative workplace.

As expressed before and also as Ms. Scholten mentions, there is not just one standard decision making practice in the business but rather, decision making practices are influenced by the cultural context, the company’s maturity and the type of decisions. That is the reason why currently, international manufacturing companies use intuitive and autocratic practices. Regarding cultural context, companies in different countries with different cultures can employ different practices. Hofstede (2010) realized a framework to assess and differentiate organizational cultures. To survive within a multicultural world as the one which exists today, one should acknowledge the differences in mental thinking and actions between the employees, the employers and the values of company as a whole. One of the reasons why so many solutions do not work or cannot be implemented is

because differences in thinking among the actors have been ignored. Understanding such differences is at least essential as understanding the technical factors (Hofstede, 2010). Within his framework, Hofstede describes 5 dimensions, which are aspects of culture that could be measured relative to other cultures. These dimensions are: individualism, power distance, uncertainty avoidance, masculinity and time orientation. The first two dimensions are the one this paper will focus on the next lines to point out on how culture can define which decision making practice to use since these dimensions are closely related to dependency, network structures and multi-actor cooperation factors.

Individualist cultures assume that any person looks primarily after its best interest and the interest of its immediate family. Collectivist cultures assume that any person through birth and possible later events belongs to one or more tight groups from which he/she cannot detach him/herself. The group, in this case the company, protects the interest of its members, but in turn expects their permanent loyalty. In collectivist cultures, actors are expected for loyalty as opposed to individualistic countries. Now, this can mean that actors will not be willingly open to express their opinions if they oppose the perception of the whole as to maintain loyalty in the group. In companies within collectivist cultures, relationships are more important than the task itself, so it is better for actors to go along rather than speaking up. Likewise, collectivist societies are marked by the fear of losing face, this is, losing authority or respect from others. This can conclude that companies within collectivist cultures may not go against autocratic practices in the sense of preserving loyalty. The dimension of power distance shows dependence relationships in a country. In small-power-distance countries, there is limited dependence of subordinates on bosses and there is a preference of consultation. The emotional distance between them is relatively small: employees will rather easily approach and contradict their superiors. In large-power-distance countries, there is considerable dependence of subordinates on bosses. In these cases the emotional distance between employees and employers is large: the formers are unlikely to approach and contradict their bosses directly. Companies in high power distance countries fare best with tasks demanding discipline. Therefore, companies in high power distance countries could incline to have autocratic and intuitive practices as opposed to other practices that support a multi-actor environment.

The second factor that Ms. Scholten describes that affects decision -making practices is the maturity of the company. According to Ms. Scholten, there are different maturity levels of a company. For example, when a company starts it can be small and very immature: one person takes the decision and he makes this decision based on his own knowledge; therefore, employing autocratic and intuitive practice. Companies that are at lower levels of maturity may incline to use more autocratic and intuitive practice. Finally, the third factor, type of decision, is homogenous in this paper for all companies. In this paper, the type of decision focuses only to those decisions having to do with manufacturing activities under dependent, cooperative and network-like structures. Therefore, for this type of decisions, the suggested decision making practices are thought to best handle them.

Different decision making practices that companies employ were identified with the help of interviews from personnel from different companies, situated in different countries. The findings regarding this topic can be found on table 5.1. It is seen that companies employ practices which the theory expects them to use given the cultural characteristics the company is situated in. However, practices change depending on the company background and vision, and their personnel more than on the cultural influence. Nevertheless, the latter still has an influence on the practices. It is true that if a certain practice does not match at all with the cultural context of a company, a change of direction is needed to provide efficient decision making. For example, if a company placed in a country which is highly individualistic and has a small power distance score, would utilize autocratic practices, the decisions perhaps would suffer from support and effectiveness.

This paper offers a framework that can standardize the practices based on a multi-actor analysis approach. These practices suggestions are made by the researcher after evaluating common and current ways to reach decisions in literature and in companies (based on the interview findings and personal experience). The suggested practices support a multi-actor analysis and value their involvement at different ranges: on one end, a practice in which one person is responsible for the outcome yet includes the input of other actors; at the other end, a practice that heavily involves all actor's input and development in the outcome. The 4 practices minimize the risk of intuition being a solely factor in decision making by using a structured approach, listening better, and reflecting on a decision before implementation and consultation (Krulak, 1999). This is done with the help of the suggested decision making techniques and method introduced in previous sections which support a multi-actor analysis approach. The researcher suggests on selecting between these next 4 decision making practices that comply with this report's objectives and situations:

- 1) Consensus decision making,
- 2) Democratic decision making,
- 3) Participatory decision making, and
- 4) Semi-autocratic decision making.

### **5.6.1. Consensus decision making**

Consensus decision making is when the decision maker gives up total control of the decision. The complete group is totally involved in the decision; therefore, the decision maker is not individually responsible for the outcome but the group and set of involved actors are. Consensus decision-making practices involve the entire group, allowing everyone a chance to be heard. The focus is on getting all actors involved in the decision making process (Hartnett, 2011). Therefore, consensus seeks to improve solidarity in the long run. Consensus should not be confused with a democratic practice since in consensus all actors must agree and go with the decision. Therefore, if total commitment and agreement by everyone is not obtained the decision becomes democratic.

The advantages of these decision making practice include group commitment and responsibility for the outcome. Teamwork and good security is also created because everyone has a stake in the success of the decision. A more accurate decision is usually made, with a higher probability of success, because so many ideas, perspectives, information and knowledge were involved in the creation. It is clear how a multi-actor analysis approach and a consensus decision making fit together. Moreover, consensus decision-making aims to seek agreement (helping everyone get the best of what they need), collaboration, cooperation and inclusion of actors (Sandelin, 2007), making actors feeling understood and involved.

The major disadvantage is being a time consuming decision. It is challenging to get the affected and critical actors involved (although a multi-actor analysis approach certainly helps addressing this). Another important disadvantage is that group members are tempted to insinuate conflict reduction techniques (e.g. majority voting and bargaining) into the process when presented with conflicting situations where no agreement is being made. However, these should not be used because the group should use conflict constructively to ensure that decision-making is a thoughtful and deliberate process.

### **5.6.2. Democratic decision making**

Democratic decision making practice refers to when the decision maker gives up control of a decision and allows the group of involved actors to vote. Democratic decision making practices



drives relatively rapid decisions, though some time is required to include all involved and affected actors in the process. Advantages of this practice involve then, a considerable fast decision, and a certain amount of group participation. Also, it helps the execution phase of a decision become faster since the actors will be on board with it, just as in a consensus practice. A democratic practice is useful for example, when there is not enough time to have a consensus practice or if a complete actor agreement is not necessary. Democratic practices are different than consensus ones since the former does not require that all actors agree with the decision, but perhaps the majority is sufficient.

The biggest limitation, however, is that the voting minority may feel little responsibility for the decision. Another limitation happens if the decision making is viewed as decision made by teams; therefore, forming winners and losers. However, in annex C, strategies and recommendations to deal with the effect of winners and losers will be presented. Furthermore, under this practice (as also in consensus) high quality decisions depend on information and knowledge from the actors involved: if these are inexperienced, misinformed or lacking skills and capabilities, voting may not produce good decisions. However, including a multi-actor analysis approach that gives the chance to see from different sides the available information can aid in minimizing the risk of untrustworthy or faulty information. Lack of group and personal responsibility seems to downgrade this style of decision making; however, the democratic style does have its place in companies. This is because it provides a place where the actors can feel involved with the course of the manufacturing activities and can boost support and cooperation, even if there is no unanimous agreement on the decision.

### **5.6.3. Participatory decision making**

Participatory decision making occurs when the decision maker involves other actors in the process yet keeps total control of the decision because, although outside information is considered, the decision maker decides at the end. Therefore, this practice can be seen as an extension to the semi-autocratic practice with the difference that this practice allows for participation and deliberation, and not only from information input of other actors, like in the proposed semi-autocratic practice. Therefore, a more complete set of information is discovered because the decision maker deliberately has a feedback mechanism and encourages other actors to participate. The decision maker in this practice is completely responsible for the outcome of the decision even if other actors have some say in the decision process. Although employees are asked for their opinions, the leader alone makes the final decision, has all control of how the decision will pan out, and takes full responsibility for all of the consequences (Connor & Becker, 2003). When actors participate in the decision-making process, they improve understanding and perceptions among each other, and enhance personnel value in the company (Probst, 2005). This is clearly fitting with what a multi-actor analysis approach aims to improve and bring as benefit. In a participative decision-making process each actor has an opportunity to share perspectives, ideas, objectives and dilemmas to improve team effectiveness. As each actor can relate to the decisions, there is a better chance of them achieving the results.

The advantages of this practice include actor participation and involvement even if they don't decide on the matter. This is especially valuable when an actor may be affected negatively by the decision. In most cases, actors are informed before the decision is implemented and usually increase moral due to their involvement. If the process is clear and allows for effective feedback, the decision maker will usually have a more accurate understanding of the situation and make a better decision. Another advantage is that the inclusion of actor's participation increases the accuracy of the decision.

The disadvantages of this style include a fairly slow, time consuming decision and a possible presence of strategic behavior and biases from the decision maker that may overcome the whole practice design. As with the semi-autocratic practice, limitations could be fairly low signs of commitment and support for the decision if they feel something changed at the end which was not discussed. However, since other actors are included in a deeper way than in the semi-autocratic practice, they know at some extent the direction of the decision so they could have a say if they detect that this kind of behavior and biases are present. Other negative aspects are indecisiveness and incompetence (de Bruin et al, 2007) if the decision maker is not capable enough to process, understand and direct the decision making process and information, and then may rely more on intuition than on the information.

#### **5.6.4. Semi-autocratic decision making**

A semi-autocratic decision making refers to that decision making practice that is based on an autocratic practice but includes flexibility in involving a multi-actor analysis approach in it. Because attention should be given to governance rules (Seixas, 2012) given that some companies employ hierarchical structures or employ standardized procedures, autocratic practices best comply with line of command features. Furthermore, it has already been stated that companies are willing to use autocratic practices based on cultural, maturity and other factors. Then again, it has also already been discussed that a solely autocratic practice misses out on the benefits of a multi-actor analysis approach and should perhaps be left only to emergency situations. This is why the researcher introduces a semi-autocratic practice in which a decision maker controls and is responsible for the decision but, as opposed to a uniquely autocratic practice, includes the perceptions, objectives and opinions of other actors. In other words, the autocratic practice includes multi-actor elements in its practice. The difference with a participatory practice, is that this only includes *input* from other actors yet do not include further *participation* of them. This way, the decision maker can gain information across functions and actors and use this information to make a more valid decision that accounts better for multi-actor characteristics, improving chances of support and minimizing risks that would be more present with a pure autocratic practice.

The advantage of this practice is that it can comply with companies in collectivist and power distance cultures while introducing elements of a multi-actor analysis approach and therefore, some of its benefits. In other words, it provides a certain deviation without losing the essence of neither a hierarchical structure nor the organizational culture elements while allowing the inclusion, even in a smaller level, of a multi-actor analysis approach and its benefits to the company. Another benefit is that is not as time consuming as other practices and that can improve chances of support from other actors when compared to a pure autocratic practice: it minimizes the disadvantages of a pure autocratic practice.

The major limitation is that the final outcome still relies on one actor and therefore, it gives room to the presence of strategic behavior and biases of this actor onto the final decision. This can also create that the rest of the actors do not fully understand the decision at the end. Moreover, since change is a major stone in processes, decision makers could feel threatened to include input from other actors as they could feel this is the first step to losing their authority and importance to the process and company.

These 4 decision making practices are the ones that the researchers finds most fitting with a multi-actor analysis approach. Understanding that a multi-actor analysis approach mandates the inclusion of various actors in the decision making process, the most fitting practices for a multi-actor analysis approach would be these given their allowance of group member's inputs to the process.

Furthermore, a mix of practices can be used that comply with a political perspective and that can support methods and techniques introduced on this paper. An example of this is to use a participatory decision making practice but in case of situations that a company finds as urgent, the practice could shift to a semi-autocratic practice.

## 5.7. Conclusions

Decision making is present every day in manufacturing (and overall) companies. It can vary in terms of importance and priorities and on consequences and effects but the fact is that decision making will be always a part of manufacturing activities. It is because of this that plenty of decision making techniques and methods and perspectives have been introduced by different authors to tackle different objectives. In this paper, the focus is on those that can fit best and improve the decisions of dependent, cooperative and network-like manufacturing activities involving several actors. Therefore, this chapter set out to answer the final sub-question:

*Which are the most fitting decision making processes, practices and techniques that acknowledge a multi-actor analysis approach and increase chances of support, collaboration and success in manufacturing activities?*

In this chapter, the definition of decision making processes, techniques, perspective and practices was made. A multi-actor analysis approach can help in decision making process for different reasons. Firstly, it allows weighing different values and important factors of the different actors. Second, because negotiation and influence is present when reaching for decisions, therefore, a multi-actor analysis approach eases trade-offs to happen. Third, a multi-actor analysis approach helps address 4 dimensions found to be important to acknowledge in conflict situations. Finally, it is important to include a multi-actor analysis approach since it greatly helps with the different steps of the decision making process proposed and introduced in this chapter.

A decision making process is defined as the iterative and analytic process that results in the selection of a course of action (i.e. a decision) from alternative options. The researches suggests 5 steps for an effective decision making process that accounts for 4 dimensions that in turn, support a multi-actor analysis approach. These steps are thought of because the researcher feels this decision making process provides a complete set of information and means towards achieving the desired goals of a including a multi-actor analysis approach and reaching decision efficiency through good problem and actor analysis, support and cooperation achievement and appropriate implementation. These steps are:

1. The classification of the situation.
2. The definition of the problem
3. The definition of the boundary conditions.
4. The decision making and the decision implementation.
5. The decision evaluation and feedback.

The chapter afterwards concluded that a multi-actor analysis approach will be best supported by a political perspective and vice versa since, among other characteristics, gives space for negotiation and trade-offs and involves several actors. After this, a decision making method called mixed scanning, or humble decision making, was found to be the most appropriate to follow the political perspective and the process before suggested. Given the limitations of the two prevailing methods, the rational and incremental methods, it was found that the mixed scanning method was very much interesting, especially since it fits to current practices within manufacturing companies that have big amount of information to process (resulting in having incomplete information), have different

number of actors involved in the process and have little time to make the decisions. Following this, a set of decision making techniques was enlisted which complemented the multi-actor techniques in the previous chapter to complete the categorization done back then. These techniques have the characteristic that can be used in a dependent and multi-actor environment so techniques that did not fit with these situations were left out. It was described that on manufacturing activities, decisions have the main objectives of choosing between options and assessing future steps; therefore the decision making techniques that were suggested comply with these objectives. Finally, different decision making practices were introduced. It was noted that these practices vary among companies first based on their needs and style of working but influenced also by the cultural context of the country the company is in, the maturity of the company and by the type of decision that is in place. It is because of this, that two decision making practices are still present within manufacturing companies, even if they fail to understand the situation of dependency and cooperation and multi-actor that is present in the manufacturing activities. These two decision making practices are the autocratic and the intuitive decision making practices. The chapter mentioned why companies use these practices and offered examples of this. However, the chapter presented 4 decision making practices that the researcher thinks best support the situations stressed in this report. Moreover, these practices could be mixed up depending on the situations at hand to best complement the decision making process and account for the best possible decision outcome. These practices are:

- Consensus decision making,
- Democratic decision making,
- Semi-autocratic decision making, and
- Participatory decision making.

It was found that the decision making practices that are in fact followed within the manufacturing companies to which the researcher had access to, match at some level with the practices that are suggested by theory, specifically by Hofstede's findings regarding cultural dimensions. Therefore, companies most often participate in decision making practices that go along with the cultural context of the country in which the company is settled in. This improves the chances of support in the decision and reduces the risk of alienation: companies should employ practices to which their employees feel most identified to.

Furthermore, it is in the mind of the researcher that no practice is perfect: hence, decision making practices have their limits. These are:

- Being time consuming,
- Presence of hidden agendas, strategic behavior and biases,
- Lack of responsibility and facts,
- Alienation, and
- Lack of competence.

It can be concluded that the use of a multi-actor analysis approach and the suggested process, method, perspective, techniques and practices can minimize the effects of these limitations. These different suggested parts of decision making offer the best chances of support and cooperation and best options for effective decisions because the suggested elements all take into account actor's characteristics which in turn, facilitate the inclusion of a multi-actor analysis approach and maximize the advantages and strengths this approach offers to the decision making. All of this can create the right environment to take decisions with a more complete and broad set of information, participation and involvement.

The fundamental objective addressed in this thesis is to define a possible framework that would allow an environment of more support and effectiveness of decisions in manufacturing activities when such decision is embedded within a multi-actor situation. It is in the researcher's belief that a framework that includes the approach, process, perspective, practices and techniques suggested throughout this research can achieve this objective. Therefore, this chapter sets the grounds to answer the main research question which will be done in the following chapter.

After reading this chapter, the reader will know of the elements this framework is all about and how and to what extent it can support and improve the decision making that occurs in manufacturing companies. Moreover, the reader will re-assess why this framework is of great interest for decision makers within a multi-actor environment to improve their decisions. This chapter is based on the findings of the previous chapter and on empirical study with the collaboration of Mr. Treviño from MEEIN, of Mr. van Delft from DSM, and of Mr. Yepis from Radiall. The goal of this chapter is to introduce the framework to the reader and to explain the elements of such framework, as well as to showcase the practical uses of the framework and indicate the results from this use.

Section 6.1 will re-assess the need of such framework, and how it can complement the current decision making practices and processes. Section 6.2 will provide the elements of the framework, basing itself on the decision making process suggested in the previous chapter and using the other elements of the multi-actor analysis approach and decision making chapters. Section 6.3 will provide an evaluation of such framework in practice by utilizing the framework situational cases happening in MEEIN, DSM and Radiall. Finally, Section 6.4 will give the evaluation from the case findings.

### **6.1. The need and relevance of the multi-actor analysis approach framework for decision-making**

This proposed framework presents a multi-actor analysis approach to a situation of dependency and cooperation needs in a multi-actor setting within manufacturing companies. A *scientific relevance* exists in the sense that it allows growth in the field of multi-actor study and introduces a new set of elements that help add to the limited amount of literature and empirical study of the field. The *practical relevance* of this framework rests on providing a guideline for decision makers in manufacturing companies to improve the chances of support and effectiveness of decisions in manufacturing activities giving room to trade-offs and negotiations and that backs up multi-actor situations.

Decision making processes are influenced by factors that may affect its effectiveness and reach. Within these factors, cultural context, coalitions, and strategic behavior are to be mentioned as some that are capable of influencing the process and the information, and therefore, the decision-maker. This framework makes use of the multi-actor analysis approach which can minimize the effect of such factors, respecting and complementing the traditional ways of working (i.e. not giving in to extreme or radical changes in the process) by utilizing such approach which can match the practical needs of dependency and cooperation structures and the presence of multi-actors in the manufacturing activities. The framework suggests specific perspectives and procedures that facilitates and supports a multi-actor environment. Furthermore, the framework provides a process

for decision making that accounts for suggested techniques and practices that, when followed, can minimize the risks, mistakes and limitations signaled throughout this paper, for example, of overlooking important information, of a wrong definition of problems or conditions, of the no inclusion of critical actors, and so on. It can minimize the risks because it puts special attention to a clear definition of problems, boundaries and responsibilities. Moreover, the framework makes space for the correct and relevant use of information coming from, among others, enterprise and control systems and from the ISA-95 standard.

These needs are validated and complemented by information from different companies' personnel. This information can be also visualized in table 5.1 on chapter 5. The proposed framework tries to come up with a model that accounts for the needs stated by the different interviewees and which match with the findings expressed in previous paragraphs. In short, the interviewees agreed that in order to improve decision making processes, the involvement of the different actors was crucial and a must. The proposed framework tackles this need by introducing the multi-actor analysis approach which makes use of distinct techniques and perspectives that favor and account for this. Likewise, the proposed framework accounts for the needs highlighted by each interviewee. These highlighted needs of actor analysis, improved communication, a better knowledge of the situation, and a common and standard procedure are also all addressed in the framework.

## **6.2. The multi-actor analysis approach framework for decision-making**

In this section, the paper will describe step by step the proposed framework. It will answer the what, the when, the why, the how and who of each step referring to the activities, responsible persons and techniques involved at each stage. The next series of steps are based on the decision making process described in the previous chapter under section 5.2. It adds one step which needs to be done before the actual decision making process begins and which will be referred as "stage 0". Therefore, the framework consists of 6 stages in which all the information from previous chapters is combined. Furthermore, in each stage, specific techniques are suggested to be used. The suggested techniques are chosen based on the feasibility of their use based on knowledge and time resources and constraints to make a decision. Those techniques that may need more information, expertise, time or resources (becoming less practical and more complex to use and be handled) are not suggested to be used but could be, as they do back up a multi-actor analysis approach and the distinct elements of decision making suggested in previous chapters.

The framework relies on the inclusion and involvement of multiple actors throughout its process. Therefore, it is important to know whom to include in the process. The researcher, based on literature study and personal thought, suggests some factors that decision makers should contemplate in order to help with a proper selection of actors. An actor, according to the researcher and based on how literature defines an actor to be, should be given a thought to be involved if:

- a) the actor is an actor who will carry out the decision,
- b) the actor is affected by the decision in the sense of changes to its way of working (e.g. work procedures, times, standards, etc.),
- c) an actor cannot comply with its objectives due to the situation or problem,
- d) the actor is responsible for the situation, and/or
- e) the actor presents valuable information or resources that can lead to address the problem and improve the situation.

Furthermore, it is important to clarify that any actor invited to participate at later stages of the framework *should not* modify previous choices from earlier stages. This is due to 2 important reasons: first, if any new actor started discussing on what was previously agreed on, the whole

process would turn itself into a lengthy, unattractive procedure; second, being able to go back and change previous choices of procedure could make room and facilitate the presence of strategic behavior of both, new and already included actors.

- Stage 0. The mapping of the company

It is in this stage that the decision maker must make an analysis of the different set of actors that are in the network of manufacturing activities. The process starts when a situation of analysis is known and defined for one actor. Based on this identified situation, the decision maker makes an analysis of the actor's characteristics to know where they stand, where they could stand and identify already possible sources of cooperation or conflict to be prepared with anticipation. The goal at this stage is to have an idea on which actors are the relevant ones to incorporate on the upcoming stages.

This stage makes use of intangible and dependency multi-actor techniques. The complete list of available techniques that the researcher introduced in previous chapters can be seen in Annex C. At this stage, the only classification the potential decision maker needs to care about are of selecting dependency and intangible methods with no importance yet to which kind of decision making practice to use given that the decision maker itself is the one choosing on the actors he/she feels more relevant to the situation. The techniques in this stage will be used with information provided by the decision maker based on information from the different actors themselves but on a not so specific level. At this stage, the researcher suggests employing a *stakeholder analysis* because it allows on a short time frame and using one technique, to perceive both, dependency and intangible notions. The stakeholder analysis allows the decision maker to map in a timely, efficient manner, the actors he/she considers important to analyze and understand. By using a stakeholder analysis, the decision maker assures to know, at a certain level, the different actor's characteristics that can influence a decision making process regarding the previously defined situation.

In chapter 3, suggestions on how ISA-95 guidelines could complement the decision making process were drawn. At this stage, the potential decision maker might use the hierarchical models (see Annex A) to help him/her see on which actors to gather information from, in order to use the dependency methods.

- Stage 1. The classification of the situation

This is the first step of the decision making process expressed in chapter 5 yet it is the second step in the framework. This step involves evaluating which type of situation the decision maker is dealing with. Before being able to define the problem and start looking at resolutions, the first thing the decision maker needs to do, with the aid of actors that are thought important to include, is to classify the situation.

Based on Drucker (2006), situations in manufacturing companies can be classified under 3 main categories: generic, unique, and generic but unique to the situation. When generic, the decision making process can rely on previous rules and principles and may choose to employ techniques, methods, perspectives and practices that do not heavily rely on a multi-actor approach. Yet, the researcher finds important to stress out that even if the characteristics of the situation can be traced down to previous set of rules, a multi-actor approach will always help to reach better decisions, at least by improving support from different actors. On the other hand, a multi-actor approach can heavily improve and beneficiate decision making when the decision is unique. Since there are no previous rules or prescriptions on how to proceed, the inclusion of several actor's takes and inputs is extremely beneficial. This holds also true for the third category. It is in the researcher's perception, as well as from Mr. Treviño, Mr. Uresti, Mr. Yepis and Mr. van Delft, that the third type

of situation is the most common in manufacturing activities. It seems generic since it presents characteristics seen before in the manufacturing process, yet new variables like dilemmas, errors, deviations and challenges occur. Therefore, it has traces of generic elements but can be seen as unique in its own way.

The goal of this stage is to know until what extent suggested decision making practices and therefore, techniques, can be used depending on which type of situation the company is dealing with. In other words, to know the type of situation to discover if, and to what extent, a multi-actor analysis approach can help.

The first step is to make clear the desired objective of the situation. Second, the decision maker will identify the decision making practice that best applies to follow. This can be due to personal interest in that particular decision making practice or because the company is used to employ that practice. Remember that a mix of practices is possible. This will give an answer to the decision rule referring to the 4<sup>th</sup> dimension as seen in section 5.2. As seen in table 6.1, the generic situation would best fit with semi-autocratic practices. The unique situation best fits with a consensus decision making practice since the involvement of actors is crucial to minimize the risk of leaving out important information for the decision making process and in which the process can best be followed by the support and agreement of the actors involved since there are no previous rules or procedures. It is most common that situations fall into the third type of classification: generic but unique to the situation. It is in this case, that the selection opens up because the decision maker can decide to adopt any decision making practice and therefore a wide array of techniques. It is then that a multi-actor analysis approach becomes important to guide the selection process to what fits the best to the problem or situation at hand.

	<b>Consensus</b>	<b>Democratic</b>	<b>Semi-autocratic</b>	<b>Participatory</b>
<b>Generic</b>			X	
<b>Unique</b>	X			
<b>Generic but unique to situation</b>	X	X	X	X

**Table 6.1 Relation between decision making practices and classification of a situation.**

It is important to include a multi-actor analysis approach at this stage to evade the risk of wrong classification by having the insight of not just the decision maker, but from a first circle of involved actors. The researcher means “first circle” of actors to those actors identified in the previous stage and that the decision maker thinks are the ones affected the most by the situation. Aside from the finding of the previous stage, the decision maker can make use of the functional model of the ISA-95 (see Annex A) to determine which actors are responsible for the functions of interest. At this stage, it is not necessary then to study actor’s characteristics or dependencies. *Nominal group technique* (VandeVen et al., 1974) is suggested to be employed at this stage due to its simplicity and quickness to reach a classification. A lengthy process to classify a problem is neither necessary nor wished and this technique offers room to include various actors and come up with a selection rapidly without harming the chances of a correct classification.

- Stage 2. The definition of the problem.

Just as the previous stage presented a risk involving a wrong classification, this stage is not exempt to those risks. It is of a wide thought throughout the scientific community that a major misstep in any study is that of a wrong definition of a problem. The researcher acknowledges those ideas and presents one from Drucker (2006), stating that a major risk at this stage is also that of a plausible yet incomplete definition. To help minimize this risk, the multi-actor analysis approach is followed.



Because this stage is very important, time should be given for a valid definition. Therefore, the definition of the problem can become an iterative process to include the relevant actors and have a complete definition. The researcher suggests at this stage to use the *stepladder technique* (Orpen, 1995) because it allows the inclusion of actors and their perception and input without the influence of other actors or other information. Therefore, the idea of this stage is to start with the decision maker and the “first group” of actors (those which collaborated in the previous stage). The “first group” members will tell their perception on what is the problem based on their characteristics (biases, perceptions, etc.) It is an iterative process because it is logical that actors can have a different view on which is the problem so they must work together in order to find the common denominators in what each actor mentioned. These common denominators will help see what are the issues that actors perceive that are affecting them referring to the situation presented, and therefore, come up with a problem that can tackle the current situation and that in their eyes, affects them. The definition should be concise, clear and with a direction in order to be able to come up with a decision to help eradicate that problem. If there is no agreement on the definition, additional techniques such as *6 thinking hats* (de Bono, 1985) should be used to help actors perceive different angles of the situation and be more open to problem definitions. If there is still no agreement on the definition, other strategies that are stated in annex C when facing halts in the process should be considered.

The researcher believes that after defining the problem, it is necessary to revise different factors in order to check for its completeness regarding information. In other words, that all information and angles can be considered at later stages to help with the decision while assessing if in fact this problem is one that can be solved and is important. Therefore, the “first group” should answer a set of questions which the next paragraphs will mention. This will help to see first, the extent, reach and priority of the problem. Second, it will help see the information that is available, the information that is missing and the information that is needed to know. This can give insight into who they think should be included to provide this additional information as to have the most complete set of information to help taking a better decision. If indeed it is found that other actors who are not currently in the “first group” are in hold of such needed information, then they should be invited to join the process. The decision maker, the “first group”, and these additional actors invited in this stage will be the ones working together from this moment and for the next stages, and will be referred as the “core group”. Therefore, it is important to not invite all of the actors, just those ones that represent a meaningful impact to the process and that are crucial to the decision making process. It may be that the “first group” of actors can come up with a complete definition of the problem that does not require additional information and thus, no additional actors should be invited at this stage. If this is the case, this same “first group” would become the “core group”. This does not mean that other actors will not be involved at later stages. In the next stage, another evaluation of actors will be made but within this stage the purpose is to come up with a complete definition.

The question here is then, when to know if a definition is complete? It is necessary to revise different factors in order to check for its completeness regarding information. Therefore, the following questions should be addressed:

1. Which information is available right now?
2. Which information is needed to be known?
3. Why does a decision should be taken for this problem?

By answering to these elements, the decision maker and its group can assess if the situation in fact needs a decision to be made. The answers will provide with information about the importance and extent of the situation and who does this situation affect and who has influence on the decision.

Moreover, it gives them a clear picture of what do they know, what they don't know and what they need to know. Therefore, they will gain insight into possible ways to have that information and who else to include in the decision making process.

A clear and complete definition of the problem is important because it allows knowing who the key actors in the process are: those that are somehow affected or that have an influence on the decision. A complete definition will make it easier to grow conscience and involvement from the actors and create the sense of necessity and urge to cooperate and reach a meaningful decision. If it is found that no clear answer can be given to any of these questions, it could mean that either the problem is not a problem but only a situation which does not need to be assessed as thoroughly now; or that the problem is not well defined and should be re-assessed. Important attention should be given in this stage, as well as in the next one, to assure that all the actors have the same understanding of terminology and situation to avoid miscommunication or misinterpretation mistakes. Therefore, the group can use the definition of functions and information flows, from ISA-95, as a dictionary, making sure that everybody is talking about the same thing.

- Stage 3. The definition of the boundary conditions

In this stage, the criteria and alternatives will be defined: these are the boundary conditions of the problem. The first step in this stage is to establish and start from what is right: after having defined the problem, a demarcation on what is right must be made in order to start from a point that is socially and ethically correct and from this point go to what is acceptable for the actors (this will be made later through trade-offs and negotiation). Therefore, with the help of a multi-actor analysis approach, the boundary conditions can be neatly defined. Having the boundary conditions well defined can allow looking at scenarios of change of these conditions to be prepared and account for those changes. This will help minimizing the risk of circumstances where the boundary conditions change while the decision is being implemented.

Having specified this to the group of actors, an evaluation of the 2<sup>nd</sup> and 3<sup>rd</sup> dimension (as mentioned in section 5.2) will be made with the objective of knowing the actors' characteristics that the group thinks are affected by the problem. The "core group" should additionally include actors (if already not included) that are identified, by means of intangible multi-actor methods, to have production or blockage power so that all the involved and affected actors (that offer a significant take to the decision making process) are forming part of the core group. The first ones, the ones that can have production power, may help to make the decision be implemented because of, for example, their resources or tasks, while the latter are important as to gain their support and avoid a stomp in the decision making. Actors that present a conflict with the problem or with other actors and are identified to have blocking power, should not be left out because excluding these actors increases the risk of lack of support for the implementation of the decision which is a goal of this framework. Therefore, it is wiser to know where they stand and offer a common ground and deliver a sense of urge so that they become interested and involved in the problem and get their support.

To define the boundary conditions, the "core group" along the decision maker will employ dependency and intangible multi-actor techniques to identify where the actors stand on that particular problem. The information will come directly from the actors involved and on a more specific level than on stage 0, and is now based on a defined specific problem as opposed to a situation. Again, the researcher suggests using a *stakeholder analysis* to help with this step as it is simple and rather quick and offers a way to see at the same time, dependency issues as well as intangible ones. Moreover, this technique is suggested because it has already been used at stage 0, so the process is simplified by the use of common techniques. Also, the decision maker can compare the findings of these techniques with the ones that he/she found at stage 0. This will help

to gain insight into how much has changed with respect to where he/she was informed the different actors stood back then and now. This can help see possible presence of strategic behavior if the decision maker notes completely different findings.

What follows is to define the criteria which will be used to evaluate if the decision made the expected impact after implementation. To be able to define criteria, the problem needs already to be completely defined and the involved actors should be participating in this decision. A bottom-up decision making process method, such as *nominal group technique*, should be used in order to facilitate the input from the involved actors while allowing room for negotiation and agreeing on important criteria in a short time frame. Furthermore, techniques such as *brainstorming* and *6 thinking hats* could be beneficial if there is no agreement on criteria. An example of a definition of criteria could be “non-conformity product presence in warehouse” with the direction of reducing this criterion. The criteria should be extremely linked to the problem definition (e.g. how to prevent client claims?). The purpose of this criteria would be to help the “core group” evaluate the decision after implementation (e.g. if the quantity of non-conformities was lowered it could mean a successful decision).

The last step in this stage is to establish alternatives from which a decision will be made and later on, conduct a scenario analysis. The “core group” will identify the decision options (i.e. alternatives) in order to reach the desired objectives based on the defined problem. These options must be selected based on their feasibility to be implemented in terms of time, resources and practicability. After this, a scenario study is made based on risk factors and defined decision options identified by the “core group”. This step is to minimize the risk that occurs where the boundary conditions change while the decision is being implemented, by looking at different possible scenarios and drawing initial ideas and plan of actions for them. This way, the involved actors can know in advance how things could turn out and be prepared for that. Furthermore, by making clear how the effects could change, there would be a short room for strategic behavior and un-cooperation from the involved actors. Moreover, the negative effects on criteria can be minimized by knowing how to act given certain scenarios. This scenario study can be done using decision making techniques that assess future steps such as *what-if analysis*. The decision options that are shown in this stage will be the ones from which a decision will be made in the next stage.

- Stage 4. The decision making and the decision implementation

Now that the “core group” has been completed based on the previous stages, and the problem and its conditions have been defined, it is time to deliberate on the problem to reach a decision that is effective and has the support from the actors. In this stage, all the previous information will be used to not only come up with a decision, but to help put it in practice; no decision is a decision until it has been put into action. The goal of this stage is, then, to reach a decision that has the support from the involved actors to increase the chance of a successful translation into practice. By involving actors, the morale of them is increased as they have been participates of the process and their opinion was heard.

The first step in this stage is to come up with a decision. The process to come up with a decision should allow room for giving and taking, give incentives for cooperative behavior, and give space for trade-offs. By following this framework, the stand of actors as well as actor’s characteristics is publicly known to other actors. This could result, some would argue, into strategic behavior. However, the first counterargument against this criticism is the fact that throughout the process, common ground have been looked at as to gain support and cooperation from the different actors (especially in a process following a consensus decision making practice since the actors should agree on what is chosen). Furthermore, because decision making is an on-going process in

manufacturing activities, actors should be clearly noted that the probability that they are included into another decision making process is big; therefore, it is counterproductive for actors to behave strategically since in other processes, they will be flagged, not trusted and even removed from an opportunity of being heard. With this it is clear that the common grounds that are known should be used not as creating resistance but more as understanding where actors stand and from that, incur in a process of trade-offs to reach a decision that is acceptable and feasible. It is in this stage that what has been regarded as “right” starts becoming “acceptable” to the involved actors. Instead of actors destroying or stopping the process because of information of perceptions and interests, actors will use this information to know what is important and allow cooperative behavior. Actors should note that cooperation may translate into having decisions that are also acceptable to them, instead of fighting for decisions that maximize their interests at the expense of others. The idea is that besides the knowledge from actors that trade-offs will have to be made, the process will actually force them to do this trade-offs. The actors learn during a process that successful decision making is possible only when they make trade-offs (de Bruijn & ten Heuvelhof, 2008).

In order to come up with a decision, the “core group” will rely on top-down or bottom-up decision making process techniques depending on the decision making practice that has been established in the previous stage. Recall the findings of chapter 5, where top-down decision making process techniques are most fitting with practices that rely on a leader (e.g. the decision maker) to have responsibility and saying in the final outcome, while bottom-up decision making process techniques are fitting in the other direction. The technique(s) selected should give space for the elements described in the previous paragraph and have as an input, among others:

- a) *The actors’ characteristics.* This facilitates the process by showing common grounds to which actors can relate with each other, as well as showing the stand of actors with conflicting demands to realize what could be done, thus, supporting cooperative behavior and allowing room for give and take.
- b) *Information from the enterprise and control systems.* Aside from the information on actors, the decision should be based on information from the manufacturing activities. A source of this information comes from the enterprise and control systems from which the “core group” can overview indicators to perceive what is the status of the manufacturing process, what is needed to be corrected and how this will be done. Furthermore, the information from these systems can be analyzed to see how it may affect the stand and support from actors.
- c) *Information drawn from other systems/sources.* Information will have other sources that influence and are important to come up with a decision. These other sources may be from external sources such as clients. Furthermore, other systems and documents may provide important information. The scenario study done in the previous stage could also be an important input of information at this stage.
- d) *Information from ISA-95.* Information such as Product Definition Information, Production Capability Information and Production Schedule Information could be used to have a more complete set of information.

The technique that is suggested to be used at this stage is a *qualitative CBA*. This is because this technique can effectively use all prior information at once. This technique can gather the criteria against the decision options (i.e. alternatives) and make use of the different information input, while allowing room for negotiation, in order to see possible courses of actions and the effects the different options have. Involving several actors in this decision process is recommended to be able to extend the available options, to secure that information is not overlooked or minimized and of course, to involve the actors so that they feel responsible, involved on the process and improve chances of support for the decision. Before making a decision, the information should be analyzed

and its reliability should be discussed by the “core group” in order to make the information as complete and thoughtful as possible. One important note is that the projections done in this CBA should note projections for a specific time frame in order to evaluate the real course of actions at this same time frame to facilitate the evaluation. For example, the projection at this stage is done with information projecting how the different alternatives and scenarios will be at time X. Then, the evaluation should be made at, or after, that time X has passed in order to compare the projection with the reality on the same time frame. If it were to happen that a blockage in the process is present and no decision can be made, the researcher suggests using some strategies as shown in Annex C.

Once the decision has been made through an iterative and interactive process, the researcher suggests taking time to manage the “core group” and the possible existence of winners and losers of the decision. If it is clear that some actor will not be favored at all and will be negatively affected by the decision, the decision maker should reward their cooperative behavior to first, entrust having the support at the implementation for the decision from these losing actors; and second, allow that these actors will be willing to participate in further decision making process without strategic behavior or resistance.

After making the decision and managing the winners and losers of it, the decision maker can assure the best it can, that the best level of support exists already and that this could represent a better chance of effective decision implementation. This multi-actor analysis approach can help minimize situations where decisions that were made after long processes, were not to be implemented at the end or were incorrectly implemented due to a failure to correctly assign responsibilities and follow-up actions, failure to achieve the support from actors, and so on. So, after the decision has been selected, the researcher proposes to answer the following questions. They should be answered before putting the decision into practice (i.e. implementing it) in order to include and make clear to everyone the accountabilities, issues and mandates in the implementation process and facilitate understanding of both, the decision and its implementation. Hence, this will improve the chances of a more efficient decision implementation. The first and last questions are most frequently overlooked when implementing decisions. Furthermore, the action must be appropriate to the capacities of the people who have to carry it out.

- Who has to know of the decision?
- What action has to be taken?
- Who is to take it?
- What has to be done so that these people can take the action?

This ensures that there is a plan of action so that the decision does not get lost and everyone is responsible and informed about the implementation. This way, the risk that something is overlooked is minimized because actors will have a clear understanding of information flows and of responsibilities: actors will know who has to do what, what has to be done exactly and at what time and where and how, and what does the actors need to know and have in order to make a successful implementation. Mr. van Delft from DSM agrees on this and reflects on the importance of “documenting a decision”: making an action and decision log in order to issue mandates and accountabilities as to secure clearness of the steps after the decision is taken.

- Stage 5. The decision evaluation and feedback

A feedback mechanism is the last stage of the proposed framework to serve the purpose of validating the decision. The “core group” will monitor and report back the outcome of the decision, from its effectiveness to its reach and next steps. The goal of this stage is to evaluate if the decision was in fact a good decision accomplishing its objectives on time and on correct manners. It will

show if the decision gained the support from the involved actors and translated into an effective implementation and results. Moreover, it will help see if there is the need of any changes or follow-up actions.

To help see the effectiveness of the decision, the “core group” should gain knowledge as: *did the decision actually serve the purpose intended?* In other words, is the outcome fulfilling the criteria and with the direction specified in previous stages? To measure the reach of the decision, the “core group” should answer questions such as: *how did it affect the actors? What consequences did the decision have to the manufacturing activities? Were these effects and consequences the ones stated in the boundary conditions? If not, were these effects and consequences foreseen in the scenario study?* Finally, to know the next steps, the “core group”, based on the previous information, will evaluate follow-up actions such as: monitoring actions (the decision went as planned and had the desired results and effects), preventive actions (the decision has the foreseen outcome yet it may suffer if certain conditions changes), and corrective actions (the decision did not go as planned or the decision is producing negative results).

In order to do this, the “core group” will hold timely meetings to evaluate development of the situation, before and after the implementation, in order to see the areas of improvement or regression. This can be done based on the information coming from the *Qualitative CBA* technique that can help compare the projections made before the decision was taken and implemented with the actual results. This will be done by, for example, evaluating the criteria established in stage 3 for the decision. If the decision went as planned, then there is no real need of comparing it with the scenario study although reviewing this could help a learning process. If however, the decision did have a variation, the “core group” will try to find if this deviation formed part of the scenario study because then, the “core group” should have already some actions prepared for this deviation. If for some reason, the decision deviated and this was not foreseen in the scenario study, then there would be a need of having corrective actions which would be appointed through new deliberation and implementation rules: an iteration to stage 4 would be made to appoint these new plans of action.

The previous framework process can be seen in a flow diagram shown in Diagram 1 of Annex C as well as the classification list of the usable set of techniques. Furthermore, Annex E presents the explanation of the suggested techniques followed in this framework and how they are used in the one.

### **6.3. Empirical research of the framework**

3 different cases are used to put into practice the proposed framework. In all of the cases, a previous problem situation that the company was faced with is used, in order to use that same case following the proposed framework and compare the process and results of them both. The first case is done for MEEIN and is in this case that the framework is followed stage by stage, from beginning to end on a specific manner. The situation is described and, along with the company, each stage is worked on with the input of the different actors and using the suggested techniques. The results after implementation of decisions are written down and these results are then compared to what in reality occurred. With this, the researcher and the company can observe if there was an improvement or not, based on indicators that are selected by the company. The second and third cases, done for DSM and Radiall respectively, are more in the form of diagnosis. The companies suggests a problematic situation, which they have faced, and then the company gives needed information of what occurred in practice plus some information that the researcher believes is necessary in order to work on the first stages of the framework. The researcher then, with this information, works on stages 0, 1, 2 and 3 of the proposed framework. The researcher gives a suggestion on techniques

and findings from these stages, giving a diagnosis of possible improvements on their process following the proposed framework. The researcher gives this diagnosis to the company which later on, gives a feedback to the researcher on the diagnosis of their decision making process. In these last case examples, there was no real involvement of several actors, just the information exchange with the decision maker. The main description of the framework process, main conclusions, suggestions and feedbacks are presented in the next sub-sections. The actual information of the process can be found in Annex D for all of the cases.

### 6.3.1. MEEIN

MEEIN is a Mexican company focusing on automation projects for the different industries in their area. MEEIN offers different kinds of automation solutions depending on the specifications that the client asks. These solutions are the design, manufacture and integration of automated machines. Mr. Treviño, Project Manager in MEEIN, wants to gain insight into a possible way of improving the budget making process. The budget making process refers to making a projection of the costs and the profit that a project will have while accounting for factors such as time and resource capabilities constraints in order to see if a project is feasible to do and is profitable enough to accept. Therefore, this process is done after the client reaches out with a description and requirements of the project to Mr. Treviño, who is the main responsible and the one doing such process. Only after the client gives this information to Mr. Treviño is when the process starts, and it finishes once the project is accepted and started or is declined. The budget making process is a crucial process for MEEIN because as stated above, its output determines first, if MEEIN has the time and resources to do the project satisfying the client's requirements; second, if MEEIN can have a profit of doing out this project; and third, determines the projection costs and benefits to be respected in order to have a profit and comply with the client's requirements.

The actual process does not purposely involve multiple actors, it's highly dependent on Mr. Treviño's expertise and area of knowledge (the missing information is informally consulted with the appropriate actors), and involves similar steps yet it is not a standardized process. Furthermore, if Mr. Treviño is not available to do this process, no one else within MEEIN has the knowledge/expertise/clearance to realize it. Because of this, this process has a great variation in terms of time: the same budgeting procedure for the same project could take different times depending the availability of Mr. Treviño. Normally, the budget is above the actual execution of the project which is good, but the desired objective of Mr. Treviño is to have a procedure that can make the budget be as close as possible to the execution, without the latter being over-budget. With the actual process, this is not done entirely and moreover, the time of doing the budget process can take longer times than expected. Mr. Treviño would like to know if employing a process with a multi-actor analysis approach may: a) improve the results of a decision (have a more efficient decision); b) achieve the objectives of the situation of study (which is addressed below); c) have an easier implementation; and d) provide an added value (e.g. better support, less conflict, less information mistakes). Therefore, the situation of study is: *Improving the budget process to minimize process time while achieving the same or better results (i.e. that the execution is as close as possible to the budget).*

To follow this situation, a practical case is used. This practical case has to do with a project from a loyal and regular client to MEEIN. This project is the design and fabrication of an assembly station that allows the assembly of a whole "family" of connectors of the type "Connector & Bolt". These connectors require the assembly of a plastic piece with a bolt which, depending on the model, can be of different sizes. So this assembly station should allow the assembly of all the different sized connectors. The client asks that this assembly station assures that the correct materials are being used and that automatic inspections are made in order to guarantee that the specifications of the

products are met. The material that is found to be “Not OK” must be separated automatically and have an electronic confirmation that the material was not mixed with correct products.

The main problem that MEEIN faced when conducting this project was that of, as it occurs in many different projects, an inefficient budgeting process. The design stage was delayed and the conceptualization of the project was wrong due to resource unavailability when the client asked MEEIN to do the project. This had as a result mismatches with the budget in time and money because of extra engineering interventions and reworking. The budget making process that MEEIN followed for this case was to do first a revision of the project’s requirements (done by Mr. Treviño). After this, Mr. Treviño proceeded to make a budget based on the requirements he analyzed. The third step involved a start-up meeting with the coordinators of different departments and with the client to validate the budget. The last step was to make a 3D design of the project and to have a signature from the client validating this design. When this design has been signed, it signifies that the budget, design and times are agreed on by all parties.

	<b>Budget</b>	<b>Real</b>
<i>Material costs</i>	24,134 USD	22,047 USD
<i>Labor costs</i>	17,732 USD	24,015 USD
<i>Indirect costs</i>	2,110 USD	1,117 USD
<b>Total Costs</b>	43,976 USD	47,179 USD
<b>Profit</b>	13,193 USD	9,990 USD
<b>Project realization time</b>	6 weeks	12 weeks
<b>Budget making process time</b>	-	38 days

**Table 6.2 Estimated versus Real costs**

As it can be seen in table 6.2, the labor costs and total costs were over budget, and the time of project fabrication increased the double which meant that the client satisfaction hurt. The latter, along with the profit decreased was unacceptable for MEEIN given that these two are important objectives.

Having introduced the situation of study and the main objective, the following paragraphs will explain the framework process that was followed by Mr. Treviño and the relevant actors. Section 6.3.1.2 provides the feedback of the framework by Mr. Treviño regarding the usability and added value of the one. The overall process was conducted in Spanish and the researcher translated the input from the actors to English.

### **6.3.1.1. MEEIN’s empirical case following the proposed framework**

Stage 0. The mapping of the company.  
 Date: 11<sup>th</sup> July, 2012  
 Actors involved: Project Manager as the decision-maker  
 Project Manager: Mr. Alejandro Treviño

A first group of actors are identified by the decision-maker who, in his perception, are the most involved with the situation. Using a stakeholder analysis technique, actor characteristics are studied. At this stage, the characteristics from each actor that are relevant are: the interests; the desired situation; what can each actor offer to the decision making process in order to help come with a better decision that improves the situation; ways in which each actor could hamper the effectiveness of such decision; and the influence each actor has on the final decision. The stakeholder analysis



presented in d.1 found in Annex D1, is filled with information that Mr. Treviño gathered from this set of actors.

Mr. Treviño identifies 5 actors as the ones most prominent to be involved in a situation like this one: Project Manager, Design Coordinator, Fabrication Coordinator, Purchasing, and the Client. From table d.1, it can be seen that Design and Purchasing can present with conflicts towards achieving an improvement of the situation based on their interests. The former looks to have a budget that allows functionality (correct design without restrictions) but in order to do this, perhaps higher costs would be present. On the other hand, the latter looks exactly for a budget that minimizes costs while still in the range of customer's requirements. Both of these actors, along the project manager, have a very high influence on the decision due to the information they can provide in quest of improving the situation. The whole situation can be said to be dependent on the information of these actors. Of course the rest of the actors are important but talking about Fabrication, the situation is dependent on their process which is after the decision has been made. Client, on the other hand, has important value since it is they who establish requirements. If these are changing or are incomplete or wrong, the whole process is damaged. This information gives an initial mapping on the actors that need to be involved in the decision-making process. Perhaps at later stages, other actors are found to be relevant. The conclusions that the decision maker should have after this stage are:

<b>Conclusions from stage 0</b>	
<b>1</b>	5 actors are identifies before conducting the actor analysis. From this analysis it is seen that there is a very high influence from Design, Purchasing, Client and Project Manager. Therefore, perhaps it is wise, for the sake of simplicity, to only include these 4 in the “first group” and leave Fabrication out of the process for now.
<b>2</b>	Design and Purchasing have opposing interests yet their cooperation is needed to achieve the improvement of the situation.
<b>3</b>	Client is an important actor to which the whole process is dependent onto. Yet, the extent of its involvement on the process has to be analyzed by the decision maker after considering leak of confidential information along with other important factors.
<b>4</b>	Project Manager has the most responsibility on the situation. This can be seen when looking at the broader set of interests and the more general desired situation.

**Table 6.3 Main conclusions from stage 0 of MEEIN's case study**

<p>Stage 1. The classification of the situation.  Date: 11<sup>th</sup> July, 2012  Actors involved: First group (Design, Purchasing, and Project Manager)  Design: Mr. Marco Hernández  Purchasing: Mr. Jorge Careaga</p>
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It is mentioned that in MEEIN, there is not an actual decision making practice defined but the ways decisions are made are depending on the different situations. It is important for MEEIN to establish and define decision making practices for the different situations prior to actually needing to make decisions. This is because such definition brings clarity and a view of the rules of the game to the rest of the actors. Having said this and after explaining the different decision making practices that the researcher proposes within his framework, the decision maker chooses one. The decision making practice that is preferred is that of a *consensus decision making practice mixed with semi-autocratic practices when urgent matters surface (e.g. conflicts unresolved, time pressures, etc.)*. A democratic practice is not optimal because a lead vote does not mean that it is the right decision. A semi-autocratic or participatory practice helps taking quicker decisions on urgent matters and is important when dealing with technical aspects as it is not optimal to leave decision of this kind to a

group. A consensus practice gives room to have more reasoning: it involves investigating, cooperating, and reasoning facts for everyone to be involved and on board. This selection of practice narrows the available list of techniques to the ones under a bottom-up classification as seen in the table c.1 of annex C. It is interesting to note the choosing of this practice since on the prior interviews made to Mr. Treviño, he had stated his preference for a semi-autocratic or participatory practice. When asking him about this, he expressed this change of preference being caused by the new knowledge gotten from the classification, and explanations, of decision making practices the researcher introduced him to. After analyzing these explanations, Mr. Treviño expressed his preferment towards the consensus decision making practice. It seems that the lack of information and knowledge of decision making practices made Mr. Treviño follow the common practice that reigns in that region and in that industry.

After establishing the rules of the game (i.e. the decision making practice), a nominal group technique is used in order to involve the “first group” into classifying the situation. It is decided that the actor “Client” should only be involved for information aspects and not actively in the process due to a fear of information leakage or strategic behavior on their part if they has more access to and more hold of information than needed. Therefore, the “first group” on this stage is involved by Design, Purchasing and Project Manager. The process can be seen in table d.2 in Annex D1. This table was filled with information from the “first group” and followed by the “first group” members. The situation at hand has been defined as being *generic yet unique to the situation*. This mainly has to do with a general procedure that is done on a regular basis but in which new variables and information are present: this situation case presents new variables, new information and new requirements.

Stage 2. The definition of the problem.  
 14<sup>th</sup> July, 2012  
 Actors involved: First group

A simple stepladder technique is used with the “first group” members to define the problem given this specific situation. A stepladder technique is considered also to favor a bottom-up process. The stepladder technique involved steps 2, and 3, of three rounds each. The overall process that will be followed, and which is made by the researcher, is:

1. Defining the objective
2. Set means to reach that objective
3. Identify problems for reaching those objectives based on those means
4. Select the problem which is:
  - The most critical
  - The most feasible to be solved

The procedure following the stepladder technique on steps 2 and 3 is as follows:

1. The decision maker points out again the situation, from which an objective is seen on and agreed on: *Maximize the chances of projects within budget*.
2. A stepladder technique as shown in table d.3 of Annex D1 is used to set means for objectives. The main ideas are written in the table. The word Enter refers to when a new actor enters into the process. This actor presents his input to the rest of the actors already in the process without debate from them. After input presentation, a discussion starts involving now all members already present in the group. In round 1, Project Manager and Design enter at the same time to the process, so they present their ideas and discuss them. In round 2, Purchasing enters and the other 2 actors listen. After presentation, they discuss

on the new input of Purchasing and after this, they come up with the most important means according to them which is:

*To know better the availability of the different resources.*

3. A stepladder technique shown in table d.4 of Annex D is used to present the different problems that are present within the selected mean to achieve the objective. Note that the starting two actors are not the same as in the previous stage. This is to minimize the effect of influence on inputs, and the potential presence of colluded acts if the same actors are always present at first rounds. The problems that actors feel are most critical for reaching the objective are:

- *Bad management of resource distribution and assignment*
- *Wrong or incomplete analysis of the project*

4. Following a consensus decision making practice, the problems set in step 3 are analyzed and selected by looking at these 2 criteria: criticality and feasibility to assess and correct. It is seen that the second problem (wrong or incomplete analysis of the project) is critical yet is not feasible to improve because of its too general description. The first problem (bad management of resource distribution and assignment) is something that impacts if a project stays on budget and can be handled. However, it needs a certain kind of re-writing. Therefore, the problem definition (with the help of the researcher) is narrowed to:

*How to best match budget with execution costs when resource availability is not optimal without hurting customer satisfaction or profitability?*

The problem definition suggests that the core of the decision is still involving a feasible, on time and correct budgeting procedure that makes budget be as close as possible to the execution of the project. However, as opposed to the situation expressed earlier in this case, the problem definition suggests a dilemma: the project is a somewhat complex one that requires specialized people and right now, some of the resources are not available given that they are not within the company or are focused on other projects. Making this project is beneficial to the company since it will potentially give a very good profit. However, a bad execution and an overrun in costs of the project can make that the client does not want to make business with MEEIN anymore, as well as a financial loss it will mean for MEEIN.

After defining the problem, it is necessary to revise different factors in order to check for its completeness regarding information. In other words, that all information and angles can be considered at later stages to help with the decision while assessing if in fact this problem is one that can be solved and is important. The following questions are answered:

- 1 *Which information is available right now?*
- 2 *Which information is needed to be known?*

The full answers to these questions are found in table d.5 of Annex D. This information is filled with the help of the “first group”. The answers show that indeed there is missing information and that important risks can happen due to a bad management of this information. Normally, the missing information is provided by the Project Manager. However, for the Project Manager, information that he needs is provided by external sources like the suppliers, and by a department which was not within the “first group” but had actually been identified as having a high influence on the decision on stage 0: Fabrication. It is suggested then, that this actor is included in the process from now on forming the “core group” of the process.

	<b>Project Manager</b>	<b>Design</b>	<b>Purchasing</b>
<b>Current Information</b>	-Client specs -Concept from client -Information from similar past project, including estimated cost and time	-Delivery times on current projects -Profile on available resources (abilities and capabilities)	-List of current suppliers -“Common” materials costs
<b>Needed information</b>	-Resource availability -Reliable budget of the unknown or different materials -Feedback of work distribution from design	Workload information of new project	-Costs of additional materials. -Estimated budget -List of materials

**Table 6.4 Answers to the first 2 questions to assess information completeness for the defined problem.**

*3. Why a decision should be taken for this situation?*

A decision should be taken to minimize the risk of a) projects having costs overrun; b) accepting projects which cannot be made with the customer’s requirements of time, quality, cost and/or functionality; and c) losing customer satisfaction. Therefore, the selected problem is a right choice regarding that is a critical problem to achieve the desired objective and in the sense that the actors have the means to eradicate or minimize it. A bad decision or a non-decision can have negative consequences towards reaching the objective and puts at risk important factors for the company such as profitability and customer satisfaction. On the other hand, a good decision is expected to improve the chances that these objectives are met.

<b>Main conclusion from stage 2</b>	
<b>1</b>	Fabrication provides key information in order to deal with the problem. Therefore, Fabrication should be included in the process from this stage onwards. Hence, the “core group” will be formed by Design, Purchasing, Fabrication and Project Manager with an open link with the Client.
<b>2</b>	The involvement of these actors is crucial because their involvement and their resources directly affect the decision which can resolve, or not, the problem. The involvement is important since the major risks identified can be minimized with the participation of these actors.
<b>3</b>	Almost all the information identified as “needed information” is manageable to be gotten by the involved actors, by control systems and by external sources like suppliers.
<b>4</b>	The assumption that the actors were dependent on each other is validated in this stage: information that one actor needs comes from the output of another actor. It is seen also how the Project Manager carries the most responsibility since other actors are dependent on him. Likewise, the Project Manager needs information from all the rest of the actors.
<b>5</b>	The involvement of all actors is crucial to minimize the risk of wrong assumptions, untimely or wrong information from other actors and suppliers. With all actors involved, each one of them can analyze the information given and with their own resources detect wrong information and wrong analysis of information. Likewise, involving the actors permits that each one of them know what the rest is expecting of each of them, and have a better idea of the how and when of the information flows: it improves accountability.
<b>6</b>	A major risk is that of getting information from the suppliers that is reliable, correct and on time. If there is no access to reliable suppliers, involving the “core group” turns out beneficial because it can help with coming with a best possible set of information without extending time. This is another important reason to use a multi-actor analysis approach in the decision making process. Involving the different actors is crucial to include all possible assumptions

	regarding the different angles each actor possesses.
7	Special attention should be given to the workload information. The three different actors identified that a wrong assessment and evaluation of workload can have negative consequences.

**Table 6.5 Main conclusions from stage 2 of MEEIN's case study**

<p>Stage 3. The definition of boundary conditions.  27<sup>th</sup> and 30<sup>th</sup> July, 2012  Actors involved: Core group (Project Manager, Design, Purchasing, and Fabrication)  Fabrication: Mr. Javier García</p>
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The framework states that it is important to start from what is right rather than what is acceptable for the decision outcome. In this case, what is right is: *having a budget which allows satisfying customer's requirements and makes space for a profit*. This definition of what is right is made by the decision maker.

An updated mapping of actors is the next step. So an updated mapping is done to:

- address once again the information that was posted in stage 0 and stage 2,
- include additional information that helps to see blockage or production power depending on the resources that actors have,
- include information from the new actors0, and
- include additional actors if it is found that with this updated information there are such.

The updated mapping of actors, using a stakeholder analysis can be seen in table d.6 of Annex D. The table shows, among others, the exact same variables that were analyzed at stage 0 in order to see if there is a difference on the information back then and the information now. Since this information is provided by the actors themselves, a difference between the information can be a sign of potential strategic behavior. In this case, the information provided by the actors is the same as the one presented at stage 0. This is important because it gives an indication that the information provided back then and now is trustworthy since they match even though 16 days had passed between the first gathering of information and this one. In further cases, the time between different stages should not be as apart as in this one though.

The last 4 rows of this table provide additional information about the actors' characteristics. The sixth row shows which actors have a genuine interest for the decision-making outcome. A dedicated actor is that with a high interest. This interest will be high if the outcome affects their objectives and ways of doing their work. Design and Fabrication may be dedicated actors depending on the impact of such a budget has onto them: if they feel that they cannot change a certain impact of the process, they will focus on other tasks. The seventh row shows the dependency features for each actor. It showcases the dependencies on working processes: information that is needed by one actor from another, functions of one actor that affect directly the functions of another actor, and so on. Project Manager is the actor who has the most network links out of all of them since he is dependent on 3 different actors and these 3 actors depend on him. The difference is the *when* each actor depends on each other. This could be a cause for strategic behavior but as it will be seen, it appears as this is non-present in this case. Fabrication is the one actor who does not need Project Management in order to provide further information; however they are still dependent on Project Management because the former assigns projects to the latter. This re-affirms what was said before: all actors involved are relevant, must cooperate and should be included. The eighth row presents the resources that each actor has for the decision. In this case, the resources are divided into knowledge (information) and process resources. Information resources are the availability of, access to and

ownership of information that can influence the problem and thus, the decision. Process resources indicate at which level an actor can influence the decision efficiency and its outcome based on its manufacturing functions and responsibilities. The resources that each actor has will influence the amount of power that each actor has on the decision process. Project Manager and Purchasing have a high power since they both account for both knowledge and process resources. Fabrication and Design have medium power in the sense that they “only” have knowledge resources. However, Design has a very high influence on the decision one should keep in mind.

There are different interests from the distinct actors and the dependency on each other is imminent, sometimes even on a two-way dependency as in the case of the Project Manager. If these actors don’t work together, in order to provide with trustworthy, complete and on time information, the process will be delayed and the process could have wrong information which could lead to bad decisions and outcomes hurting profitability and customer satisfaction. Offering a common ground, that they all will be affected with a negative decision is a way to make them all being involved since it can be seen that 2 actors are not so interested in this situation

After making this analysis of actors, accounting for possible strategic behavior based on this new information is made. Strategic behavior in this case is most present by the (un-)reliability of the information given to the rest of the actors. However, as already stated, the information appears to coincide with the one gotten in previous stages which can indicate trustworthy information and no signals of actors trying to take advantage of the new information brought up after the development of the process. Reminding the actors once again that each of them has an influence on a correct decision which should impact achieving an objective which in turn, creates a better business nature, is a way to keep the actors involved, committed and trustworthy.

Once the problem definition has been defined and the “core group” has been finished, the definition of criteria, which will be used to evaluate if the decision made the expected impact after implementation, is made. These criteria are defined with input and involvement of the “core group” following the nominal group technique. The procedure is shown in table d.7 of Annex D. The selected criteria are: *Cost of the project*, *client’s satisfaction*, and *duration of project*. At first instance, Design and Fabrication did not evoke cost as important criteria but after hearing from Project Manager and Purchasing, they acknowledged and supported this as an important one. Likewise, Purchasing agreed that the time is an important one to consider. The actors agreed that the duration of the project is a common criterion to be included over specific time evaluations such as design or fabrication time. The duration of project is one factor that gives a better overview to see if the budget actually is as close as possible to the execution.

Finally, a scenario study is done in this stage. This scenario study is made in order to have in mind how changes on certain factors impact the criteria established in this stage and that influence the effectiveness of a decision. It has been identified (refer to table d.5 of stage 2 in Annex D) that these risk factors are wrong/untimely information, wrong assessment of workload, wrong material selection and wrong costs evaluations from MEEIN’ side (there is a chance that wrong costs evaluations are made on the client’s side but then the risk and wrong outcome falls back to the client; therefore, client’s satisfaction would not be hurt). Under a what-if analysis, these factors are analyzed by the “core group” on how they could change and what consequences these changes would bring to the criteria and ultimately to a decision of what to do when not having optimal available resource and wanting to have a budget as close as possible to reality without hurting profitability nor customer’s satisfaction. The process of the scenario making that the researcher proposed to follow is seen as follows, and can be seen in Annex D:

1. Explain the purpose of this activity

2. Brainstorm on options to be used on the following stage for which a decision will be taken on which of these options to select when considering quantitative and qualitative factors.
3. Discuss about how each set of criteria (benefit, costs, etc.) could be changed or affected based on the following:
  - a. How the criteria could be changed, specially by the risk factors
  - b. How the criteria could change the risk factors
  - c. Which other things could the criteria change
 These will serve as the basis for the identification of scenarios. Develop a causal map to facilitate the view on the previous discussion.
4. Discuss what-if these previous scenarios were to happen. Name these events to facilitate identification.
5. Set up general plans of action for each of these events.

After the brainstorming session and discussion on which options are most feasible to implement in terms of time, resources, logistics and practicability, the following options are selected:

1. *Improvisation*
2. *Don't do project*
3. *Outsource the project*
4. *Negotiate on times with client*

With this, it can be seen that indeed the risk factors, if present, have an effect on the criteria. However, the inverse causal dependency is non-existent: criteria cannot influence the risk factors since the criteria is measuring the whole project outcome and not the budget making process as opposed to the risk factors that have a direct influence on the budget making process. The “core group” analyzes this and chooses out of these risk factors the one that is most probable to happen and is most critical in order to simplify the process of identifying scenarios. It can be that in other processes, this simplification is not made and a wider range of scenarios are analyzed. The “core group” believes that a *wrong cost evaluation* is the risk factor that presents the worst effects on MEEIN and is feasible to occur. In other words, when evaluating the risk factors that are most probable to occur, the “core group” evaluates the impact of such factors to choose the one that had the highest impact on the established criteria, and therefore, on the objective attainment. The “core group”, taking into account the risk factors and the defined options, identify and name 4 possible scenarios for which general plans of actions are made and which are explained in Annex D. These will be used if the outcome is found not to follow the expected path and a deviation occurred. Then, hopefully this deviation should fall into one of these scenarios and therefore, a plan of action should already be in place. The identified scenarios are:

- Scenario A – “*Improved Nightmare*”
- Scenario B – “*Heavenly Laziness*”
- Scenario C – “*Warm Potato*”
- Scenario D – “*Turning Tables*”

<b>Main conclusions from stage 3</b>	
<b>1</b>	Project Manager, Fabrication, Design and Purchasing Departments are the actors that should form the “core group” of the decision process as they all contribute with key information and have strong dependencies based on the work network they are part of. No additional actors should be contemplated to include at this point.
<b>2</b>	Design and Fabrication could present the most trouble to involve as they seem to be the less dedicated actors on the matter. Therefore, a common ground should be given to entice their involvement with quality and commitment. These actors should be included due to dependency and resource issues as well as the influence they have on a decision.

3	Project Manager Department and Purchasing have the highest power level, by having both knowledge and process resources. However, Project Manager seems to be the most involved in the process, just as thought in the previous stage given the greater network link the former has.
4	All actors are needed to complement information gaps, to analyze the information obtained both internally and externally, and have better means of accountability for that information.
5	The benefit of involving several actors to analyze information and be able account for information is a way to minimize possible strategic behavior of these actors. Another way to minimize this behavior is by offering a common ground which all of them relate to: a faulty match between costs and profits can lead to a wrong decision of choosing a project when there are no available resources and can derive on greater costs, bad functionality, and longer delivery times which then can result in less profitability and less customer satisfaction, both important to the company. However, so far there seems not to be presence of strategic behavior as the information that has been obtained seems trustworthy given its consistence from one stage to the other.
6	The major risks present are <i>wrong/untimely information</i> , <i>wrong assessment of workload</i> , <i>wrong material selection</i> and <i>wrong cost evaluations</i> . These risks are taken into account to develop the set of scenarios
7	The selected criteria are: <i>Cost of the project</i> , <i>client's satisfaction</i> , and <i>duration of project</i> The actors agreed that the duration of the project is a common criterion to be included over specific time evaluations such as design or fabrication time. The duration of project is one factor that gives a better overview to see if the budget actually is as close as possible to the execution. This highlights the benefit of using a multi-actor analysis approach: the actors agreed on a quick manner what they think is important to analyze as opposed of each analyzing the project separately on their own terms. This was seen when costs became an important criteria after fabrication and design did not see this as one initially.
8	The options that are most feasible to implement in terms of time, resources, logistics and practicability, looking to reach the desired objective, and based on the problem of non-optimal resource availability are: 1) Improvisation; 2) Decline the project; 3) Outsource the project; and 4) Negotiate on time with client.
9	The risk factors, if present, have an effect on the criteria. However, the inverse causal dependency is non-existent: criteria cannot influence the risk factors. The "core group" believes that a <i>wrong cost evaluation</i> is the risk factor that presents the worst effects on MEEIN and is most feasible to occur
10	The "core group", taking into account the risk factors and the defined options, identify and name 4 possible scenarios for which general plans of actions are made. Scenario A – "Improvised Nightmare" Scenario B – "Heavenly Laziness" Scenario C – "Warm Potato" Scenario D – "Turning Tables"

**Table 6.6 Main conclusions from stage 3 of MEEIN's case study.**

Stage 4. The decision making and the decision implementation  
31st July and 1<sup>st</sup> August, 2012  
Actors involved: Core group

A qualitative CBA is suggested to be used at this point in which the different options and scenarios presented by the "core group" are analyzed in terms of the selected criteria. The table is filled with data for each different option and scenario. Before making a decision, the information should be analyzed and its reliability should be discussed by the "core group" in order to make the information as complete and thoughtful as possible. The option which ranks the highest and/or which the "core group" agrees is the best one (following a consensus decision making practice) will



be selected. The information of the CBA is of projections after the project has been concluded since in this empirical study, the results are already known. To measure costs, the criterion “cost of the project” is broken down to material costs, labor costs and indirect costs. This last one refers to costs of tools, machinery, specialization, etc. The criterion “client satisfaction” is assessed through a point score table found in Annex C. MEEIN considers that a client satisfaction is acceptable when it is between ranges 8-9. Below that, they face the risk of losing the client or downgrading their value severely. They have currently a score with this client of 9. “Client satisfaction” can be also assessed through the profit: if a customer is not satisfied (i.e. not all its requirements are met in quality and on time), then the client does not pay the entire amount or MEEIN suffers a certain type of penalization; both things make their profit decrease. The information is drawn from each actor and between all of them, is revised so that nothing is overlooked and is complete and correct. It can be seen that this CBA is not entirely based on money values but it is made of numerical values. On Annex E, section E4, the reader can explore on how the researcher suggests using this technique and on how to manage values that are not entirely economical without incurring in complex processes of transformation that could lead to mistakes or wrong weighing of values. In this case, table d.9 in Annex D also shows how the different criteria are valued by MEEIN.

After conducting this analysis, it is seen that the best option is the option of not accepting the project. This because it presents with the lowest overall sum of grades for the criteria, which as explained in Annex E, section E4, means that it was a preferred choice on each criteria. However, the “core group” is not entirely comfortable with this option because of the client’s importance to them and the consequences that rejecting a project may have on them. The “core group” establishes that it is important for future business to realize the project. This is contradicting the projection of “client’s satisfaction” (which state that by not doing the project they only lose 1 point in the client satisfaction score which is still acceptable) but they argue that if they do not do this project, the client will turn to another company to do it, and the risk of losing the client for another company is one that cannot be taken. After it is established that options 1 and 2 (i.e. “improvisation” and “decline the project” respectively) are out of consideration, the “core group” selects the second best option: “*Negotiating time with client*”. They choose this option as well because they feel that by negotiating with the client, they show honesty and transparency in their process which they feel the client will appreciate. With this, it can be seen how intangible factors are very important when taking decisions.

After choosing the option of “*Negotiating time with client*”, the “core group” can reflect on the findings of the scenario study done in the previous stage. Back then, 4 distinct scenarios were identified based on the 4 options and on one risk factor. Now, the options have been reduced to one with the decision just been taken. Therefore, the scenario analysis reflection should focus on Scenario D, “Turning Tables”. Given this, the “core group” should ensure that the client gives relevant and complete information on time, that the different actors within the company produce the right information in order to have a correct costs evaluation. Therefore, it is incredibly important to assure Purchasing’s information is correct and complete.

After the decision has been selected the following questions should be answered before putting the decision into practice (i.e. implementing it) in order to include accountabilities, issues and mandates in the implementation process and facilitate understanding of both, the decision and its implementation. Hence, this will improve the chances of a more efficient decision implementation. The answers to these questions can be seen in table 6.7. The main responsible to assign responsibilities and tasks is the decision maker in this case. However, he supports himself with the rest of the “core group” so that there are no gaps in terms of clearness and accountabilities and to better assure that everyone understands, supports and cooperates with these implementation “rules”.

<b>Who has to know of the decision?</b>	General Manager, Client, “core group” and Accounting
<b>What action has to be taken?</b>	<ol style="list-style-type: none"> <li>1) Descriptive and informative meetings</li> <li>2) Awareness to the rest of the actors that the situation is not a normal one so that they give it special attention.</li> <li>3) Periodical revisions and review throughout the project of progress and critical situations.</li> <li>4) Ensure that information is correct through information gathering involving visits to client.</li> <li>5) Cross-reference the information as much as possible with the client throughout the process but especially at initial stages.</li> <li>6) Cross-reference to revise information between departments with the help of meetings.</li> </ol>
<b>Who is to take it?</b>	<ol style="list-style-type: none"> <li>1) Project Manager</li> <li>2) Project Manager</li> <li>3) Project Controller</li> <li>4) Design</li> <li>5) Design</li> <li>6) Project Manager</li> </ol>
<b>What has to be done so that these people can take the action?</b>	Actors have the means to realize the actions. It is necessary, though, to inform them about the situation, the procedures and accountabilities.

**Table 6.7 Implementation rules for the MEEIN case.**

<b>Main conclusions from stage 4</b>	
<b>1</b>	The best option, according to the qualitative CBA is not realizing the project. However, important intangible factors make this not to be a viable option. Therefore, the “core group” selects the second best option, “negotiating time with client”. This is something that MEEIN had thought about in the real developing of the situation but because they did not have evidence of the consequences of such option and the one they decided on, they went on the latter. This shows the value of following this standardized framework process.
<b>2</b>	The scenario analysis reflection is reduced and should focus on Scenario D, “Turning Tables”. Given this, the “core group” should ensure that the client gives relevant and complete information on time, that the different actors within the company produce the right information in order to have a correct costs evaluation. Therefore, it is incredibly important to assure Purchasing’s information is correct and complete.
<b>3</b>	The main responsible to assign responsibilities and tasks is the decision maker who supports himself with the rest of the “core group” so that there are no gaps in terms of clearness and accountabilities and to better assure that everyone understands, supports and cooperates with the implementation “rules”.
<b>4</b>	Other actors, other than the ones that were involved in the decision making process, should be made aware of the decision to ensure its correct implementation and support.
<b>5</b>	The actions needed to be done are all feasible and clear. Moreover, these actions are realized by actors from the “core group”. This shows the great importance and right decision to include these actors in the decision making process.

**Table 6.8 Main conclusion from stage 4 of the MEEIN’s case study**

<p>Stage 5. The decision evaluation and feedback  4<sup>th</sup> August, 2012  Actors involved: Core group</p>
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With the CBA and the implementation rules present, the course of action selected is evaluated. The evaluation concerns the overall results of the project. In this case, the implementation “rules” cannot be evaluated since the implementation did not actually happen but a feedback is made based on the assumptions and ideas of “how it would have been” from the “core group”. In the introduction of the project description it was stated that the project execution was over budget in total costs and more specifically, in labor costs. The profit decreased to what was estimated and the client was not so satisfied with the overall process since it took longer than expected and still had to pay for some of the cost-overruns. Also, the realization time of the project doubled and the budget making process was of 38 days. This had to do mainly because MEEIN decided to do the project with a decision that now could be labeled as a mix of improvisation and outsourcing since they did not have enough labor availability for the design. However, MEEIN accepted the project because of the importance of the client. Nevertheless, MEEIN failed in exploring alternatives; this could have been the cause of not actively involving several actors who could have expressed that the project was not going to be done optimally under the conditions each department was at the moment, or who could have suggested other options to the client in order to comply with its requirements and not hurt MEEIN’s reputation in the making.

Coming back to this empirical case, the “core group” evaluated the decision of the framework based on assumptions on how the project would have turned out to be with the decision taken. With this, they were able to compare the projections made with the CBA in stage 4 with what they think would have happened. This table can be seen in table d.11 of Annex D. The “core group” expresses that the decision would have allowed the project to be, not only within budget, but really close to execution. Second, the realization time would have been reduced also and instead of compromising with the client the delivery of the project in 6 weeks and failing to comply with this, they could have negotiated a bit more of time and complied with this negotiated time. The costs would not have been as high given that more time would have been given to provide a correct design which would have reduced costs of re-works and further engineering services. Moreover, the time of the budget making process would have significantly taken much less time. Important also, due to the reduced costs, the project would have earned them more profit than expected and had reached a good client satisfaction keeping high MEEIN’s reputation with it. Therefore, the framework allowed taking a decision that met with the desired objectives and gave an answer to what to do when there is not the optimal availability of resources. In this case, the answer that best fits without hurting client’s satisfaction or profitability is negotiating time with the client and this allows the execution to be on budget and close to the budget, and reduces the time of the budget making process.

The following set of questions is answered to facilitate the evaluation. The evaluation is made comparing the information of Option 4 “Negotiating time with client” with what in reality actually occurred using another option (which followed a mix of outsourcing/improvisation actions). Therefore, some of the evaluation data is drawn from assumption from the “core group” since actually the process did not occur.

<p><b>Did the decision actually serve the purpose intended?</b></p>	<p>Yes, the decision met the desired objective of having the project within budget and made the budget be much closer to the execution.</p> <p>Furthermore, the risks of losing face to the client is reduced since we are honest with them and make the best decision that allows both of use to feel good and continue doing business. Strategies are set to compensate for the delay of the project so that it does not affect us.</p> <p>Moreover, accountabilities are set to ensure that the decision</p>
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	is made as planned.
<b>What consequences did the decision have on actors and activities?</b>	Actors were more supportive of the decision since they did not feel as pressured as if other courses of action were taken (as it occurred in reality). The activities to realize the project were not that different other than it was with less time-pressure and with the correct people doing the activities. There was more collaboration between actors and they ensured that the information was correct and on time. It seems that working together helped each actor understand the stands of the others and more importantly, the needs to be able to realize their activities correctly. Moreover, they got involved in the problem.
<b>Were these consequences the expected ones?</b>	Yes. The risk factors did not occur given the involvement, collaboration and coordination of the actors.
<b>If not, were these differences accounted for in the scenario study?</b>	N/A
<b>How did the criteria fare up with the projections?</b>	They were similar in most of the cases.
<b>Are these results the desired ones?</b>	Yes. The budget is close to the execution, the project is within budget, we do not lose points of client satisfaction and we did not incur in more costs than expected.

**Table 6.9** Evaluation stage for the MEEIN case.

Monitoring action should be done based on the fact that the outcome proved to be closely equal as the expectations. *No further actions* should be made given that the project is finished and the results are already known.

<b>Main conclusions from stage 5</b>	
<b>1</b>	In the eyes of the “core group”, the decision would have been an effective one, reaching the desired objectives and handling the problem in a good manner.
<b>2</b>	Following this framework process, the actors would be more involved in the process, in tackling the problem, would have better understanding of the objectives and push for the same goal, giving space for more cooperative a supportive behavior.
<b>3</b>	The results would have been the desired ones. The budget close to the execution, the project within budget, not losing points of client satisfaction and not incurring in more costs than expected.
<b>4</b>	In results were not actually known, monitoring action should be done based on the fact that the outcome proved to be closely equal as the expectations
<b>5</b>	In the real practice, MEEIN suffered a loss in their profit and had an overrun of costs, because their process did not actively involve multiple actor’s valuable information. In this sense, Design should have expressed that the time and costs estimated were not feasible to be met given the resource unavailability. Fabrication should have expressed the consequences of bad designs unto them.
<b>6</b>	It is most probable that the hierarchical working preference in MEEIN towards an autocratic practice was one of the reasons of this bad performance.
<b>7</b>	The decision that was taken in MEEIN in the real practice was highly influenced by the importance of the client but no alternatives were explored; it could be that lack of exploration was caused by the lack of ideas and/or lack of involvement from other actors.

**Table 6.10** Main conclusions from stage 5 of MEEIN’s case study

### 6.3.1.2. Feedback from MEEIN

After completed the framework process of this practical case, Mr. Treviño provided valuable feedback on it can be seen in table d.12 of Annex D. The main conclusions of this practical case and about evaluating feasibility and practicability of the proposed framework are:

	<b>Main conclusions from MEEIN case referring to feasibility and practicability of the framework based on Mr. Treviño´s feedback</b>
<b>1</b>	The proposed framework offers added value to MEEIN. First, it showed them the value of incorporating a multi-actor analysis approach in the decision making. Second, it helped them to choose a decision making practice. Third, it gave them an initial idea on how to evaluate client satisfaction.
<b>2</b>	A much more effective decision was taken following the proposed framework as opposed to the real case. The decision of this empirical study proved to have more support and is thought to be able to achieve the desired objectives.
<b>3</b>	Due to these advantages and added value, Mr. Treviño states that they will try to incorporate the framework process into their decision making; at least for the situations that were studied in this paper.
<b>4</b>	Based on the expectation and assumption of the “core group”, and following on the desired goals of Mr. Treviño, it can be seen that the framework process: a) improved the results of the situation based on a new decision; b) on paper, allowed to take a decision which achieved the desired objectives of keeping as close as possible the budget under a “normal” execution of a project, and reduced the time of the budget making process; c) would have allowed an easier implementation through more support from the different actors; d) created added value.
<b>5</b>	The answer to the defined problem can be narrowed to: negotiating time with the client. This because it allows not to have a major loss, to continue doing project with the client and not risking its satisfaction. Moreover, it prevents the risk of losing him towards other competition due to a rejection of a project.
<b>6</b>	The limitation of the framework fall into not having the enough knowledge or expertise of the techniques. However, this can be offset with practice given that the techniques are not complex to use. Another limitation could be that actors may in fact not participate as it would be required or wanted.
<b>7</b>	The framework is in fact feasible to use in MEEIN.
<b>8</b>	The conclusions made throughout the process were correct and very useful to guide the decision making and to detect and prevent risks. The framework allows through its process to have this insight while conducting the process and not until a decision has already be made.

**Table 6.11 Final conclusions for MEEIN´s case study**

### 6.3.2. DSM

The situation of analysis is that of the production scheduling of DSM. Production scheduling is important since it gives information on what to produce and when to produce it. The purpose of such scheduling is to minimize the waste in costs and times of production. In this case, the scheduling is done mainly on a weekly basis and it involves multi-product installation: different products in one production site. The main actors involved are Marketing and Sales, Operations and Quality. The case study is that of *improving the decision making process of deciding if they should stay with the current schedule that could be affected by some external factors such as demand, priorities, etc., or if they have to change in order to have a profit*. Chemical products would be

involved in this kind of situation. The process would be that of a batch production with various stocks keeping units. The typical size of batches ranges from 1 day to 1 week of production. When referring to a multi-product installation, it is referred to typically handling 2 products simultaneously, but the total range might be between 10 and 100. No specific information was given regarding the amount of time in changing between products, time of cleaning machines, installation or change-over costs, and so on. This information is all important to have when considering and evaluating schedule changes. The case is a general one in which DSM wants to observe the benefits that this framework can bring to the case situation.

The following paragraphs will explain the process the researcher followed for the first stages of the proposed framework, in order to give a diagnosis to DSM on ways that the decision making process can be improved. The information was given by Mr. van Delft.

**6.3.2.1. The diagnosis of DSM’s case following the proposed framework**

Stage 0. The mapping of the company.  
Who should be involved? Decision-maker

Using a stakeholder analysis technique, actor characteristics are studied. The characteristics that are relevant are the same as in the previous empirical case. The stakeholder analysis presented in table d.13 in Annex D2 is filled with information gathered from an interview done with Mr. van Delft. In real cases, the information should be filled by the decision maker using information from both the respective actors and own perception.

The main actors are 3; the actor named “Operations” involves Production and Planning Departments. “Sales” involves Marketing and Sales Departments. It can be seen from this initial stakeholder analysis that Sales and Operations can have conflicts based on their interests. The latter looks to gain as much as possible while the former can be seen to be more of a risk-adverse actor: they will validate a production schedule that minimizes costs and only when they feel certain they can meet with it all external factors (e.g. product changes due to different demand or different priorities). Both of these actors have a high influence on decisions of keeping or changing a current production schedule. Quality, on the other hand, may not have as much influence as the previous actors but its involvement is imperative to ensure that key information is not overlooked as possible ways that changing or maintaining a certain production schedule could hurt the quality level of the products. This information gives an initial mapping on the actors that need to be involved in the decision-making process. It is valid that at later stages, other actors that are found relevant are included. The conclusions that the decision maker should have after this stage are:

<b>Conclusions from stage 0</b>	
<b>1</b>	Operations, Sales, and Quality Departments are important actors to involve in the process as they all contribute key information that may benefit or hurt the case situation.
<b>2</b>	Operations and Sales Departments are the most likely to have conflicting points of view on the situation. Their involvement is a must.
<b>3</b>	Quality Department is an actor that even if it has a lower influence on the decision, can act as a deal-breaker in the decision process since it could state that a certain schedule could hurt/benefit quality of products more than other schedule. Furthermore, the failure to involve this actor is naïve as information that this actor gives is crucial for the company’s objective of meeting with customer’s satisfaction.

**Table 6.12 Main conclusions from stage 0 of DSM’s case study**

Stage 1. The classification of the situation.

Who should be involved? “First group” (Operations, Sales, Quality and Decision-Maker)

A technique such as a nominal group technique should be used in order to involve the different actors into classifying the situation. In this diagnosis case, however, the classification was made by Mr. van Delft and the researcher based on the information and characteristics of the situation. The nominal group technique process involving Mr. van Delft and the researcher can be seen in Annex D2. The optimal case would have been following this technique with the actors identified in the previous stage.

In this case, Mr. van Delft signals that DSM has procedures in place that follow a consensus practice, yet if a conflict cannot be resolved, a decision should be made in an autocratic way. Therefore, the decision making practice that is suggested in this case is that of a *consensus decision making practice with the possibility of using semi-autocratic practices when urgency matters surface (e.g. conflicts unresolved, time pressures, etc.)*. This is interesting because it shows the importance of a multi-actor analysis approach and the selection of those techniques that strive more for *bottom-up* decision making processes.

The situation at hand has been defined as being *generic yet unique to the situation*. This is because the production scheduling is done periodically (in this case, on a weekly basis) and these types of situations often occur, having to decide if continuing with the actual schedule or changing it. Therefore, previous set of procedures apply and are followed. However, the situation might require different variables and then the previous parameters cannot be fully followed but used as a baseline. With this classification, it is seen that the inclusion of the different actors is needed in the process. This is because, even if there situation like this one are present on a quite often basis, the variables differ so previous procedures and decisions cannot apply and, even more, previous information.

Stage 2. The definition of the problem.  
Who should be involved? “First group”

A simple stepladder technique was used with Mr. van Delft to define the problem. Again, it is optimal to include the actors that have been identified in the first stage of the framework to come up with a complete, understandable and specific definition. The overall process to define the problem is the same as the one showed in MEEIN’s case. For this situation case, however, the process was between Mr. van Delft and the researcher and not including the first group, so for the sake of the diagnosis and due to resource constraints, the technique was adapted to what could be done between Mr. van Delft and the researcher. The process to define the problem, using the stepladder technique involving one iterative round can be seen in table d.15 in Annex D2.

In this practical case the problem definition is not as specific as in reality it should be, but the objective in this case is to have a general understanding of the situation and how the proposed framework could facilitate this general and repetitive procedure of production scheduling. The problem definition is narrowed to:

- *How to correctly match profit against costs in order to see if the production is profitable (while accounting with possible external factors) to decide on to keep with current schedule?*

This problem definition suggests that the core of the decision will rely on deciding if to stay or not with current production schedule. Yet, the problem lies in how to come with reliable and complete information in order to evaluate the course of the decision. Therefore, multi-actor involvement is

imperative to maximize the chances of having reliable and the most complete information set possible. The framework process will result in a plan of action and responsibilities indicating what each actor needs to present as to be able to make a final decision of staying with current production schedule or not. Therefore, the final decision depends on the information given by each actor and is subject to risks like unreliable information, which could be minimized by the approach the framework uses.

After defining the problem, it is necessary to revise different factors in order to check for its completeness regarding information. The following questions should be answered:

- 1 Which information is available right now?
2. Which information is needed to be known?

The answers to these questions are found in table d.16 in Annex D2. This information should be filled with the help of the “first group”. In this case, the information was presented by Mr. van Delft, limiting the scope and access to different angles and knowledge from the different actors. It is seen that there is information missing yet this information is provided by the actors already involved in the process so no need to include other actors for now. This missing information is real time capacities and extra production costs from “Operations” and sales prospects from “Sales”.

3. Why a decision should be taken for this situation?

A decision should be taken to a) minimize the risk of committing to production that is not feasible, b) minimize the risk of producing with lower quality in order to meet production that has been committed, c) to minimize costs due to changeovers of products and d) to maximize the profits, all factors considered. Therefore, the decision is relevant and crucial for the company since it affects the overall objective of the company of a profit and customer satisfaction.

<b>Main conclusion from stage 2</b>	
<b>1</b>	The actors thought of in stage 0 are in fact the ones that can provide with information that is needed to be known and therefore fill out information gaps. Hence, no other actors should necessarily be included.
<b>2</b>	Almost all the information identified as “needed information” is manageable to be gotten by the involved actors, by control systems and by external sources like clients. Therefore, no need to include other actors. However, a major risk is that of getting information from the market that is reliable and on time.
<b>3</b>	The assumption that the actors were dependent on each other is validated in this stage: information that one actor needs comes from the output of another actor.
<b>4</b>	Special attention should be given to the sales prospect information by Sales Department. The decision of knowing if there is a better profit with a schedule modification depends largely on these sales prospects.
<b>6</b>	The major risks involve the assumptions on the market if no reliable information can be gotten on time in order to have scenario studies on how the schedule could be modified and how can these modifications affect the overall problem and decision. Involving the different actors is crucial to include all possible assumptions regarding the different angles each actor possesses.

**Table 6.13 Main conclusions from stage 2 of DSM’s case study**

Stage 3. The definition of boundary conditions.  
Who should be involved? Core group (Operations, Sales, Quality, and Decision Maker)



It was stated by Mr. van Delft that what is right is clear and simple: *having a schedule that allows a profit*. The updated mapping of actors, using a stakeholder analysis can be seen in table d.17 of Annex D2. In this case, the information basically is entered by Mr. van Delft and as expected, the information in table d.17 is the same as table d.13 for these first variables. This is a limitation in this case study since strategic behavior cannot be really accounted for, since the different actors are not actively participating in the different stages. So for this case, the same conclusions that were drawn from stage 0 apply here.

Furthermore, it is seen then, that Quality is a non-dedicated actor since in reality, the outcome does not affect its objectives of assuring quality: they will strive for the highest possible quality regardless of the schedule. Moreover, Operations is dependent on Sales and Quality, and Quality actions affect both Operations and Sales. This clearly shows what stated before: Quality should be included in the process even if the interest of the outcome is not as high as of the other actors. Operations has a high power, since it accounts for both information and process resources. Sales has a high power as well, since the information it has will influence what Operations does. Quality in this sense has a medium power since the resource it has is of a process type. In this practical case, the problem is more focused on information that may help match clearer if a schedule is profitable enough to stay with such schedule compared to other possible schedules that come up based on external factors as demand and priorities. Hence, information resources have more weight.

The problem in this case is that of a conflict situation. There are different interests from the distinct actors and the dependency on each other is imminent. While Operations depends on Sales regarding information, the latter depends on the former in the sense that it is Operations who has the most production power, them being the ones responsible if the schedule becomes profitable at the end. If these two actors don't work together, both of them will see their objectives attainment diminish. Furthermore, a third actor cannot be neglected since both of them, Operations and Sales, depend on the function of Quality to achieve their objectives. Offering a common ground, that they all will be affected with a negative decision (and with a process that does not facilitate coming up with an effective decision) is a way to make them all be involved (including Quality since its dedication to the problem is not high). Strategic behavior in this case is most present by the (un-)reliability of the information given to the rest of the actors. Unfortunately, an analysis of strategic behavior presence is not applicable in this case as the information does not come directly from the rest of the actors. Likewise, as opposed with the case of the previous section, the criteria in this case have been selected by Mr. van Delft. In most cases, it is recommended that these criteria are defined with input and involvement of the "core group" following a nominal group technique, just as in the previous case. The criteria that Mr. van Delft suggests can be used to evaluate the decision are: total value of the production; customer's satisfaction; and operational criteria such as OEE (Overall Equipment Efficiency) or production costs. Finally, a scenario study should be done to analyze how changes on the detected risk factors impact the boundary conditions. It has been identified that these risk factors are a change in priority of products, a change in demand, rush orders, machinery breakdown and machine maintenance, as well as wrong or untimely information. Under a what-if analysis, these factors should be analyzed by the "core group" on how they could change and what consequences these changes would bring to the boundary conditions and ultimately to a decision of either staying put with a certain schedule (that would be affected by these factors) or pursuing a different schedule. Sadly, because there is no access to the rest of the actors and there is no specific information, this scenario study cannot be made as opposed to the previous case of MEEIN.

<b>Main conclusions from stage 3</b>	
<b>1</b>	Operations, Sales, and Quality Departments are the actors that should form the "core group" of the decision process as they all contribute with key information and have strong dependencies based on the work network they are part of. No additional actors should be contemplated to

	include at this point.
2	Quality seems to be the less dedicated actor of them all, as well as the one with less power and resources. However, Quality should be included in the process due to dependency reasons. Work dependencies show how all are dependent on each other, and only by having information from all of these actors, can an effective decision be made, and can match effectively costs with profits accounting for the external factors.
3	Operations Department has the highest power level, by having both knowledge and process resources. But even with this higher power, Quality and Sales could have a not optimal effect on the decision. Therefore, the power is not proportional to heavier weight in the decision process.
4	All 3 actors are needed to complement information gaps, to analyze the information obtained both internally and externally, and have better means of accountability for that information.
5	The major risks present are from the assumptions done by Sales for sales prospects; wrong or untimely information by Sales and/or Operations; and market information.
6	A multi-actor analysis approach helps deal with wrong information and with Sales assumptions by a better analysis from all involved actors. It provides better accountability so that each actor is motivated to give and have relevant information on time. It cannot however, help with getting complete, trustworthy and on-time information from the market. It does help to deal with the assumptions that are made when reliable information on the market is absent.

**Table 6.14 Main conclusions from stage 3 of DSM’s case study**

Stage 4. The decision making and the decision implementation.  
Who should be involved? Core group

Given that the purpose of this case study is just of a diagnosis one, suggestions for stages 4 and 5 are given to go along with the conclusions from the previous stages. These suggestions were sent to Mr. van Delft which gave a feedback.

The suggestions for stage 4 are:

1. To employ a qualitative CBA in which the different options presented by the “core group” are analyzed in terms of the criteria. Information sources should come from: each actor themselves, control system and the market. A proposed Qualitative CBA as proposed can be seen in table d.18.
2. The decision making should start with the following steps:
  - a. Decide based on the grades given to the criteria factors. At this stage, the information has been analyzed and discussed by all actors before trying to come up with a decision. Therefore, it should be said that the information that is presented on the table should have been approved by the “core group”. Hence, the logical argument would be to choose the option which scores the highest.
  - b. However, it may be the case that an option that has the most benefits in the table, presents some negative effects on a certain actor (refer to the interests and desired objectives of each of them). If this is the case, trade-offs should be allowed.

If a halt in the decision making process would occur at this point of trade-offs, strategies that should be followed in order to come up with a decision should be used as follows:

- c. Opening the process to see if it is possible to compensate an actor elsewhere: perhaps, broadening the benefits to impact the value of each criterion, and perhaps then, the grades.

- d. After negotiation has failed, and due to time limits, a change in practice should be made. The decision will no longer come via a consensus but it will be made by one actor: the practice will shift from a consensus one to a semi-autocratic one.
3. After the decision is made, the “core group” should be managed accounting for the winners and losers of the process. In this case, this step should be done if the decision has affected an actor against its interest and desired situation. This will help the actors feel compromised and supportive of the decision even if this one was not the optimal in their eyes.
4. Finally, after the decision has been selected but before putting it into practice, the following questions should be answered in order to include accountabilities, issues and mandates in the implementation process and facilitate understanding of both, the decision and its implementation. Hence, this will improve the chances of a more efficient decision implementation.
- a. Who has to know of the decision?
  - b. What action has to be taken?
  - c. Who is to take it?
  - d. What has to be done so that these people can take the action?

This ensures that there is a plan of action so that the decision does not get lost and everyone is responsible and informed about the implementation; this minimizes risks of overlooking important aspects of the process of transforming an idea into an activity.

Stage 5. The evaluation and the feedback of the decision.  
Who should be involved? Core group

The suggestions for stage 5 are:

1. Having on paper the accountabilities, mandates and issues as drawn from stage 4 in order to revise if these were done and on the proper manner.
2. Having at hand the Qualitative CBA done in stage 4 in order to compare what was thought with what is happening/has happened.
3. Evaluate the current course of action (specifically the actor’s behaviors and the criteria) with what the Qualitative CBA information stated, and answer:
  - a. Did the decision actually served the purpose intended?
  - b. What consequences did the decision had on the actors and manufacturing activities? Were these the expected ones?
  - c. If the results are not the same as the expectations, were these changes accounted for in the scenario study? If the answer to this question is Yes, then a plan of action should already be in place. If the answer is No, then an urgent meeting and follow-up decision should take place in order to evaluate why did the decision go wrong and how can the course of action be corrected.
4. Establish future step actions.
  - a. If the outcome proved to be closely equal as the expectations, then monitoring actions should be made, especially if it is detected that the risk factors may be subject to more changes.
  - b. If the outcome proved not to match the expectations, assess if the scenario study acknowledge this outcome. If it did, then follow the plan of action proposed at this scenario study. If not, corrective actions should take place.

### 6.3.2.2 Feedback from DSM

After making the diagnosis of this practical case, the researcher sent this along with conclusions and suggestion to Mr. van Delft. After revising this, Mr. van Delft provided valuable feedback on it can be seen in table d.19 of Annex D2. The main conclusions for the purpose of evaluation of feasibility and practicability of the proposed framework, based on Mr. van Delft’s findings are:

<b>Main conclusions from DSM case referring to feasibility and practicability of the framework based on Mr. van Delft’s feedback</b>	
<b>1</b>	The fact that not all stages were realized limits the validation of the framework. It is due to this that it is difficult to assess on the suggestion for the last 2 stages since the process and outcome of these were not seen by Mr. van Delft.
<b>2</b>	The limitation of the framework can be that it may be too complicated and elaborated. This perhaps would limit DSM to use the framework. Another shortcoming is the inability to assess the value of the framework towards other decision making methods and perspectives because it does not compare them.
<b>3</b>	However, the proposed framework offers added value to DSM current decision making processes as things are being made more explicitly. With this, implicit assumptions are being prevented. Other advantages include quicker and more effective decision making, as well as being able to capture more business opportunities.
<b>4</b>	Due to these advantages, Mr. van Delft states that they will look into incorporating some of the framework elements to their decision making.
<b>5</b>	A decision could be taken quicker and be more effective, yet Mr. van Delft worries that it still may not improve support and collaboration since people don’t like following frameworks. Anyway, the framework is quite feasible to be implemented in terms of time and resources.
<b>6</b>	Mr. van Delft agrees with the conclusion made after each stage. The only remark comes out from the following one: “having production power is something different than having power overall”. However, this does not change the overall suggestions of the diagnosis. In the researcher’s point of view, if the framework was done with the inclusion of various actors, this remark would certainly have come upon and handled within this stage process.

**Table 6.15 Final conclusions for DSM’s case study**

### **6.3.3 Radiall**

Radiall, Ciudad Obregón, is composed of 3 plants: assembly, machining and “electro-plating” (consisting of covering a surface with a pure metal layer). It is in this last plant where the empirical case occurs. The process of electro-plating is highly automated yet extremely complex so only specific and highly capacitated people can operate this process. Just to give an example, new personnel have to go through extensive and elaborate certification in order to have clearance to operate this process. In this case, Radiall does electrical connectors for the aviation industry. It has to be noted that despite being a chemical industry, Radiall has received numerous awards including awards for social and sustainable responsibilities. They are the only chemical company in Mexico being certified on the first run as a clean industry. These aspects are highly appreciated by Radiall’s upper management which will be seen later on in the framework process.

A study case presents itself when there is a sudden increase of production demand from one of the main clients. Planning Department should have given a prior notice in order to increase capacities but failed to do so, and they just state that in one week there is the need to produce 30% more. Therefore the situation happens when one production line needs to increase its production capacity on a 30% level. The delivery must be done, satisfying all client’s requirements. If this is not fulfilled, there are highly serious consequences for Radiall. At no point in time they can fail to deliver parts for airplanes fabrication because, among others, this could open the door for the other

suppliers in a highly competitive and lucrative market. Radiall currently possess a delivery efficiency of 99.965% and an efficiency of resources used versus resources obtained of 85 to 90%. Therefore, Radiall does not wish to lower this efficiency at no point. It is important to note that the situation of study is not a normal one, at most occurring 1 to 2 times per year.

The case situation analyzed will be: *Satisfying a sudden 30% increase of production demand in one production line, satisfying client’s requirements of functionality, quality and time.*

**6.3.3.1. The diagnosis of Radiall’s case following the proposed framework**

Stage 0. The mapping of the company.  
*Who should be involved?*  
 Decision-maker (Department of Added Value)

The stakeholder analysis presented in table d.20 is filled with information gathered from an interview done with Mr. Yepis. In real cases, the information should be filled by the decision maker using information from both the respective actors and own perception.

Mr. Yepis identifies 5 actors as the ones most prominent to be involved in a situation like this one: Department of Added Value (referred from now on as AV and which in other companies goes by the name of Production), Planning, Quality, Human Resources and Plant Manager. In table d.20, it can be seen that all actors have an avid desire in complying with the 30% production demand increase. It is also seen how interests of one actor overlap interests of another department. For example, AV desires to comply with the production increase without putting aside quality aspects of the product, which is a vivid interest of Quality Department. This facilitates cooperation between actors to reach a quicker and more effective decision. However, it can also be seen risks factors and certain dependencies. The first risks detected are in the sense of wrong/untimely information that the other actors need to know in order to make a valid and effective decision Potential conflicts can be present between Human Resources and AV, because the former would like to reach the production demand increase without violating any labor regulations and law which could mean not being able to provide with the specific and necessary personnel resources that AV needs to comply with such demand. All the actors have a high influence on the decision based on the information they provide to the others and that can determine if a certain plan of action is viable or not to do. Given this information, all actors should be involved in the decision making process on paper.

This information gives an initial mapping on the actors that need to be involved in the decision-making process. It is valid that at later stages, other actors that are found relevant are included. The conclusions that the decision maker should have after this stage are:

<b>Conclusions from stage 0</b>	
<b>1</b>	All actors have a high influence on the decision. Thus, they should be all included in the “first group”. Therefore, the actors forming this “first group” are: AV, Planning, Quality, Plant Manager and Human Resources.
<b>2</b>	The desired situation of all actors point out to comply with the 30% production demand increase. Moreover, it is seen that the desired situation of each actor involves complying with interests of other actors. This can facilitate cooperation between the actors.
<b>3</b>	Human Resources and AV are most probable to have some sort of conflicts given the interests each of them have. AV and Planning could also have conflicts if information is not clear or on time.
<b>4</b>	Certain dependencies can be found. The situation is dependent on the involvement of Plant

	Manager to facilitate support and authority to have resources to work with. AV specially is a bit dependent on the information that Planning gives in order to have a correct production. Nevertheless, all actors depend on each other to reach their desired situation at its best given the information and functions they all must share
5	Potential risks observed at this stage are wrong or untimely information.

**Table 6.16 Main conclusions from stage 0 of Radiall’s case study**

Stage 1. The classification of the situation.  
*Who should be involved?*  
 “First group” (AV, Planning, Quality, Human Resources and Plant Manager)

In this case, the 4 suggested decision making practices are introduced to Mr. Yepis. Mr. Yepis then states that the decision making practice that most resembles how it is done within Radiall is that of a *democratic decision making practice*. This is because in Radiall, within their decision making processes, all the actors are actively contributing and all inputs have the same weight. However, at the end of the day, the responsibility falls down to one actor: AV, in this case. Therefore, the researcher suggests to employ a *democratic decision making practice mixed with a participatory practice*. This mix is especially useful when urgent matters surface (e.g. unresolved conflicts, time pressures, etc.) and an actor should have more power on the decision outcome.

A nominal group technique should be used in order to involve the “first group” into classifying the situation. A process example can be seen in table d.21. The classification was made by researcher yet in practical cases, this table should be filled and followed by the “first group” members. The situation at hand has been defined as being *generic yet unique to the situation*. This is because the production itself is an everyday process but what is unique is the unnoticed and sudden increase in production demand. This gives new variables to consider as time constraints, accommodation of the extra production demand, accommodation and management of material, machine and human resources in this extra period of increased production.

Stage 2. The definition of the problem.  
*Who should be involved?*  
 “First group”

A simple stepladder technique is used to define the problem. In this practical case the main input was from Mr. Yepis and the researcher. The process is the same used in the previous cases:

1. Based on the situation at hand and from the information of stage 0 the objective could be traced down to: *Satisfying extra production demand in all aspects*.
2. A stepladder technique as shown in table d.22 is used to set means for objectives. The ideas coming from the researcher regarding what each actor could identify as means are written in the table. In this case, the means that is found most critical could be: *To correctly assure the availability of the correct resources*.
3. A stepladder technique is used to present the different problems that are present in the selected mean to achieve the objective. This information can be seen in table d.23. The problems that may be most critical for reaching the objective are:
  - *Bad management of resource distribution and assignment*
  - *Not complying with law and environmental regulations*

4. Following a democratic decision making practice, the problems set in step 3 would be analyzed and selected by looking at these 2 criteria: criticality and feasibility to assess and correct. It is seen that both of the problems are critical in the fact that if they are present and not managed accordingly it may a) cause that the new production demand is not met or is not fulfilling all of client's requirements and; b) cause that Radiall may be involved in penalties and/or fines. Nevertheless, both problems are feasible to assess and correct. Therefore, the main problem based on the current situation and the objective is defined as:
  - *How to achieve the extra production requirement while fulfilling client's requirements of time, quality and functionality without violating environmental, safety and legal regulations?*

The problem definition suggests that the core of the decision is assessing how to meet with the increased production demand. However, as opposed to the situation expressed earlier in this case, the problem definition suggests two dilemmas: the first one presents itself when the production process is a somewhat complex one that requires specialized resources, so a decision should be made that a correct assignation of resources is made to ensure the fulfillment of the client's requirements. The second dilemma happens when this assignment of different resources could pose a threat to different regulations: special attention should be given to ensure these regulations are not violated or overstepped while trying to achieve the main objective. After defining the problem, the following questions should be answered:

1. *Which information is available right now?*
2. *Which information is needed to be known?*

The answers to these questions are found in table d.24. This information should be filled with the help of the "first group". In this case, the information was presented by Yepis and on assumptions from the researcher, limiting the scope and access to different angles and knowledge from the different actors. The answers show that indeed there is missing information and that important risks can happen due to a bad management of this information. Normally, the missing information is provided within the actors already involved, so no need to include other actors. Therefore, the "core group" will be formed by the same actors from the "first group". As it can be seen, the assignment of resources and wrong information are big risks, which can be assessed better with the involvement of all the actors. This backs up findings from previous stages. Special attention should be given to assure that the suppliers give correct, on-time information and material. It is discovered that Human Resources and AV are mutually dependent in the sense that Human Resources needs to know how to proceed regarding extra personnel yet AV needs to know until what extent they can stretch labor use. Therefore, potential conflicts between these actors are still present but the common ground they share should entice in cooperation. Furthermore, as it was described in previous stages, all actors should be heavily involved since they all bring important information to the table.

3. *Why a decision should be taken for this situation?*

A decision should be taken to ensure that the increase production demand be met fulfilling clients requirements but assuring that this is not at the cost of labor, machinery or other resources rights, safety and/or future performance. Therefore, a decision should minimize the risk of a) penalties or taxes for not complying with certain laws and regulations, b) safety hazard, c) losing client's satisfaction and with this, hurt Radiall's reputation and market position. Therefore, the selected problem is a right choice regarding that is a critical problem to achieve the desired objective and in the sense that the actors have the means to eradicate or minimize it.

<b>Main conclusion from stage 2</b>	
<b>1</b>	Most of the information that is needed comes from the actors already involved in the process. Hence, the “core group” will be formed by AV, Quality, Planning, Human Resources and Plant Manager; all that were part of the “first group”.
<b>2</b>	The involvement of these actors is important since the major risks identified can be minimized with the participation of these actors.
<b>3</b>	The assumption that the actors were dependent on each other is validated in this stage: information that one actor needs comes from the output of another actor.
<b>4</b>	The involvement of all actors is crucial to minimize the risk of wrong information from other actors and suppliers. With all actors involved, each one of them can analyze the information given and with their own resources detect wrong information and wrong analysis of information. Likewise, involving the actors permits that each one of them know what the rest is expecting of each of them, and have a better idea of the how and when of the information flows: it improves accountability.
<b>5</b>	Special attention should be given to a correct resource assignment from all actors.
<b>6</b>	The potential conflict of Human Resources and AV has more importance now since they are mutually dependent on each other due to information they each can give. Yet, because they each pursue the same objective, this common ground along with the dependency nature between them, should make them increase the cooperation between them. Therefore, the researcher thinks that no specific strategies will be used to promote cooperative behavior since this will come naturally.

**Table 6.17** Main conclusions from stage 2 of Radiall’s case study

Stage 3. The definition of boundary conditions.  
*Who should be involved?*  
 Core group (AV, Planning, Quality, Human Resources and Plant Manager)

In this case, what is right is: *don’t overstep regulations and laws while meeting client’s demands.*

The updated mapping of actors, using a stakeholder analysis can be seen in table d.25. It is seen then, that Human Resources may have the less dedication to the problem. However, Human Resources is still a dedicated actor given that the outcome affects how they do their work (i.e. hire and train new personnel, coordinate extra time resources, etc.). Moreover, AV is somewhat dependent on Planning for the product description; AV and Human Resources are mutually dependent as explained in the previous stage; Quality is dependent on the production process being on schedule to assure quality with enough time and pressure-free as possible. Furthermore, AV is dependent on the involvement of the Plant Manager to secure support and authority to have resources to comply with objective. Furthermore, AV has a high power, since it accounts for both information and process resources. The same goes for Planning and Quality: the former possesses information needed by AV and the latter can influence if the production is validated or not. Plant Manager has a high power since it can influence the decision and problem with its support and authority conceal. Finally, Human Resources also possess a high power since its information is crucial to assess the problem. If the problem was defined differently and did not include regulations and law compliance, the power of Human Resources would for sure diminish.

The problem in this case is that of a negotiation situation. The different interests from the involved actors all pursue towards a common objective. Conflicts can appear but it is in the researcher’s point of view that this will be resolved naturally since it is in all the actors’ interests to coordinate efforts and cooperate; thus, negotiating on trade-offs to achieve the desired outcome.



Strategic behavior in this case is most present by the (un-)reliability of the information given to the rest of the actors. It appears that because all actors are pushing for the same goal, strategic behavior should not be a major factor. Unfortunately, an analysis of strategic behavior presence is not applicable in this situation case as the information does not come directly from the rest of the actors so deviations on their characteristics (i.e. interests, desired situations, etc.) cannot be analyzed to see possible presence of this kind of behavior.

The possible criteria in this case have been selected by Yepis. In real cases, it is recommended that these criteria are defined with input and involvement of the “core group” following nominal group technique. The criteria that Mr. Yepis suggests can be used to evaluate the decision are: process capacity, available (volume) capacity, legal restriction, and environmental restrictions. These criteria will be used in the next stage to evaluate the behavior of the different options, hence, facilitating the view of best choices in order to take a good decision. It can be seen here the heavy weight that factors such as social and sustainable responsibility have in this company when coming up with decisions.

It has been identified in table d.24 that these risk factors are wrong/untimely information, wrong resource assignment, wrong resource disposal, unawareness of regulations and laws. Under a what-if analysis, these factors should be analyzed by the “core group” on how they could change and what consequences these changes would bring to the criteria and ultimately to a decision of how to meet the 30% increase in production demand. Sadly, because there is no access to the rest of the actors and there is no specific information, this scenario study cannot be made for this diagnostic case.

<b>Main conclusions from stage 3</b>	
<b>1</b>	AV, Planning, Quality, Human Resources and Plant Manager are the actors that should form the “core group” of the decision process as they all contribute with key information and have strong dependencies based on the work network they are part of. No additional actors should be contemplated to include at this point.
<b>2</b>	Human Resources could be less dedicated actor of them all, yet it should be included due to the nature of the problem definition (i.e. importance in regulations and laws), and to the mutual dependencies with AV.
<b>3</b>	All actors possess a high level of power due to the information and/or process resources each of them possess. Thus, they all need each other.
<b>4</b>	All 5 actors are needed to complement information gaps, to analyze the information obtained both internally and externally, and have better means of accountability for that information.
<b>5</b>	The benefit of involving several actors to analyze information and to be able account for information is a way to minimize possible strategic behavior of these actors. Another way to minimize this behavior is by offering a common ground which all of them relate to: not meeting with the production demand and with the client’s requirements hurts the company reputations and thus, risks further business with the client.
<b>6</b>	The major risks present are wrong/untimely information, wrong resource assignment, wrong resource disposal, unawareness of regulations and laws
<b>7</b>	The criteria that are drawn from this stage will be used at the next one to evaluate the different options (i.e. plans of action). In this case, the criteria that could be used are: process capacity, available (volume) capacity, legal restriction, and environmental restrictions
<b>8</b>	A scenario analysis allows seeing which changes of the risk factors could occur based on different angles from the different actors. It allows seeing how these changes could affect the criteria established in this stage. This scenarios could help draw specific plans of action should they occur.

**Table 6.18 Main conclusions from stage 3 of Radiall’s case study**

Stage 4. The decision making and the decision implementation.  
*Who should be involved?*  
Core group

Just as in DSM’s case, suggestions for stages 4 and 5 are given to go along with the conclusions from the previous stages.

The suggestions for stage 4 are:

1. Employ a qualitative CBA. A proposed Qualitative CBA as proposed can be seen in table d.26.
2. Decide based on criteria factors but giving room to trade-offs and intangible elements that may cause a certain option not be viable anymore. If necessary, employ strategies to overcome halt in the process due to deadlock or conflicting situations as explained in the previous case study.
3. After the decision is made, the “core group” should be managed accounting for the winners and losers of the process. In this case, this step should be done if the decision has affected an actor against its interest and desired situation. Since all actors seem to share interests and pursue the main objective in the same way and weight, it seems that this step could be skipped.
4. Finally, after the decision has been selected but before putting it into practice, the following questions should be answered in order to include accountabilities, issues and mandates in the implementation process and facilitate understanding of both, the decision and its implementation. Hence, this will improve the chances of a more efficient decision implementation.
  - a. Who has to know of the decision?
  - b. What action has to be taken?
  - c. Who is to take it?
  - d. What has to be done so that these people can take the action?

This ensures that there is a plan of action so that the decision does not get lost and everyone is responsible and informed about the implementation; this minimizes risks of overlooking important aspects of the process of transforming an idea into an activity.

Stage 5. The decision evaluation and feedback  
*Who should be involved?*  
Core group

The suggestions for stage 5 are:

1. Having on paper the accountabilities, mandates and issues as drawn from stage 4 in order to revise if these were done and on the proper manner.
2. Having at hand the Qualitative CBA done in stage 4 in order to compare what was thought with what is happening/has happened.
3. Evaluate the current course of action (specifically the criteria) with what the Qualitative CBA information stated, and give answer to the evaluation questions as in the previous cases.
4. Establish future step actions based on if the outcome was closely equal to expectations.

### **6.3.3.2 Feedback from Radiall**

After making the diagnosis of this practical case, the researcher sent this along with conclusions and suggestion to Mr. Yepis. After revising this, Mr. Yepis provided valuable feedback on it can be seen in table d.27 of Annex D2. The main conclusions for the purpose of evaluation of feasibility and practicability of the proposed framework, based on Mr. Yepis’s findings are:

<b>Main conclusions from Radiall case referring to feasibility and practicability of the framework based on Mr. Yepis’s feedback</b>	
<b>1</b>	The framework proposal is very workable and amiable to the current culture of problem solving and being more specific, to the way Radiall tackles its decision making. Thus, the framework is feasible to be used in manufacturing companies.
<b>2</b>	Radiall would like to follow current case outcome with the framework proposal to see if any learning can be made and a later introduction can be achieved.
<b>3</b>	The suggested techniques are also adequate since they are practical, logical and simple.
<b>4</b>	Mr. Yepis finds many benefits in the use of the proposed framework for decision making. For example, a more accurate and permanent corrective action and system improvement will be achieved following this process. Also, it brings to light some elements not normally considered such as s risk analysis and the potential elements of dysfunction that an actor can bring to the table.
<b>5</b>	Radiall finds added value in the proposed framework such as exposing on an organized way the point of view of each actor giving the work group the capacity to understand and perceive the issue from each actor’s angles. Likewise, there is a lesson on improvement and broad analysis capability that Radiall can learn and implement.
<b>6</b>	The shortcoming that Mr. Yepis identifies in the framework is that it can be potentially over-analytical or subject to power-debating.
<b>7</b>	The conclusions and suggestions are correct and aligned to the situations. If any, there are more variables to consider per actor but the main ideas and things are covered.

**Table 6.19 Final conclusions for Radiall’s case study**

## **6.4. Evaluation of framework based on case findings**

### **6.4.1. Conclusions from empirical study**

The conclusions that surface after the empirical study back up what was thought after the literature research. This literature research had stated how a multi-actor analysis approach certainly has plenty of benefits that could make a decision-making process become better. Furthermore, it stated how the decision making needed the inclusion of a multi-actor analysis. Therefore, a framework was introduced to make this possible. Obviously, this framework had to be proven somehow, so 3 empirical studies were made to provide this validation on the framework.

After conducting this empirical research, 4 main conclusions are found to exist. **First**, the framework is feasible and practical. The decision making process that the framework suggests can be employed within manufacturing companies. Not only that, but it is a not time or resource consuming process and does not require extensive expertise in the matter. **Second**, the framework process of decision making provides added value. It showed a way to make important factors more explicit; it demonstrated how involving multiple actors can reduce time without affecting quality of decision-making; it showed how intangible factors are important to take into consideration; it generated knowledge on unknown important factors and allowed to define certain important decision making elements which were not studied or were not given the right importance before; and finally, it provided with a new simple yet attractive way to evaluate client satisfaction. **Third**, the framework process of decision making brings various benefits to the companies that adopt it.

Putting aside the benefits of added value, the framework process allows reaching and having quicker and more effective decisions. It seems that the decisions will have more support and have clearer path for its implementation, reducing the risks of making a decision that at the end of the day, stays in thoughts and not actions. It also minimizes various potential risks of missing, overlooked, wrong, untimely information, as well as placing too much weight to unimportant information or too less importance to crucial one. In short, the framework process provides with interesting means to achieve improvement in Key Performance Indicators (KPI) that are commonly used in companies to evaluate the success of a particular activity. Moreover, it was shown how by using this framework process, decisions which were thought of but not pursued because of lack of evidence in their benefits, drastically became more notorious and valuable with facts. **Fourth**, the framework process provides exactly that, a standard procedure that companies can follow step by step to ensure that decisions can be quicker and more effective. A standard procedure is always beneficial because it allows guiding the path of actions and can be used as a reference on what to do on given situations, instead of just trying to improvise. This makes for a better management and use of resources, better chances of reaching objectives and less risks of “running around in circles” and not finding a decision, selecting a wrong decision, selecting a decision for a wrong problem, selecting a decision for an un-existent problem, or not thinking there is a problem. **Fifth**, the framework does possess certain limitations and shortcoming, for example, that it may be somewhat complex and elaborated to follow at the first glance. These limitations will be further explored in section 6.4.3 and in the next chapter.

The empirical cases gave more interesting observations. Specifically, the case of MEEIN showed how decisions can be made different following the proposed framework process: by explicitly showing each actor’s concerns and interests, a situation was tackled through a well- defined problem which is something that their normal decision making process did not take into account. Furthermore, the use of a decision making practice that followed a multi-actor value made the actors feel more involved in the process and it helped select the criteria and options which were the most valued and important ones thanks to a more complete set of information. This, in their normal way, did not occur at all: one actor decided what to do and the subordinates had to follow this decision even if they thought something could be improved. Third, a decision was taken with the help of actors which were the most important to involve and not just informally approaching ones who were thought to help shape a decision and correct the outcome as it occurred in reality. Finally, decision options were hard thought looking at different angles, information and concerns instead of, as it happened in the reality, making a decision based on feeling and what was thought best at the time without exploring alternatives.

#### **6.4.2. Key Performance Indicators Evaluation**

The researcher claims then, that the decision making process of this framework can have a direct positive impact on different KPI depending on the situation. For example, it was clear for MEEIN that another decision should have been taken and the proposed framework showed them that this was true: the decision that was taken in the framework process would potentially have reduced 7,330 USD in total costs, increased in about 5,000 USD the profit, the duration of the project would have been reduced by 4 weeks approximately and the time to make a correct budget would have been of nearly 3 weeks less which would have given a better image to their client. How much difference a correct decision making process can have! It is in the researcher’s belief that these observations can be applied to a greater number of situations and on different companies as well. Table 6.20 provides a comparison of the Key Performance Indicators for MEEIN’s case, comparing the results of their normal decision process against the framework process. The values on this table are the difference between the estimated criteria (the budgeted values) and the actual outcome.

KPI	Normal decision making process	Proposed framework decision making process *
<i>Project costs</i>	+ \$ 7,330 USD	-\$3,283 USD
<i>Project profit</i>	-\$ 8,478 USD	+ \$3,823 USD
<i>Time of fabrication</i>	+ 4 weeks	On time
<i>Time of budget making</i>	+ 20-16 days	-3-7 days
<i>Time to reach decision<sup>a</sup></i>	360 minutes	300 minutes

**Table 6.20. KPI evaluation of MEEIN's case study**

- These values are a close assumption of results.
- a. These values are drawn directly from Mr. Treviño's input and from the researcher's experience

The previous line showed how an improvement was made in KPI such as profit, costs and productivity (in taking less time to realize the project and less time to realize a correct budget). All sorts of different KPI can be influenced and improved by a correct implementation of the framework process based on the results of the MEEIN case. In the case of DSM and Radiall it could not be proved that an improvement would be made since the decision was not actually taken. The KPI that could potentially be improved by a good decision referring to DSM's case are OEE, total value of production, and costs. In the case of Radiall, these KPI could be productivity rate of defect goods and rework rate.

Moreover, the researcher claims that a sound and effective decision can be achieved quicker than with existing decision making process. It is important to emphasize on the term effective decision, since a decision can be taken in a matter of seconds but its effectiveness may not be the optimal just as in MEEIN's case. In this case, a decision was made rather quickly since an autocratic practice was used but as it can be seen, the results were not good. Following the framework process, an effective decision was taken in what Mr. Treviño states a shorter time than if using other processes. According to Mr. Treviño, when dealing with important decisions they can take up to one week, or around 360 minutes (of 6 meetings of 1 hour each) to reach one depending on the complexity and importance of the one (and when involving other actors at some secondary level). In this empirical case, it took around 300 minutes to take a decision which proved to be a correct and effective one. This points out that in fact, an effective decision can be achieved in less time. Even more, the researcher believes that around 140-180 minutes would have been more than enough, and should be more than enough, to come up with an effective decision using the framework process. The reduction from 300 to 140-180 minutes is because in reality, there would be a certain sense of urgency, which was lacking in the empirical research, and this should make actors be more involved and the process be followed on a more constant and demanding nature.

### 6.4.3 Limitations of empirical study

This section will mention limitations from the case studies that could make room for criticism towards the framework application. Chapter 7 will provide general limitations of the framework. A limitation in the empirical study exists regarding the *time gap between stages*. Because the study was not made physically but through interviews, the different stages were made whenever interviews were held. It is not clear if this time gap between stages affected in some way the information or the process. Referring to the results, it must be said that the results were already known since the empirical study used cases that had already occurred to compare this results and process to the ones the framework provided. Therefore, it may be true that this *previous knowledge on how the situation in reality turned out*, on what could have been done better, on the missing opportunities, etc. influenced in some way the behavior and/or ideas of the actors involved in the empirical study. A limitation of the framework found while doing the empirical study is that the

output gotten from the distinct techniques (and the process itself) is still subject to the *knowledge of the actors involved in the process*. If they do not know how to properly utilize the techniques or do not know how to handle the information, to say some, the results from the framework will not be ideal and the decision will lose chances of being an effective one. An important limitation in the empirical research done is the inability, as for now, to assess with solid and specific criteria the framework. In other words, there are *no specific and solid criteria to validate the framework* other than the opinions and feedback from the cooperating companies. This has to do mostly to the fact that the cases analyzed with the framework were cases that had previously been done and were used to serve as a basis of comparison. The final outcome of the research analysis was never known because the actual implementation was not made. The evaluation is made on assumption of “what could have happened if we used this framework”.

In the case of MEEIN, a limitation is that the data used to evaluate the decision made are drawn from assumptions of the “core group” based on experience and past similar projects. The results from the real decision were known but the results of applying a new decision were not since the action was not carried out. However, the “core group” manifested the strong belief in backing up the information drawn in stage 5 of the MEEIN practical case given their knowledge and experience with this type of projects.

As for the cases of DSM and Radiall, four limitations can be seen. The first is the *time constraints* which allowed only one interview with one actor. This leads to the second limitation: the information of these cases come from one actor and the researcher and not from a “core group” as in the case of MEEIN. Therefore, there was also the presence of *actor and information constraints*. Yet, it must be said that the purpose of these two cases was to make a diagnosis on how the framework could provide better insight into information and options based on using techniques supporting multi-actor input and multi-actor valuation to improve decision making. Third, given that the purpose was a diagnostic one, stage 4 and stage 5 were not actually made: therefore, a *decision was not made or evaluated*. Not made neither were the evaluation of criteria or scenarios which limits in a way the value of the proposed framework. However, this value downgrade is compensated through the direct feedback from these companies. Lastly, given the purpose of the empirical study along with the time constraints, it was not possible to explain in a clearer and general way the framework along with the techniques and the rest of the decision making elements to the interviewees. Therefore, it was *unclear some of the concepts and alternatives* to them.

#### **6.4.4. Revised Framework**

Important lessons were drawn from the empirical studies on ways to improve the proposed framework. First, it was observed and agreed that the techniques employed are useful and are adequate; they all are part of a whole and serve on specific things in order to come up with the most complete set of information and to be able to involve in the most possible and structured way the several affected actors. Therefore, it is seen that none of the techniques, based on this limited sample empirical frame, should be changed or not used.

An important lesson from this empirical research was the observation that the process could be over-analytical, elaborated and complex to follow correctly. This can limit the framework to be followed at some capacity, or at all, by companies. In order to avoid that, the researcher introduces a more-friendly framework. This “friendlier” framework still maintains key elements which provide added value to the companies and which provide the benefits expressed in earlier sentences. Originally, the framework consisted of 6 stages but, in an attempt to improve the framework and make it more attractive, the stages has been reduced to 5; the stage eliminated being “the classification of the situation”. Even if this stage did not take too much time or resources, it still

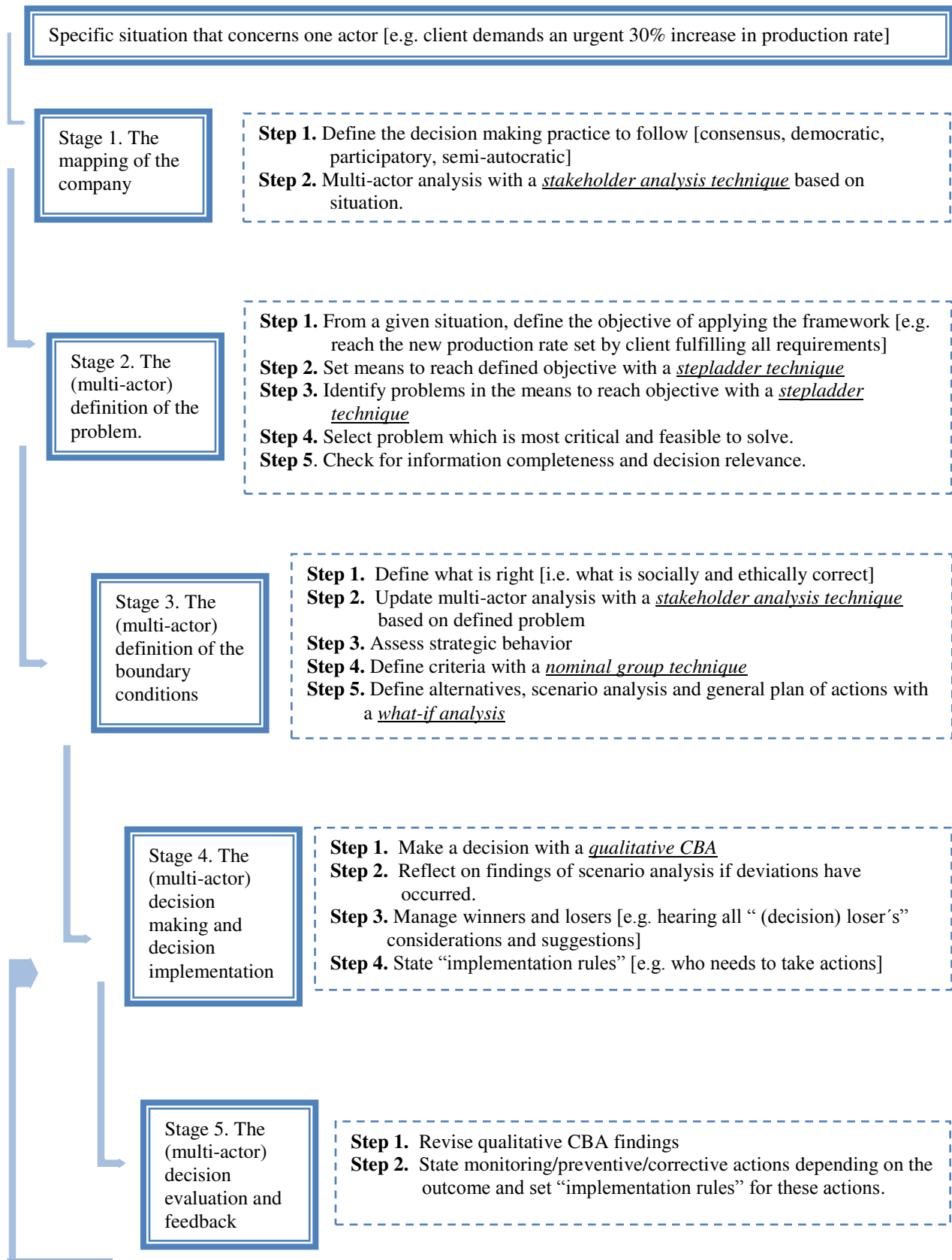


Figure 2. Lean framework process

took time and resources, and it is found by the researcher not to provide an added value because: a) most of situations in manufacturing companies are generic but unique, meaning that there is no real need to classify the situation, and b) there is no real need to know the type of situation given that the researcher exhorts using the 5 suggested techniques.

On the other hand, the rest of the stages are kept mostly untouched since they are found to provide added value and to help the cause of reaching the framework's goals. Another change is selecting the decision making practice to be followed right at the beginning of the process. The third change is to be more descriptive in the name of the different stages; to be more explicit if the stage involves multi-actor interaction or not. With this, it is better seen that the first stage is done with the perception of the decision-maker. This leaner framework process can be seen in figure 2. Perhaps the framework could be found to be simplified much more resulting in a "quick-scan" version. However, as of now, it is difficult to judge with the limited empirical research which steps could be dismissed without losing the value of the framework process.



There is a gap in manufacturing companies between how they approach and take into consideration to make sound decisions and what the decision making process in practice needs. There is an existence of a multi-actor value placed on decisions based on today's manufacturing activities and its characteristics: that these activities incorporate various actors and these actors, and their functions, are dependent on each other to reach an overall objective. This is an effect of a shift of manufacturing processes which have changed from being mostly localized to having a network-like structure. This dependency feature and network-like structure promotes a sense of cooperation among the involved actors. Therefore, the problem is that manufacturing companies may not be taking the best decision making activities within their manufacturing processes due to a dismissal in the value of multi-actor integration in the decision making process. Thus, an important perception for this research was that the manufacturing activities have a mismatch between practical needs and how they actually conduct and take into account for their decisions. An additional observation for this problem perception was the need to introduce a multi-actor analysis approach due to a belief that the introduction of such kind of approach will help improve decisions and support for these decisions, thus, better chances of good implementation and results. However, due to factors such as inexperience of, lack of knowledge of or untrustworthiness, decision makers have overlooked the benefits that a multi-actor field study could give to their decision making processes. This chapter then, sets to answer the main research question:

*How and to what extent can a framework be provided that improves the decision making processes and practices for manufacturing companies when addressing their manufacturing activities which involve several actors?*

It is the goal of this chapter to re-assess the findings of previous chapters in order to give grounds on the need of providing such a framework that could improve decision making processes; in other words, to assess if such framework is really needed. In this thesis, three fundamental research sub-question have been addressed that helped to give an answer to the main research question. In this chapter, the different research question will be re-addressed in section 7.1. Section 7.2 will revisit the framework process to include the findings and feedback gotten from the empirical cases. Then, the answer to the main research question will be given on section 7.3. A conclusion will be made in section 7.4 regarding the findings and referring to the initial assumptions. It is also in this last section that further research is addressed.

### 7.1. Revisiting the research sub-questions

*What is the standard ISA-95 and how can the information from the standard and enterprise and control systems improve decision making?*

ISA-95 is an international standard with the primary objective of integrating enterprise and control systems and with this, reducing the risk, cost, and errors associated with implementing these interfaces. The relevance of the ISA-95 standard within decision making processes is that the standard is used to implement an enterprise and control system solution and it is the output from these systems that help take decisions on manufacturing process. Therefore, the main focus is not on decision making itself although the following of such standard can bring benefits that can improve decision making such as: improving communication among actors and across levels, allowing integration within and across processes, helping developing reports, allow visibility of

information, and have correct and reliable information, allowing making decisions in real time, and having better control and overview of the company and its processes.

The researcher argued that the ISA-95 could provide an added value to decision making other than the benefits mentioned in the previous lines. Within the proposed framework, the ISA-95 standard can play an important part in two ways: first, by providing models to the decision maker that can help give insight into the structure and the relationship features across functions and actors. This can help with the early stages of the framework. Second, if the guidelines of the standard are followed to ensure a correct integration of enterprise and control systems, the decision making process can ensure that the information that is given by these systems is trustworthy, reliable and on real time to help making the decision in stage 4 of the framework.

However, in reference to the first research sub-question, it can be concluded that the standard guidelines do not support decision making in manufacturing companies since it is not within its focus and objectives: the goal of the standard is serving as an analytical tool that deals with information and stops when management activities, like decision making, starts. The standard serves as a way to implement a system solution: to implement and integrate enterprise and control systems. It is these systems which really affect the decision making process with the output they provide to the decision maker. It is due to this that the careful reader could see how the standard went into a backstage on this report and was only referenced after chapter 3 when stating on ways that the standard's output and information could somehow help with facilitating information for decision making. It became clear after having examples of conflicting situations in manufacturing companies that the focus was more on the challenges between actors and not on the standard's guidelines. Hence, after analyzing the standard it is seen that the way it can influence decision making is only by allowing a correct system implementation which will give information that later on will be discussed by the actors involved in decision making: it is a source of information.

*What is a multi-actor analysis approach and why is such approach necessary to be considered to support decision making?*

A multi-actor analysis approach is a set of guidelines that allows for the study of relevant characteristics of multiple actors. These actor characteristics are the set of perceptions, interests, objectives, resources and linkages that each actor has and that have an impact on their individual framing of the problem or situation. A multi-actor analysis approach is needed within manufacturing activities because **first** of all, these activities are within a network which suggests dependency and cooperative needs. **Second**, because of the complexity that arises from the diversity in problem perceptions among the actors involved. Not only perceptions, but differences in interests, objectives, resources, and targets are present: therefore, there is a need to manage complexity arising from these differences which lead to conflict and deadlock situations. **Third**, the inclusion of several actors is a must in order to ensure decision support and viability. **Fourth**, to help offset and minimize the functional and cultural biases present across the workplace. **Fifth**, it gives support for decision making due to negotiations that are needed because of strategic behavior and scientific uncertainty that involve making trade-offs in information processing and decision-making. **Sixth**, it can help in detecting the potential presence of strategic behavior and set common grounds for making trade-offs in information processing and decision-making. **Seventh**, it can help coming up with a more complete set of information. This increase in available knowledge allows for more effective solutions and therefore, along with the cooperation this approach yearns to obtain among actors, improves the chances of better implementation of decisions and strategies. **Finally**, the way manufacturing activities really work and are structured (in which several actors are involved) calls for an approach that can manage this network structure that occurs in reality.

Example cases were provided by companies and after looking at these cases, it is clear that a multi-actor analysis approach can benefit in their decision making processes. Therefore, a multi-actor analysis approach can benefit situations that are present in daily basis on manufacturing activities. Therefore, referring to theoretical and practical information, multi-actor analysis approach's strengths can support decision making processes and is a valuable option when analyzing and using information coming from different sources, including enterprise and control systems and from the ISA-95 standard itself. Besides providing with more reliable information, a multi-actor analysis approach helps actors to better understand the decision. This has the effect of having better support and collaboration for making and implementing a decision.

*Which are the most fitting decision making processes, practices and techniques that acknowledge a multi-actor analysis approach and increase chances of support, collaboration and success in manufacturing activities?*

The researches suggests a decision making process which best supports a multi-actor analysis approach and offers better chances of support and collaboration for decisions. This decision making process is the one followed in the proposed framework. The use of this process ensures that dimensions that are acknowledged to be critical in decision-making are considered and answered. The paper suggests not following a rational decision making perspective but a political process one since the latter tries to come up with decisions through interaction and negotiation. A mixed scanning (or humble decision making) method is suggested since it fits most, according to the researcher, to current manufacturing activities that have big amount of information to process (resulting in having incomplete information), that have different number of actors involved in the process and have little time to make the decisions. An overall set of techniques and their classification can be best seen in table c.1 of Annex C. These techniques have the characteristic that can be used in a dependent and multi-actor environment so techniques that did not fit with these situations were left out. Out of these available techniques, the researcher suggests to use a few of these on the proposed framework due to their simplicity, feasibility, cheapness and practicability to use. These suggested techniques are: stakeholder analysis, nominal group technique, stepladder technique, qualitative CBA and what-if analysis. Additional techniques that could be used if there is no agreement on the process are 6 thinking hats and brainstorming sessions.

Decision making practices (this is, the way that a decision is reached) vary among companies: first based on their needs and style of working but influenced also by the cultural context of the country the company is in, the maturity of the company and by the type of decision that is in place. It is because of this, that autocratic and intuitive decision making practices may be still preferred to be used even if they do not fully comply with multi-actor characteristics and fail to understand the situation of dependency, cooperation and multi-actor that is present in the manufacturing activities. Companies should employ practices to which their employees feel most identified to but that also comply with today's dependent and network-like nature of business. The researcher suggests the following decision making practices:

- a) Consensus decision making,
- b) Democratic decision making,
- c) Semi-autocratic decision making, and
- d) Participatory decision making.

These different suggestions offer the best chance of a successful implementation of the proposed framework as they offer the best chances for effective decisions because the suggested elements all facilitate the inclusion of a multi-actor analysis approach and maximize the advantages and strengths this approach offers to the decision making.

## 7.2. Revisiting the multi-actor approach framework for decision making

The objective of the framework is to allow an environment of more support and effectiveness of decisions in manufacturing activities when a decision is faced with a multi-actor situation. More concise, the framework's main goal is to have a decision making process which includes the key actors in order to have a strong support and involvement of these for a correct decision making and a correct decision implementation. This framework strives, via the inclusion of the key actors, to have the most complete and reliable set of information under limited time and resources, in order to make a decision which is efficient, and in order to have clear mandates and enough support for a correct implementation. Furthermore, the framework process closes the loop by a follow-up mechanism to ensure a correct implementation or corrective actions if needed.

The involvement of such actors is crucial since they can provide with a broader set of information and alternatives to decide upon, can analyze the information by different angles to assure correctness and completeness, and reach together a decision which is agreed on. This last notion is an important one which this framework brings to the table. The framework utilizes a multi-actor analysis approach which deals with conflicting and opposing interests, perceptions and objectives of different actors in order to facilitate trade-offs. This helps, for example, to better see common grounds which facilitate agreeing on what in principle were, opposing points of view. Therefore, by using a multi-actor analysis approach, the proposed framework is ideal for decision making situations where conflicting or negotiating situations between several different actors are bound to appear. Moreover, the framework process is one which recognizes time and resource constraints manufacturing companies are often dealing with. This means that this proposed framework, according to the researcher, is manageable and attractive to be used since it can improve decision making efficiency and support among the different actors, all within a short time frame.

The researcher used 5 techniques on the empirical research out of all the potential techniques as seen in table c.1. This is because these techniques are the ones the researcher felt were the most practical and less-complex to use. The researcher was eager to see if the same techniques could be used in different situations or if in fact, techniques would be in the need to be carefully chosen depending on specific situations. As for now, with this limited sample frame, it appears that the 5 techniques that were used can be used under different situations. This means that decision makers can just use these techniques and not worry about selecting others. This is good since, as it is shown in literature study, the knowledge on the different techniques listed in table c.1 is limited. On the other hand, the option is open for decision makers to choose other techniques from this table.

After the empirical research was done, some interesting and valuable feedback and observations were gotten. First, it is an agreed opinion that the use of this framework can provide with quicker and more effective decision making. Likewise, it can provide with more accurate preventive and/or corrective actions. Not only that, but it provides added value by showing factors more explicitly which are not currently really considered. The framework exposes on an organized way the point of view of the different actors giving a capacity to better understand the problem from each different angle. It is because of this, that the companies which collaborated on this empirical research all mentioned they will study on how they could incorporate some or the entire framework to their decision making processes. An important lesson was the observation that the process could be over-analytical and complex to follow correctly. Therefore, the researcher introduces a more-friendly framework which keeps key elements providing added value to the companies. The leaner framework process can be seen in figure 3 below which gives references of where in this thesis report, information on each step can be better found. Nevertheless, the option of using the original extended version of the framework is still open.

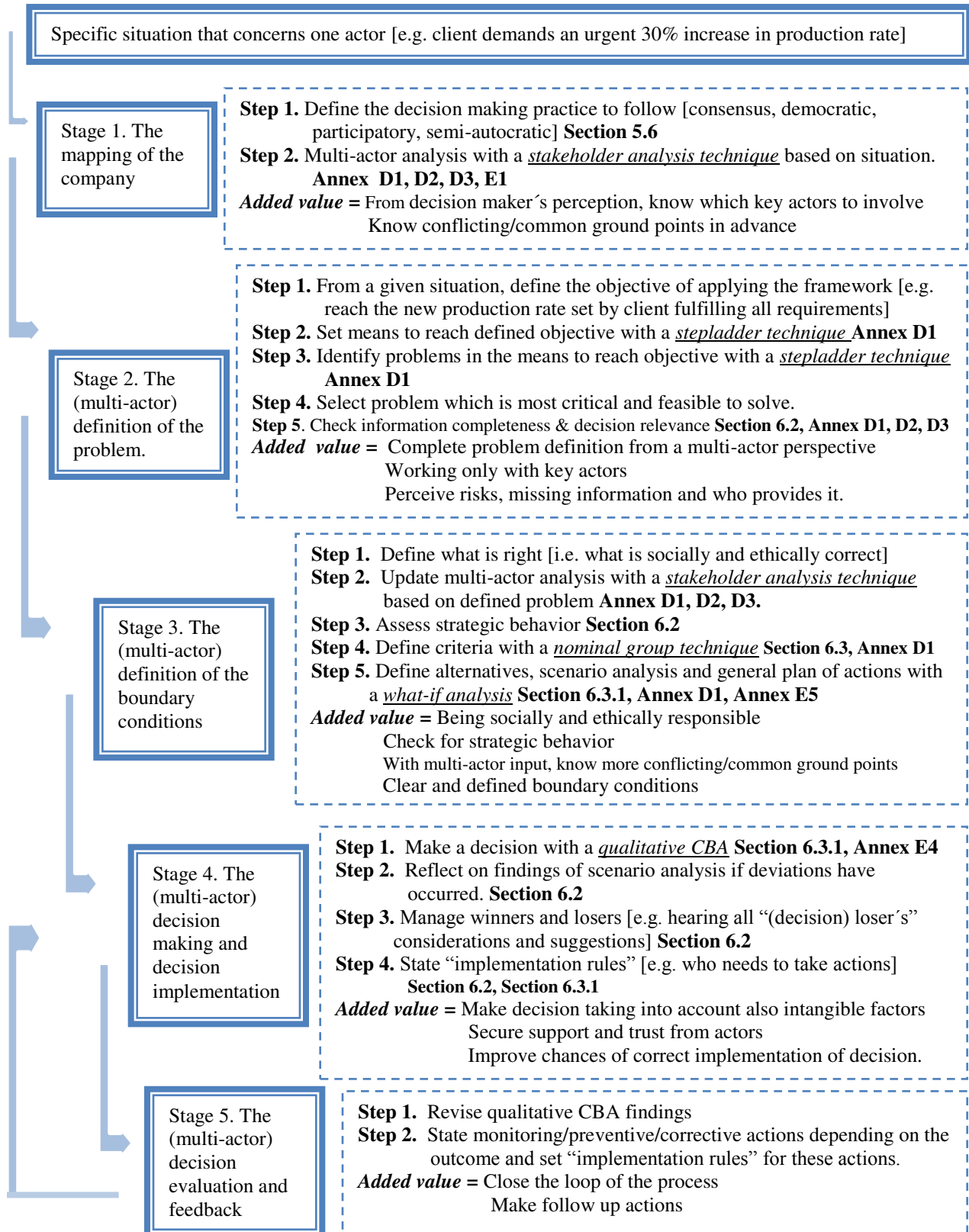


Figure 3. Lean framework process with references

### **7.3. Answer to the main research question**

The main research question introduced back in chapter 2 of this research tackled on knowing how and to what extent a framework could be made to improve decision making in manufacturing activities involving several actors. Before giving an answer to this question, other topics had to be analyzed in order to gain knowledge upon which a framework would be done. Now that the different research sub-questions have been addressed and that these answers have helped develop a framework which has been empirically tested, the main research question can be answered.

To answer the question how a framework can be provided, a leaner version of the original framework has been introduced to facilitate the inclusion of such process in manufacturing companies. This leaner version comes from the feedback and observations of the empirical research which stated that the original framework process could be over-analytical and elaborated. The researcher agreed and tried to come up with a friendlier version which kept the added value and benefits recognized of the original framework, and eliminated those steps which added little or no value. In short, there were no drastic changes yet the ones made look to provide a more attractive and less complex framework process. A framework that improves decision making process is the one that includes a multi-actor analysis approach in its stages and incorporates specific techniques, methods and practices of decision making in order to account and deal with conflicting points of view, potential strategic behavior and unclear implementation mandates.

To answer the second question, to what extent a framework can be provided, the focus shifts towards the role of the decision maker within the process. The decision maker and the “core group” become an integral part of the decision making process as they are responsible for the conduction and later on, the selection of the decision. Therefore, if these have no knowledge or expertise in handling the suggested decision making elements, the results may not be optimal and it could possibly lead to sidelining the framework for known and more trusted procedures. Another element in the role of the decision maker lies into how much influence does he/she has on the outcome and conduction of the process: if it really is following the framework, the steps and the stages, and if it is involving accordingly the “core group”. The extent to which the framework can be provided is influenced also by the decision making practice that is used. For example, using an autocratic or intuitive decision making practice minimizes the strengths and benefits of a multi-actor analysis approach and the main characteristics of the framework. It can be said then, that the extent of the proposed framework is limited to the knowledge, expertise, and management of actors and information that the decision maker has or is willing to offer to the process; the extent also relies to how much trust the decision maker is willing to give to this proposed framework. If these limitations are not present, the framework can offer important positive results as shown in the empirical studies.

### **7.4. Final conclusions, further limitations and research**

The nature of today’s manufacturing activities open the path for new decision making processes that can, first of all, incorporate in a deeper and more valued manner, the points of view of those actors which affect or are affected by the decision outcome. Likewise, that can analyze and solve, under a standardized and organized way, the conflicts that may happen due to conflicting demands across functions among the distinct actors. Third, that can facilitate trade-offs and negotiation aspects that are bound to occur in such decision making processes. Fourth, that can improve reaching efficiently a decision, in time and in support. Lastly, that can ensure that the decision is implemented correctly by attaining sufficient level of support and understanding from the involved actors.

The proposed framework, the multi-actor analysis approach framework for decision making, looks to fill the perceived gaps found in literature and practical experiences of manufacturing activities in companies. The empirical and theoretical analysis offer significant results. First, it shows that the inclusion of the multi-actor field in manufacturing companies is not only needed but desired. Sadly, given that there is not a broad knowledge on this field study, it was seen how different companies do involve different actors in their decision processes but not following a standardized process and more on intuition. Moreover, these companies believe they are efficiently utilizing techniques that maximize the involvement of the different actors even when in reality, this does not hold true. This shows that special attention should be given to enrich the study and application cases in this field as well as to improve the preparation of student and workers on techniques in the multi-actor discipline. Second, it shows that a change in the business activities is present and one would benefit from following a process that regards the new elements of conducting a company: dependency, cooperation, and conflicting demands of several actors. Finally, it gives an answer to the initial assumptions from which this thesis project was born. It shows that manufacturing activities as of today do have a mismatch between their practical needs and in reality what, who and how they include in their decision making processes. It validates the assumption that an introduction of a multi-actor analysis approach can help improve the support and the effectiveness of taking and implementing decisions. It is also shown that manufacturing companies may overlook the importance of multi-actors in their decisions depending on the cultural context and on the maturity level of the company, and even if they do not overlook the importance, plenty of companies do not effectively make use of the multi-actor value, and there is no clear way of involving them in the decision making process: the way varies from one company to another, and this brings different results. Finally, it is seen that a research as this one was in fact, lacking as of today.

The framework has high practical relevance. First, the framework suggests ways that the ISA-95 can play an increased role in the decision making process and how relying on ISA-95 can benefit the reliability and trustworthiness of information that is used. This has an additional benefit of attracting more companies to adopt such standard. Second, the framework is socially and ethically responsible by including a fixed step where the decision maker needs to acknowledge what is ethically and socially correct before looking at further options and steps. Third, the framework suggests a more standardized way to reach a decision; one that involves several actors and acknowledges an environment of dependency and presence of opposite and diverging interests across functions and among actors. This standard way is yet to be available in literature. Fourth, by using the suggested elements of decision making plus the multi-actor approach within the proposed framework, the decision maker can gain insight on the network in the company and on variables that before were left out of scope for the decision making process. Gaining knowledge in these aspects can improve the chances of having the support from actors before and after making a decision, and before and after implementing such decision. Fifth, it is relevant in that it is internationally applicable. In short, the framework provides a guideline for decision makers in manufacturing companies to improve the chances of support and effectiveness of decisions in manufacturing activities.

Likewise, there is a scientific relevance for the use of this framework. Literature is scarce referring to multi-actor studies, and for sure there is a great lacking of practical cases. Moreover, the available literature for this study area is quite inclined towards public policy analysis and not so within the private sector. This framework can indicate a first step in re-introducing the multi-actor field in the private and manufacturing industry sector which can benefit the ones using it since the nature of this sector has shifted to networks and involving several actors. Thus, a scientific relevance exists in the sense that it allows growth in the field of multi-actor study and introduces a new set of elements that help add to the limited amount of literature and empirical study of the field.

As an example, this paper introduces on new ways to value and evaluate options on a qualitative CBA, as well as introducing a new way to evaluate client satisfaction.

The proposed framework is in fact feasible, usable and provides a process that has proved, even on a very small sample, that it improves the process of decision making and improves the results of such decision when compared to the results and process of the same situation using other means. Upon further research and empirical studies, the framework has the potential to be catalogued as a smart practice regarding the relation cost-benefit it can offer. It is simple and cheap to use yet can provide with greater benefits regarding taking decisions that are better studied, better supported and better implemented which may bring better results at the end. Therefore, the expectations of the researcher to provide a framework that is usable, feasible and that improves decision making process are met, at least within the empirical study done.

#### - **General limitations**

The sample of multi-actor techniques is limited mostly to the ones mentioned in this paper. The researcher is aware that other multi-actor and decision making techniques are existent which could comply with the objectives of the proposed framework but their study was not possible considering the time and resource factors this thesis was written in. Even more, the researcher acknowledges that the selection of these techniques may bring criticism; however, it is in the belief of the researcher after studying these techniques that these fit best with the process and objectives of the framework.

There is a limitation in terms of assessing this approach onto practical situations and specifically, onto a manufacturing company process. Little research and literature has been made regarding, for example, which techniques work best under which situations and why. There is no strong evidence in the practical field suggesting that a multi-actor analysis approach will indeed help produce desirable outcomes, and it does not help that the system of study is small. The number of applications of multi-actor techniques and sample of these techniques are limited (van der Lei, 2009).

The framework itself suffered upon translating the theory into empirical studies. Lack of full support from various international companies was present throughout the development of the thesis. This may have been caused by confidentiality issues in not being able or willing to provide information, that collaborating with this thesis was of no importance to them, or that they had other urgent priorities and could not accommodate time and resources to collaborate on this research. Therefore, a limitation of the paperwork is the small amount of empirical study. It would have been optimal having being able to have case studies in more varied locations, especially on another region with different cultural characteristics. Considering the time frame available to conduct this research, the 3 empirical cases bring interesting and solid conclusions about the proposed framework.

#### - **Further research**

Efforts should be placed in training personnel and students in the proposed techniques and into this multi-actor area. The benefits that such framework provides will be able to be seen as more and more decisions are taken with this framework since more actors will know about it and the overall knowledge and experience will improve. With more experience and knowledge on how to manage, conduct, and handle the framework, it will be clearer how the use of this framework beneficiates in minimizing strategic behavior and biases and how it boosts support, collaboration and involvement from the inclusion of several actors. Therefore, patience and trustworthiness in this new process of



the proposed framework is necessary for those who are not familiar with the multi-actor study field or the techniques that are suggested.

This further knowledge and expertise that needs to be had can give the means for the companies, and decision makers, to develop and go through a learning process using this framework in order to later on, adjust it if needed according to their demands and specific situation. People with knowledge in the multi-actor field, in the suggested techniques and in using the proposed framework is needed in order to “maintain” the framework and keep it running. It is logical that if these knowledge and expertise is not obtained, the conduction and making of the proposed framework will suffer and therefore, so its results. Even if the suggested techniques and the framework itself are not complex to use and follow, if there is no one within the company who possesses knowledge on first, the multi-actor field, and second, on the suggested techniques, the extent of the framework use will suffer since it will be probable that the results will not be optimal and this could lead a regression to old decision making processes which do not incorporate the multi-actor values, nor any of the other added values this proposed framework gives to the company and to the decision making. However, given that the benefits and added value of this proposed framework are real, perhaps this will encourage companies to dig in and gain knowledge on these topics important for the proposed framework.

The framework is based on a multi-actor analysis approach which incorporates multi-actor and decision making techniques. However, the amount of practical cases and literature reviews on the applicability of the techniques in different situations is quite limited. Furthermore, it appears to be non-existent the availability of applications and studies of such kind of techniques in manufacturing companies. Most of the studied literature appears to apply for public policy analysis and not in a private manufacturing sector. Therefore, further actions should be done to investigate and apply the multi-actor analysis approach into a higher number of cases and within private manufacturing sectors. It is possible that this research paper can help complement the previous studies and open a new area of interest from which future research and case studies can be conducted in order to promote knowledge wealth regarding a multi-actor analysis approach. Further research should be done in analyzing and evaluating if the framework applies in distinct sectors of the manufacturing industry and if it is usable and feasible in manufacturing companies from different cultural backgrounds. Moreover, there is more to be studied in applying the framework in more practical cases, and using this framework in real cases not only on “ex-post” cases, as was the case in this research. As sections 6.4.4 and 7.2 pointed out, more empirical research also should be done in order to see if a) a quick-scan version of the process can be obtained without hurting its value and reach, and b) the leaner framework does keep all the added value and benefits from the extended version.

Finally, more research and study of this framework should be conducted to ensure that the one does not fall into common deficiencies as being an inappropriate framework or/and an imprecise framework. To prevent these deficiencies, more research and application cases using this framework should be done. This framework is by far not finished; this research was just a first step, a first idea and a first small test, but perhaps it will lead to way to bigger steps.

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## **A1. Basic explanations of the standard**

ISA-95 is quickly becoming the tool for stating requirements between corporate cultures and departments (e.g. production, corporate IT, business analysts, maintenance, procurement, quality, etc.) Each corporate area has its specific terminology and is now able to use ISA-95 to translate between the areas through a common baseline. The ISA-95 definitions and models assist in organizing disparate application requirements into a manufacturing application framework based on developing ISA-95 best practice methods and technical applications.

### **ISA-95 Parts**

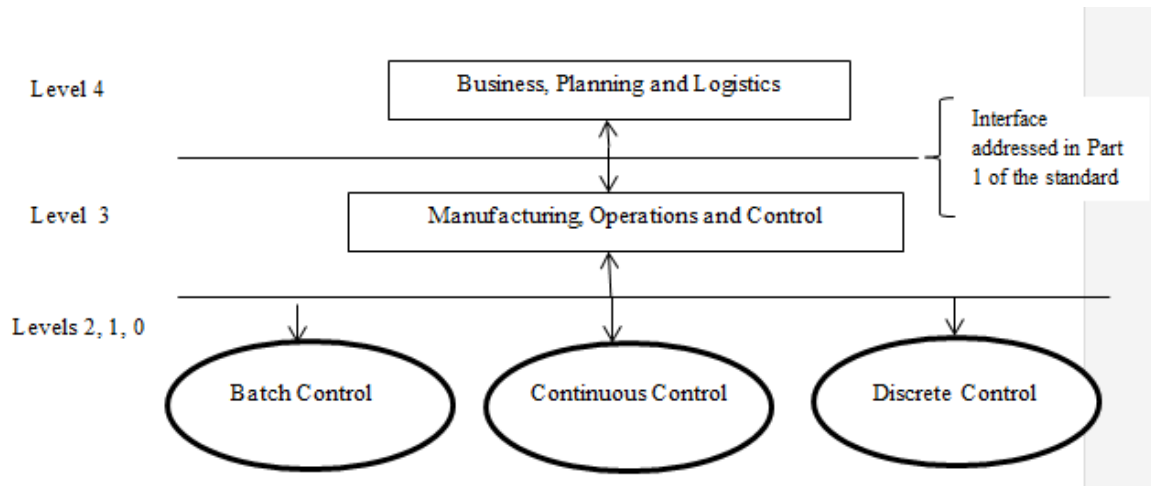
ISA-95 is thought to be composed of 5 parts. However, part 4 is not described in this section since they had not been published at the time of conducting this thesis work.

#### **Part 1: Models and Terminology**

This first part of the standard consists of the standard terminology and object models. The scope is limited to describing the relevant functions in the business and the control domain, which is known as level 4 and level 3 respectively. This set of standard terminologies, concepts and models yearns for the integration of the control systems with the enterprise systems and looks for the improvement of communication between all parties involved. It could be said then, that this first part of the standard is a dictionary of common terms and models so that personnel can use this to document information that is shared between enterprise and manufacturing systems. Which tasks are executed by which function? And which information must be exchanged from where to where? These questions can be answered by using the models and terminology of part 1 of the S95 standard.

The successful integration of enterprise-control systems requires the boundary identification between the enterprise and the manufacturing operations and control domains (MO&C). This is identified using models representing functions, equipment, and information flows within and between the domains. The models are aimed to define the functions and integration of enterprise and control systems. Multiple models are used to explain these integration elements. The different models all focus on a specific aspect of the integration requirements.

One of the models used in the standard is the *hierarchy model*. This gives a clear picture of where in a specific company, in which department and by which system specific activities take place. Figure 2 illustrates one type of this model that includes the interface that is addressed in this 1<sup>st</sup> part of the standard and the different levels.



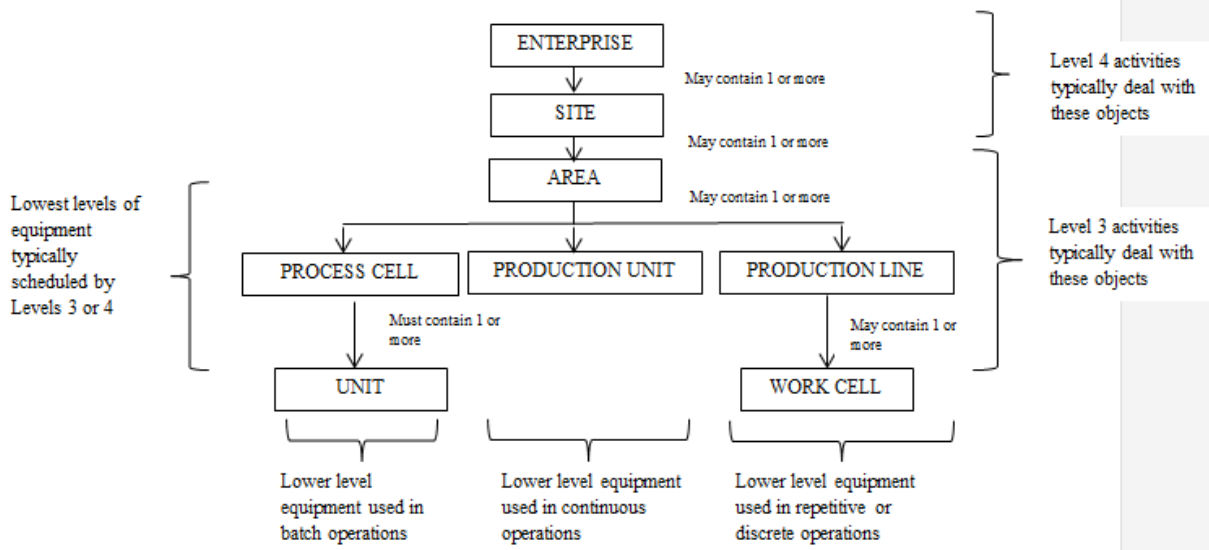
**Figure 4. Functional hierarchy**  
 Taken from (ANSI/ISA-95.00.01-2000)

As figure 2 shows, the interface addressed in this standard is between levels 4 and 3 of the hierarchy model. This is generally the interface of plan production scheduling with operation management and plant floor coordination. On a side note, levels 2, 1, and 0 (on the lower part of the model) are the supervision, operation and process control functions. Level 4 activities include plant production scheduling, operational management, capacity planning, etc. Level 3 activities refer to production dispatch, detailed production scheduling, reliability assurance, local cost optimizations, etc. Level 3 activities also include the resource management associated with control and manufacturing. These resources include machines, tools, material skills, documents and other entities that must be available for work to start and to be completed.

To be more precise and referring to figure 2, a clearer definition regarding the different levels is needed. Level 0 refers to the actual physical process. Level 1 defines the functions involved in sensing and manipulating the physical process described in Level 0 and operates on time frames of seconds. Level 2 defines the functions that are involved in monitoring and controlling this same physical process, operating on time frames ranging from hours to seconds. Thus, level 0, 1, and 2 are the levels of process control. On a higher level, level 3 defines the functions involved in managing the work flows to produce the desired end products and level 4 the functions involved in the business-related activities needed to manage a manufacturing company. Level 3 typically has a time frame of days, shifts, hours and faster, while level 4 operates on time frames of months, weeks and days.

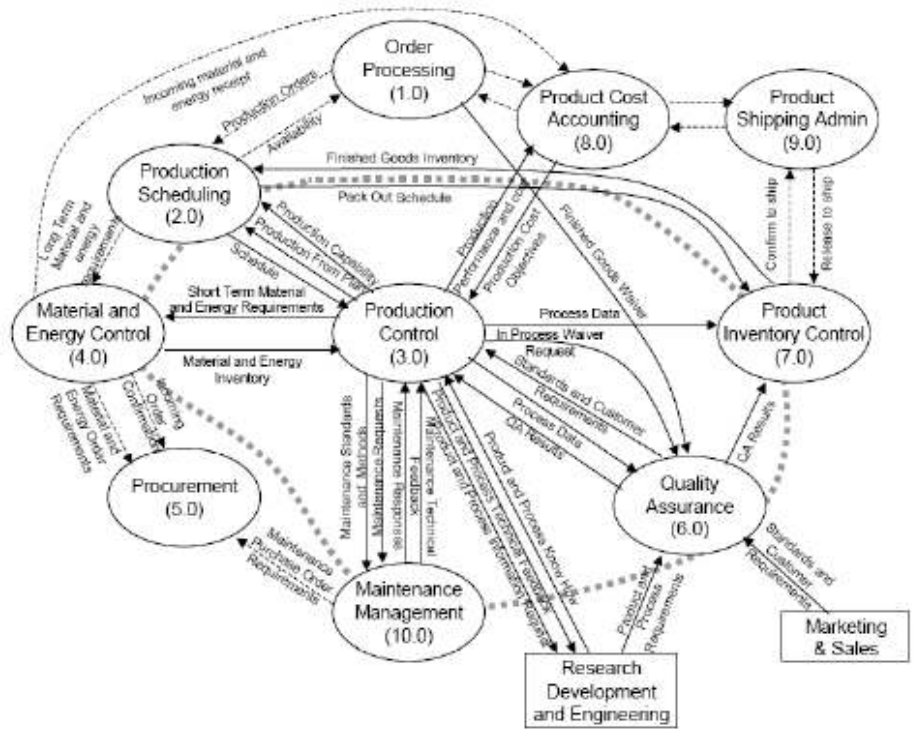
A different type of the hierarchical model includes the definition and hierarchical organization of assets and defines the areas of responsibility for the different function levels. This is presented in the *equipment hierarchical model* shown in figure 3. To summarize, hierarchical models can be seen through two lenses: through a functional model and through an equipment one.





**Figure 5. Equipment hierarchy**  
 Taken from (ANSI/ISA-95.00.01-2000)

A second model used in this first part of the standard is the *functional data flow model*. This model presents the functions of an enterprise involved with manufacturing as well as the information flows between the functions that cross the enterprise interface. Different companies may accommodate the functions in different groups. Figure 4 shows the functional enterprise-control model.



**Figure 6. Functional enterprise-control model**  
 Taken from (ANSI/ISA-95.00.01-2000)

The wide dotted line illustrates the boundary of the enterprise-control interface. The functions will be discussed with more insight in the section 3.2.2. It is of importance to highlight the relationship its function has with each other. It is of importance given the dependency on functions and/or information flows each function has towards others. This model, then, can be used to define which functions are executed within the company, at which department, and which system is responsible for the execution of this function. Compared to the hierarchical model, the functional model focuses on functions, without taking into account the different levels within the enterprise. By combining the hierarchical and functional model, a complete view of the company can be obtained.

Finally, diverse types of models fall under a category that the standard refers to as *Object models*. These object models pretend to clarify and define common terminology concerning the overlapping information within the following 3 main areas:

- a) Information about the capability to produce a product. This is the information on production capability or, in other words, what is available. Explained in another way, is the collection of information about all resources for production for selected times.
- b) Information required to produce a product, expressed as Product Definition Information. It is the shared information between production rules, bill of materials and bill of resources. This information is made available to other level 3 and level 2 functions as required.
- c) Information about actual production of the product including information on what to make and results from the production. Examples of this information are production parameters. A production parameter is information contained in the level 4 ERP that is required by other levels and operation systems for correct production. Examples of production parameters are: quality limits, set points, targets, customer requirements, transportation information and final disposition of the end product.

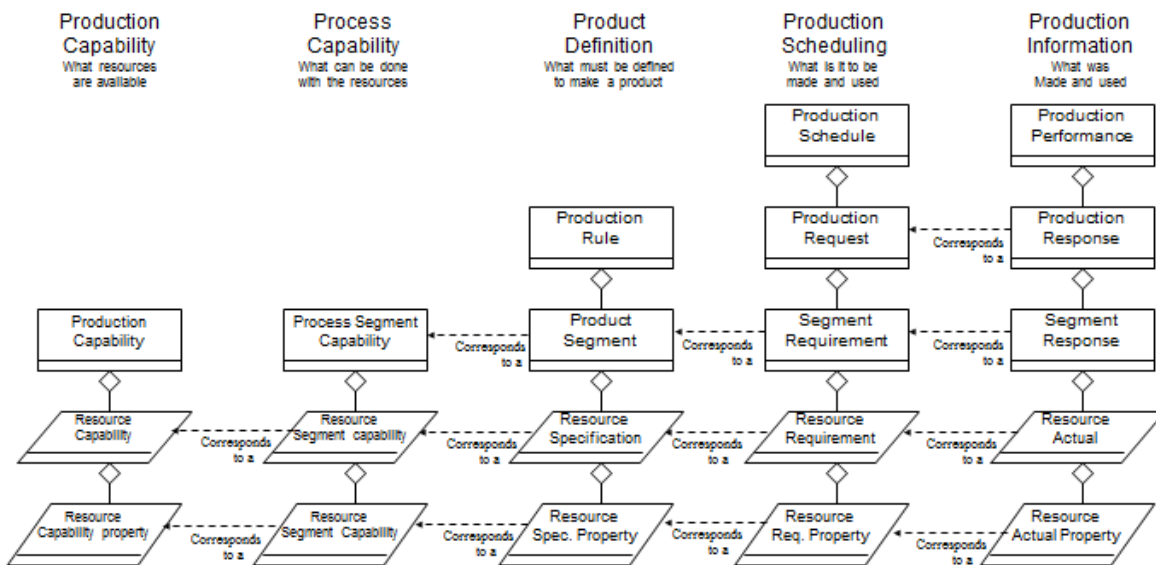
It is necessary to be able to show clearly in the object models, the main characteristics of the relationships of the functions involved in a plant management and control system. These include answering questions as:

- 1) which of the functions are dependent upon others for instructions in carrying out assigned tasks,
- 2) which of them have the major function of supplying information for other functions to carry out the other's assigned tasks, and
- 3) how does the data flow, where does this data originate from and where does the resulting information have its ultimate use.

It is of utmost importance that these models contain semantics, of the various terms used, that can be interpreted by all readers in the same way. It is also important that these models are generic and can be used in any industry. The object models that are expressed in the standard are:

- a) Personnel, Equipment and Material model, containing information about specific, classes and qualifications of personnel, equipment and materials respectively.
- b) Production capability model, which illustrates the collection of personnel, equipment, material and process segment capabilities for a period of time.
- c) Process segment model, which defines the needed classes of personnel, equipment and material.
- d) Product definition model, which shows the information shared between production rules, bill of materials and bill of resources.
- e) Production schedule model, and
- f) Production performance model.

All of the previous models inter-relate. The production information defines what was made and what was used. Its elements correspond to information in other models and functions, such as production scheduling, which defined previously what to make and what to use. Likewise, the elements in the production scheduling correspond to information that the product definition gives, such as the specifications to make a product. This product definition, then, relates to the information in the process segment definitions that define what can be done with which production resources. These inter-relationships can be simplified and better seen in figure 5.



**Figure 7. Object model inter-relations**  
 Taken from (ANSI/ISA-95.00.01-2000)

To conclude, this first part of the standard is an excellent method to determine which information must be exchanged between enterprise systems and production control systems. The object models of part 1 are the basis for part 2 of the standard, which defines the attributes for the objects defined in part 1. These functional and object models are a good starting point for making the adequate starting point analysis of a company's specific process flows. ISA-95 is intended to help communicate data elements and requirements.

## Part 2: Object Model Attributes

The second part of the standard further defines the object models described in Part 1 by adding attribute definitions and specifying criteria that should be taken into account when assessing the completeness, compliance and conformance of the different object models. Therefore, its goals are that the models emphasize good integration practices between control and enterprise systems (i.e. level 3 and level 4) and provide a standard terminology that will improve communication between all parties involved. Part 2 is limited to the definition of the attributes for the Part 1 object models. Attributes are defined as the minimum set of industry-independent information. Some examples of attributes are:

- a) ID,
- b) Description,
- c) Location,
- d) Element type,

- e) Quantity,
- f) Value,
- g) Start and end time.

These attributes are added to the information of object models. So the attributes needed vary from model to model. For example, for a maintenance work order (depicted under the equipment model), attributes such as “planned start and finish” and “responsible person” are needed whereas these attributes are not needed for personnel capability or for material definition.

The object models of 4 resource schemas (Personnel, Material, Equipment, and Process Segment) are used to construct the 4 Information Category Schemas (Product Definition, Capability, Schedule, and Production Performance), which can be seen in figure 6.



**Figure 8. Categories of Information Exchange**  
*Taken from (ANSI/ISA-95.00.03-2005)*

The derived Product Definition and Production Schedule object models use scheduling, dispatching and execution applications to “translate” Level 4 business process information into a form required for Level 2 and Level 3 applications. On the other hand, the derived Production Performance and Capability object models allocate real-time data in data collection applications so that analytics, tracking, reporting and Level 3-4 interface applications are easily able to aggregate Level 2 and Level 3 applications into a form required for Level 4 applications.

With these object models and attributes, all the information flows defined by the functional model (figure 4) can be built. Therefore, the objects and attributes defined in these first 2 parts of the standard can be used for information exchange between different systems and also as a basis for relational databases.

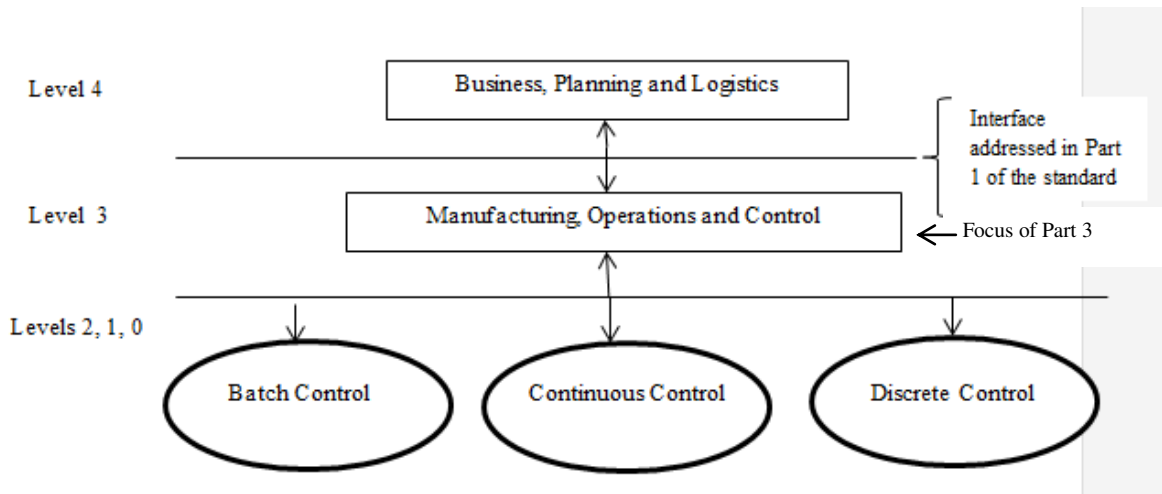
### **Part 3: Activity Models of Manufacturing Operations Management**

The third part of the standard focuses on functions and activities occurring at level 3. It provides guidelines for describing the level 3 of different sites in a standardized way. A site is defined as a physical, geographical or logical grouping determined by the enterprise. The latter is the highest

physical level of a company and is responsible for determining what products will be manufactured, how and where.

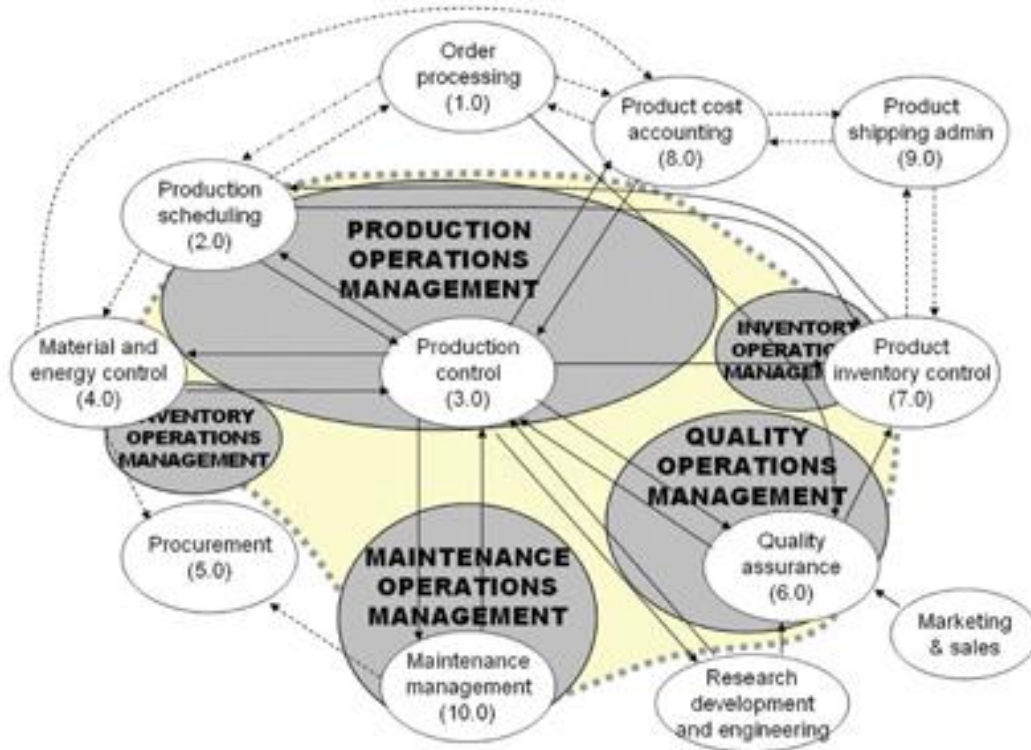
Part 3 shows activity models and data flows for manufacturing information to help enterprise-control system integration. The careful reader will remember Part 1 of this standard focused on the interface between levels 4 and 3, but the activities in Part 3 operate between Level 4 logistics and planning functions and level 2 manual and automated process control functions. Figure 7 below, shows this.

The activities modeled in this part 3 of the standard can be better visualized in figure 8 and they are referred as manufacturing operation management (MOM) activities. These set of activities refer to those that coordinate the personnel, equipment, material and energy in the production process. Thus, MOM activities are derived from resource schemas and are subdivided into four categories: production operations management, maintenance operations management, quality operations management, and inventory operations management.



**Figure 9. Functional hierarchy revisited including part 3 focus**  
*Adapted from (ANSI/ISA-95.00.03-2005)*

It is also important to highlight that within each category, information flow is not always exchanged between levels (e.g. between level 4 and 3) but also within the same level. For example, within the subcategory of maintenance operations management, maintenance requests and maintenance responses may be exchanged individually and are often generated internally within manufacturing operations.



**Figure 10. Manufacturing operations management model**  
*Taken from (ANSI/ISA-95.00.03-2005)*

Moreover, an important point to remember is that there is no single definition of MOM, since the determination of what activities are covered and where the overall system must integrate (e.g. with business level) is different for every company. The models defined in this standard only define a systematic way to approach the problem and define solutions.

#### **Part 4: Object models and attributes for Manufacturing Operations Management**

At the time of this report realization, this part 4 of ISA-95 was yet in development. This part will define object models that determine which information is exchanged between activities defined in Part 3.

#### **Part 5: Business to Manufacturing Transactions**

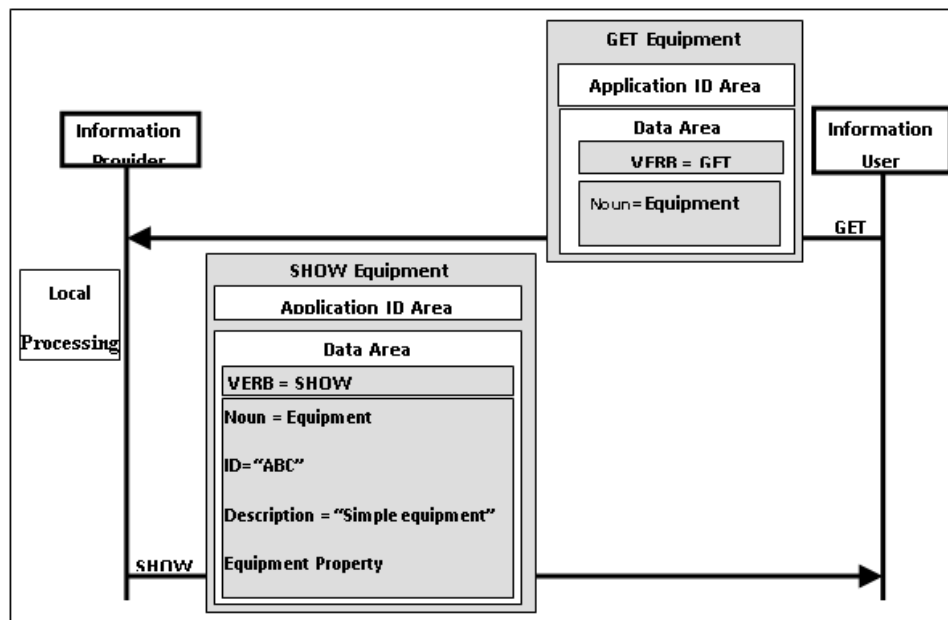
Part 5 of ISA-95 standard defines the transactions to support the interface of business and manufacturing activities, that is, between level 4 and level 3 activities. ISA-95 Part 5 defines transactions as information exchanges between applications that realize business and manufacturing activities. These exchanges have the goal to enable information collection, retrieval, transfer and storage in support of enterprise-control system integration.

Three different transaction models are defined in part 5:

1. A publish model, where the owner of data publishes it to users of the data. This model is used for data synchronization.

2. A pull model, where a user of data requests the data from a provider of data. This model is used for transaction processing.
3. A push model, where a provider of data requests an action (processing, changing, or cancelling) on the data by another user. This model is used for reporting.

This transaction shall contain both a noun and a verb, as its intention is to have an action taken based on information within the message. Furthermore, every message shall not only contain the action to be done, but also present the information required to identify the source of the message and the type of message. Figure 9 illustrates a typical exchange data set. The nouns, where the information of the message is shown, represent one or more objects from the object models defined in Parts 1 and 2 of this standard. Thus, the nouns employed describe the following object models: personnel model, equipment model, maintenance model, material model, process segment model, production capability model, product definition model, production schedule model and production performance model.



**Figure 11. Typical exchanged message in a transaction**  
*Taken from (ANSI/ISA-95.00.05-2007)*

The messages deal with both the scheduling manufacturing tasks and those actually performed. The transaction models are intended to provide visual tools for explaining information flows and functional coordination between the business and manufacturing processes.

## A2. Functions

The activities of MOM are those which coordinate the personnel, equipment, material, and energy in the conversion of raw materials and/or parts into products. In other words, MOM tasks are those responsible to coordinate resources in manufacturing processes. The MOM activities correspond to the activity set defined in the Part 1 of the ISA 95 standard under the functional model (i.e. see Figure 4). It defines 10 functions in an enterprise-control model and two additional functions:

1. *Order processing*, including customer order handling and acceptance, sales forecasting, and determination of production orders. There is generally no direct interface between the functions of order processing and the manufacturing control functions. Recall the wide dotted line in figure 4.
2. *Production scheduling*. Production scheduling functions interface to the manufacturing control system functions through a production schedule, actual production information, and production capability information.
3. *Production control*, including process support engineering, operation control, and short-term operations scheduling. The production control functions encompass most of the functions associated with manufacturing control.
4. *Material and energy control*, including managing inventories, transfers, and quality of material and energy. The functions of material and energy control generate or modify information such as material and energy requests for use in other control functions.
5. *Procurement*, including placing orders with suppliers, and monitoring progress of purchases. The functions of procurement generate or modify information such as expected material delivery schedules for use in other control functions.
6. *Quality assurance*, including testing and classification of materials, setting standards for material quality, and releasing material for further use. The functions of quality assurance generate or modify information such as applicable standards and customer requirements for material quality, and quality assurance test results for use in other control functions.
7. *Product inventory control*, including managing product inventory control, reporting on inventory to production's scheduling and reporting on balance and losses to product cost accounting. The functions of product inventory control generate or modify information such as finished goods inventory, inventory balances and requirements for use in other control functions.
8. *Product cost accounting*, including setting cost objectives for production, and calculating and reporting on total production cost. The functions of cost accounting generate or modify information such as cost objectives to production for use in other control functions.
9. *Product shipping administration*, including organizing transport for product shipment, negotiating and placing orders with transport companies, and confirming shipment and releasing for invoicing to general accounting.
10. *Maintenance management*, including providing maintenance for existing installations, and preventive maintenance program.

The two additional functions are:

- *Research, development, and engineering*
- *Marketing and sales*

It is important and interesting to observe how information of one function can directly impact other functions according to the information they modify or generate within their own activities. This can be seen in some of the functions as for example, material and energy control, quality assurance, and product inventory control. This aspect highlights, again, the interdependent and cooperative nature of multiple actors (e.g. departments) within a company.



## **B1. Accenture Belo Horizonte. Mr. Constantino Seixas**

An interview was conducted with Mr. Constantino Seixas, working in Accenture Belo Horizonte, in Brazil. Mr. Seixas is responsible of the delivery of the Belo Horizonte delivery center. He is focused on the technical aspects of delivery of automation. Mr. Seixas and his group are greatly experienced with MES and ISA-95 topics, having themselves created a MES framework and are pioneers in this kind of development.

Accenture is a global management consulting, technology services and outsourcing company, with more than 249,000 people serving clients in more than 120 countries. Combining unparalleled experience, comprehensive capabilities across all industries and business functions, and extensive research on the world's most successful companies, Accenture collaborates with clients to help them become high-performance businesses and governments. Its home page is [www.accenture.com](http://www.accenture.com). The specialties in Accenture include Management Consulting, Systems Integration and Technology, Business Process Outsourcing, Application and Infrastructure Outsourcing.

The purpose of conducting this interview was to gain practical insight of decision making practices and ISA-95 guidelines in order to complement the literature study previously done. Also, to know more about their perception on strengths and limitations of the standard that could have been overlooked in literature study.

The main findings of this interview include:

- The important experience of Mr. Seixas and his group with MES systems.
- Identification of the following as strengths of ISA-95 standard:

Being able to group different functionalities into a general vision which includes 4 pillars: production, maintenance, quality and inventory

Having a degree of freedom, not only to make a configuration, but also to bring new functionalities.

Being able to adapt these functionalities into a specific process.

Being able to evaluate different MES systems with ISA-95 procedures.

- Considering ISA-95 as a very good guideline, good tool for analysis and an important reference for the market.
- Identification of the following as limitations of ISA-95 standard:

Incompleteness. There is a need to extend ISA-95 in different directions. Yet, it is impossible to have a complete configuration.

Stating that the committee should continue the development of ISA-95 to try to accommodate the lack of real cases that are present in the market.

That ISA-95 does not consider all the documents, all the ideas that are present in the market.

That ISA-95 is not so complete on perspectives such as downtime management, or on KPI management.

That ISA-95 does not acknowledge anything regarding decision making.

- Acknowledging the inevitable presence of several perspectives on data that is produced by MES.
- Accepting that different actors have different perspectives of the same business. Supporting the take that actors are present with different objectives.
- That there is the presence of bottlenecks produced by these competing points of views.

- Expressing the need and inclination towards governance rules to solve conflict situations.
- Expressing the importance to have facts inside decision rooms. However, most of companies don't use decision making tools but decide by feeling according to him. Furthermore, decision making should be based on facts, but today it is not only on that but also on interests.

## **B2. Accenture Netherlands. Ms. Bianca Scholten**

Two interviews were set with Ms. Bianca Scholten. Ms. Scholten is a principal consultant, has worked as a trainer for several hundreds of persons in applying standards such as ISA-95. She has written over 100 articles and published 2 books, one of which is about ISA-95 and the other about manufacturing execution systems. Additionally, she has been working as a manufacturing execution consultant over the past 8 years

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The purpose of conducting these interviews was to gain practical insight of ISA-95 guidelines in order to complement the literature study previously done. Also, to know more about their perception on strengths and limitations of the standard that could have been overlooked in literature study. This is to know more about limitations and strengths than the interviewee considers most prominent when companies choose to follow this standard. Moreover, to get to know areas of improvement when implementing the ISA-95 standard in manufacturing companies.

The main findings of the first interviews include:

- The important background and experience of Ms. Scholten with knowledge and implementation of ISA-95 and MES systems.
- How Ms. Scholten helped the researcher realize that the first approach on the standard was not the right one, as the approach back then on the thesis was in the sense of putting emphasis on the standard influencing decision making, but as Ms. Scholten pointed out, it is the system (e.g. MES) that is implemented based on ISA-95, and this system is the one influencing decision making in the manufacturing process. Decisions based on ISA-95 are mainly decisions regarding the manufacturing needs, the selection of interfaces; finding a balance between the real world and the abstract standard.
- That the main difference after an implementation using the ISA-95 standard is that the different actors can understand what needs to be done. Furthermore, the fact that after implementation they have MES and other shop-floor systems integrated with each other.
- Stating that nowadays, companies turn to ISA-95 as a common practice and not so much as a conscious decision.
- Identification of the following as strengths of ISA-95 standard:

Using the ISA-95 as an analysis tool.

Being able to define user requirements.

Being able to define scope of projects.  
Being able to compare functionality of different system providers.  
Having a better internal communication with colleagues about projects.  
Connecting MES to ERP based on standardized interfaces  
Facilitate the developing of MES templates.

- Identification of the following as limitations of ISA-95 standard:

That the standard is abstract, so it does not provide explanation about how to apply it.

To clarify certain aspects of this first interview and to gain more insight from an experienced and valuable interviewee as Ms. Scholten is, a second interview was made. The main findings from this second interview are:

- That an important benefit from using a MES system is with providing with immediate information.
- Clarifying that the way that MES supports decision making is about the ability of taking decision in real time.
- Providing information of the exact status of a production line is an example on how MES supports the cooperation between different actors and functions within a company. With this, different actors with different functions can know about issues, quality mistakes, in order to take immediate actions.
- Expressing how the same way it is wanted that different departments work together, it is also desired that different systems do, for which ISA-95 supports this desire.
- How all the interfaces between MES, ERP and other systems re-help improving communication between all actors.
- Stating that these systems also provide more efficient and less risk taking procedures.
- Highlighting that there is not just one way of decision making in companies. It depends on the culture, on the type of decision and on the maturity of the company.
- Sharing the fact that companies implementing new MES and ERP systems will see more improvements than those just replacing the old system for a new one, basically because the former represents a cultural change of working.
- Those important additional limitations of the standard are that not everything is in the scope, it does not solve everything and if you have to get another standard as well to solve your whole problem then it becomes very complex. This has the effect that it becomes an attractive idea just to find an easy solution and go away from the standard.
- Showing that 2 types of actor types can be found talking about MES and ISA-95 depending on the scope. One is when dealing in regular operations. The second involves when implementing the system and it involves other actors as well as not being not in a process anymore but in a project. For both types, MES and ISA-95 can help improve communication.
- Accepting that a framework that could complement MES and ERP systems and ISA-95 standard's information for reaching better decisions involving several actors and competing demands could be useful. It could be useful since ISA-95 does not really focus on departments or actors on that matter. Furthermore, it could be interesting to see for example, who are the stakeholders in a quality process to take decisions.

### **B3. DSM Netherlands. Mr. Alex van Delft**

Two interviews were made with Mr. Alex van Delft. The first interview had the purpose of filling knowledge gaps and complementing literature study in topics such as ISA-95, control systems and decision making. The second interview provided key information to put in practice the proposed

framework; that is, it involved the practical case mentioned in chapter 6. Mr. van Delft has over 20 years of working experience and works at the Corporate Operations Department and is responsible for the Process Control and Operations Improvements.

Royal DSM N.V. is a global science-based company active in health, nutrition and materials. DSM delivers innovative solutions that improve performance in global markets such as food and dietary supplements, personal care, feed, pharmaceuticals, medical devices, automotive, paints, electrical and electronics, life protection, alternative energy and bio-based materials. DSM's 22,000 employees deliver annual net sales of around €9 billion. The company is listed on NYSE Euronext. DSM's specialties include life sciences, material sciences, innovation and sustainability.

The main findings from the first interview include:

- The important experience of Mr. van Delft regarding MES systems and knowledge in ISA-95.
- The highlight of incompleteness of the standard in the shop-floor as a weakness, which was not mentioned before in other interviews.
- On the other hand, the relevance of closing the loop as a strength as well as the benefits the implementation of such standard and MES functionalities has brought to his company. An interesting factor was pointing out the innovation as an element of improvement.
- That within his company, decision making considers several actors and functions across the company. Moreover, decisions are not done unilaterally yet it respects a hierarchical structure.
- That improvement of the MES functionality and framework, thus, improvement on the ISA-95 standard is needed in order to improve in allowing more accurate information to be given for decision making.

The information from the second interview can be found under section 6.3.2 and on Annex D. This information is basically the one that is used during the different stages of the proposed framework.

#### **B4. Schott AG. Mr. Arturo Armendáriz**

An interview with Mr. Arturo Armendáriz took place at the end of May. Mr. Armendáriz works as a Project Engineer at Corporate Machinery and Technology, Technical Production Management from Schott AG in Mainz, Germany. Among his responsibilities and functions, he feeds information to a control system and gathers reports from it. He uses this system to manage inventory levels, production requirements, production steps, yields and KPI reports generation.

Schott is a German multinational, technology based group developing and manufacturing special glass, specialty materials, components and systems for more than 125 years to improve how people live and work. Schott is specialized in glass manufacturing.

The purpose of this interview was to know how decisions are taken in his company and know about specific examples of conflict situations. Additionally, to get input on how the interviewee thinks these decision making practices might be improved and the conflict situations better resolved.

The main findings of this interview include:

- The quick acknowledgement of the benefits of using a MES system, such as visibility throughout the manufacturing process, easy gathering of information, and report generation.
- That the reasons for such utilization are clear: managing inventory levels, production requirements, production steps, yields and KPI reports generation.
- That aside from the advantages of implementing such a system, a MES was needed due to ISO requirements. Thus, the criteria to implement such a system that was accounted for was reliability in information.
- Identification of the following as limitations of the MES system:

No actual way of insuring that the information entered is real. The results are not actually seen but after some time; this can lead to increased cost and production mistakes. Furthermore, training on SAP and mastering its results can be expensive.

- Stating how the usage of MES can help decision making by providing with trustworthy information. However, decisions should not only rely on MES information.
- That a multi-actor perspective is acknowledged in decision making practices by Schott AG, however there is still the risk of subjectivity and strategic behavior. As Mr. Armendáriz points out, values and interests should also be integrated in the decision making.
- That decision making could be improved with better knowledge of techniques and a standard process.

## **B5. Grupo Antolin. Mr. Evaristo Uresti**

Mr. Evaristo Uresti works as a Process Engineer where he is responsible of among others, revising costs and feasibility of new projects. Previously, he had the responsibilities of managing a control system in the areas of Production, Engineering and Materials. Using this experience, an interview was made with Mr. Uresti.

Grupo Antolin is a Spanish leading global supplier of components for vehicle interiors which offers the conception, design, development, manufacture and distribution of overhead systems, doors and seats. This Spanish multinational operates in 25 countries with 96 plants and 22 technical-commercial offices.

The purpose of this interview was to know how decisions are taken in his company and know about specific examples of conflict situations. Additionally, to get input on how the interviewee thinks these decision making practices might be improved and the conflict situations better resolved.

The main findings from this interview include:

- The quick acknowledgement of the benefits of using a MES system, such as having an easier control of the plant. Also, that the utilization of such system involves and concerns different actors.
- That this system has a great influence in decision making as the decision makers base entirely on the information that the system provides. Therefore, these systems are the basis to make an informed decision on most issues at the plant.
- That the main limitation of such system is the human factor.
- Acknowledging the presence of situations of conflict between actors, offering a good example of this. As a conclusion of this example, for Mr. Uresti, the way the decision was made was the correct one. Although he mentions that an improvement can be made by involving more actors.

- Explaining how decisions are taking following the hierarchical structure of the company yet not clarifying how these decisions are taken or how the decisions are made; only mentioning that meetings are held with the involved actors.
- Stating that the most common problem situations can be classified as being generic but unique to the situation.
- Stating that the main reasons to take decisions are to overcome conflicts and choose between options
- That the difficulty of solving situations of conflicts between different actors depend on how upper management can come to an agreement themselves on the solution. This suggests a more autocratic and hierarchical decision making practice.

## **B6. MEEIN. Mr. Alejandro Treviño**

A couple of interviews were first made with Mr. Treviño to gain insight into information that could complement the literature review already done of topics regarding decision making and enterprise and control systems. Afterwards, several rounds of interviews were made to put into practice the proposed framework. Just as with DSM, a practical case was used following the proposed framework. Mr. Treviño is a Project Manager, responsible for approving and overseeing the different projects that his company does. Amongst his responsibilities and functions, delivering quotations and budgets for the proposed projects is one of them in order to accept or decline certain projects. Following terminology of ISA-95, Mr. Treviño is situated at level 4 of the company.

MEEIN is a Mexican company focusing on automation projects for the different industries in their area. Their first market is the automotive industry since it is the one most present and most important. MEEIN offers different kinds of automation solutions depending on the specifications that the client asks. These solutions are the design, manufacture and integration of automated machines.

The main findings from the first interviews as to complement literature study include:

- As an ERP user, pointing out the main reasons and benefits of implementing this system: having more order in processes and products, and having the whole control and view on the projects and company.
- Pointing out that the system is more focused on manufacturing and also on some point of administration like project costs.
- How the output of this system influence decision making is important. By having the correct information on the correct time, most of the times, a quickly and correct decision will be made.
- That training of the personnel managing the system is of utmost importance to have reliable information. Therefore, a limitation on the system can be the human factor.
- That the way the system supports cooperation among different actors is by helping them see what they need to do and which kind of information they need to provide or receive.
- Acknowledging the presence of situations of conflict between actors, offering good and relevant examples of this.
- Pointing out that there exist individual objectives but also a general company objective which should be matched. Actors should not lose the focus on the overall objective.
- Stating that there is room for improvement to manage conflicting situations.
- Highlighting that in order to have better decision-making, the involvement and analysis of actors is important. Currently, they try to involve actors not directly involved in the

situation to decide on the right action. Additionally, having the incomplete or incorrect information and also on the wrong time, damages taking a good decision.

- Pointing out a preference towards a hierarchical structure on decision making.
- That the most common types of decision are to choose among options and assess future options.
- Stating that the most common problem situations can be classified as being generic but unique to the situation.
- Accepting the un-familiarity with a multi-actor study field. After explanation, stating that this approach could have a very important positive impact on decision making. By better knowing each actor that is involved in the decision-making, better decisions should be taken.
- Pointing out the need of a decision making process that is fairly rapid and cost-effective. A lot of times, to save on time or costs, decision makers can have a univocal saying. But the problem is that then the issues are shown afterwards in the process when it is failing.
- Normal decision making procedures that make use at some level of different actors can take up to 1 week, depending on the complexity of the process. This would be more or less of, 360 minutes because they employ 1 hour meetings to discuss on the problematic situations.
- The time that was used to come up with a decision using the framework is quicker in Mr. Treviño's eyes. He points out that of course he has not a real reference because the process was made not constantly, often having to cut and reschedule meetings to attend other issues in the plant. However, it is his feeling that if the framework process would have been followed with the sense of urgency as it should have, the time would have been much less.

## **B7. MEEIN. Mr. Miguel Angel Reina.**

Additional interviews were made with personnel from different levels of this company to have a better scope and knowledge in their perceptions of topics of decision making and conflicts that could be present in different levels. These set of interviews with different personnel across different levels of the company allowed the researcher to see if indeed there was a match in the perception and knowledge of conflicting situations that occurred within the manufacturing activities.

Mr. Reina works as a mechanical designer, which is at level 3 following the terminology employed in ISA-95. Within his functions, he creates the 3D concept of the projects and afterwards fabricates the drawings.

The main findings from the interview with Mr. Reina are that:

- Within his functions, Mr. Reina has direct involvement with various other departments and also with the customers. It is due to this, that conflicting situations do occur.
- He acknowledges that decisions are tried to be reached between the affected actors but not following any procedures and even not based on facts but more on the perception and on helping each other out.
- The designer (i.e. the higher authority in this case) should have the responsibility and final say on the decision. But the other actors should be involved.
- Mr. Reina is not familiarized with a multi-actor analysis approach. Yet he states that it would facilitate and improve decision making. It helps if all actors are following the same path.

- Decisions are influenced by the information that is given to and given from enterprise and control systems.

## **B8. MEEIN. Mr. Rafael Lara.**

Additional interviews were made with personnel from different levels of this company to have a better scope and knowledge in their perceptions of topics of decision making and conflicts that could be present in different levels. These set of interviews with different personnel across different levels of the company allowed the researcher to see if indeed there was a match in the perception and knowledge of conflicting situations that occurred within the manufacturing activities.

Mr. Lara works as a mechanic, which is at level 2 following the terminology employed in ISA-95. Within his functions, he is involved in the assembly and machining of different machine fabrication projects.

The main findings from the interview with Mr. Lara are that:

- Within his functions, Mr. Lara has direct involvement with various other departments. It is due to this, that conflicting situations do occur. He provides a nice example of this.
- He acknowledges that decisions are tried to be reached between the affected actors but not following any procedures and even not based on facts but more on the perception and on helping each other out. There are cases that after decisions have been made, risk towards the worker, the material and the machine is present. This suggests that not the most acceptable decision was taken and certainly they did not consider what is right.
- Depending on the nature of the problem, decisions can be made on shop-floor, univocally and quickly or the inclusion of a higher authority needs to be done.
- The perception towards decision-making can be of the nature “if you help me, I help you” in order to reach agreements.
- To improve decision-making, Mr. Lara point out that capacitation and experience of the people is important.
- The morale from Mr. Lara is good when involved in the decision making process. Likewise, he feels that the opinion of his department and his are really heard in upper levels when making decisions. He states that they ask for their input in order to come with decisions. However, this implies not a standard process and not an active involvement of this actor.
- Mr. Lara sees a correlation occurring between successful decisions and the involvement of different actors.

## **B9. Radiall. Mr. Francisco Yepis**

Interviews were made with Mr. Yepis from Radiall. Mr. Yepis is a plant manager for this company. As with DSM and Mecatrónica e Integración, interviews were set with Mr. Yepis to put the proposed framework into practice using a case situation from Radiall.

Radiall is an international and global manufacturer of interconnect components including RF coaxial connectors and cable assemblies, antennas, fiber optic and microwave components and multi-pin connectors. Radiall serves the Aerospace, Automotive, Defense, Industrial, Medical, Space, and Telecommunication industries.



The purpose of this interview was to know how decisions are taken in his company and know about specific examples of conflict situations. Additionally, to get input on how the interviewee thinks these decision making practices might be improved and the conflict situations better resolved. Furthermore, to get information in order to make an empirical study of the proposed framework.

The main findings upon the input by Mr. Yepis include:

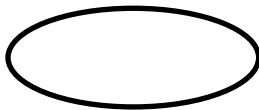
- The extensive experience regarding management from Mr. Yepis. Thus, he has worked directly in decision making and also used ERP systems.
- That the use of ERP system is a sign of standardization which leads to improvement and adaptation.
- That an advantage of this type of system is to take the operating and administrative tasks towards standardization and improvement of processes.
- That systems influence decisions by having better condition examinations and hopefully better output.
- Expressing that a risk in the use of systems is the human factor. Input data must be combined with logic and rationalization.
- That decisions at Radiall follow the scientific method of analyzing the problem, verifying conditions, along with multi-actor involvement (team problem solving). Moreover, they account for the culture of the organization.
- That in their decision process, they do in fact classify (unknowingly) a situation into being generic or unique or a combination of both. What they analyze is if the conditions are the root cause of a problem or a symptom of a deeper problem.
- Considering that the most common classification of situations are those of being generic yet unique to the company.
- Stating that the decisions help improve situations. They have as major elements goals oriented to quality, cost and delivery.
- Mentioning various examples of conflict situations between several actors that could be subject of study for the proposed framework.
- Stating that lack of data, talent and respect are reasons why problems in decision making occur.
- Stating that he is familiarized with multi-actor study and its techniques and that it is used empirically in his organizations.

## **C1. Flowchart diagram**

A flowchart diagram represents a process and it shows the various steps of the process as different types of boxes (each having a specific representation) and their order by connecting them with arrows. This representation helps oversee a step-by-step solution or procedure to a given problem. The activities of the process are represented in these boxes and the flow with the arrows. Therefore, flowchart diagrams are used to document processes and help visualize and understand the process. The most common type of boxes in a flowchart diagram are activities denoted as a rectangular box, and decisions denoted as a diamond.

Diagram 1 shows a flowchart diagram of the framework process explained in chapter 6. The goal of this diagram is to help visualize and better understand the sequence and the activities of the different stages of the framework. It also highlights crucial questions, referred in the diagram as decisions, which the answer validates moving forward to the next stage. Additionally, it helps see which kind of documentation is needed at each stage.

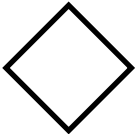
The symbols of such flowchart diagram are as follows:



Start and end of the framework.



Framework activities. In this case, the different stages of the framework.



Represents a decision, usually a Yes/No question or True/False test.



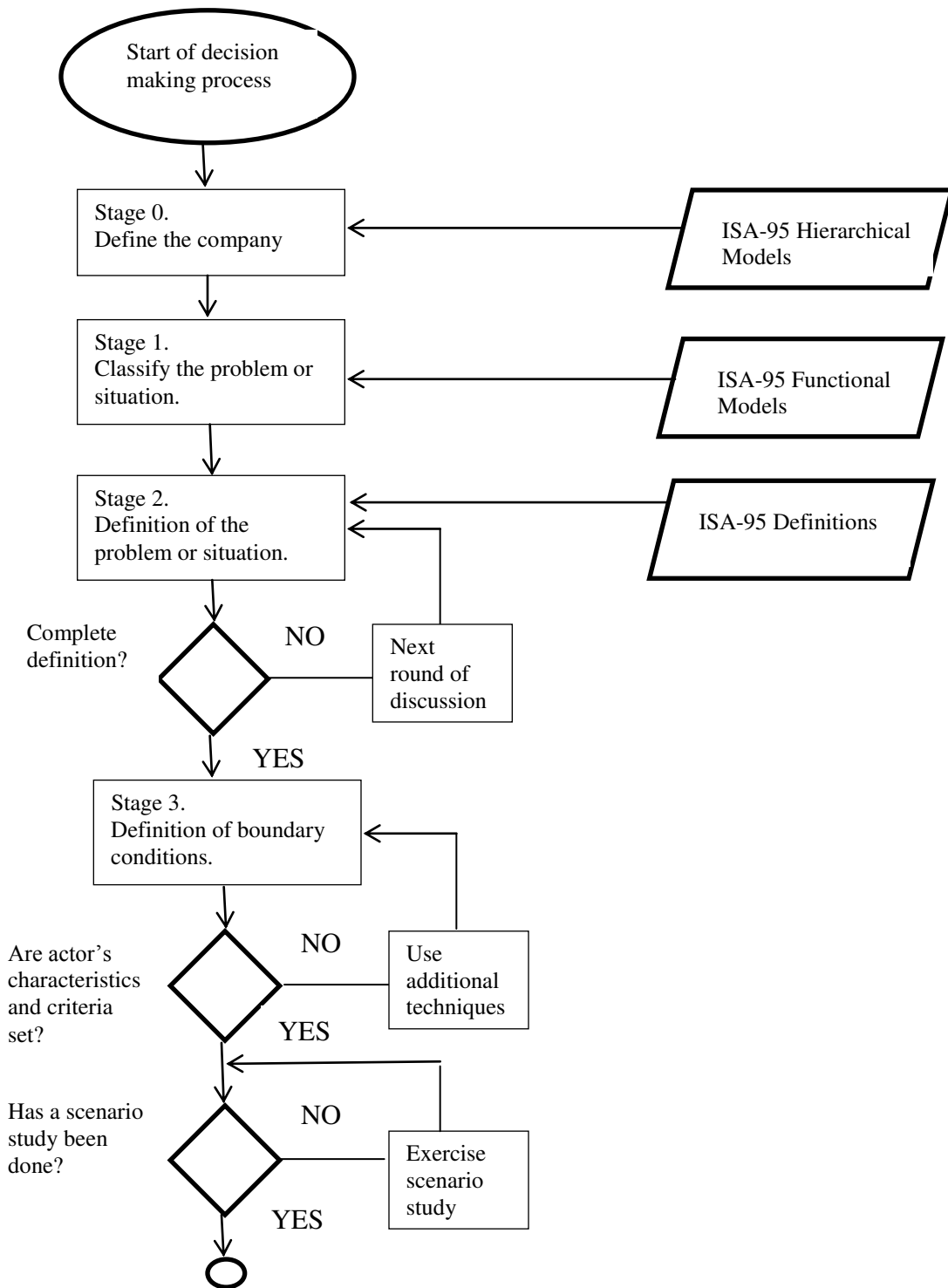
A connector; it connects the diagram in case its parts are separated.

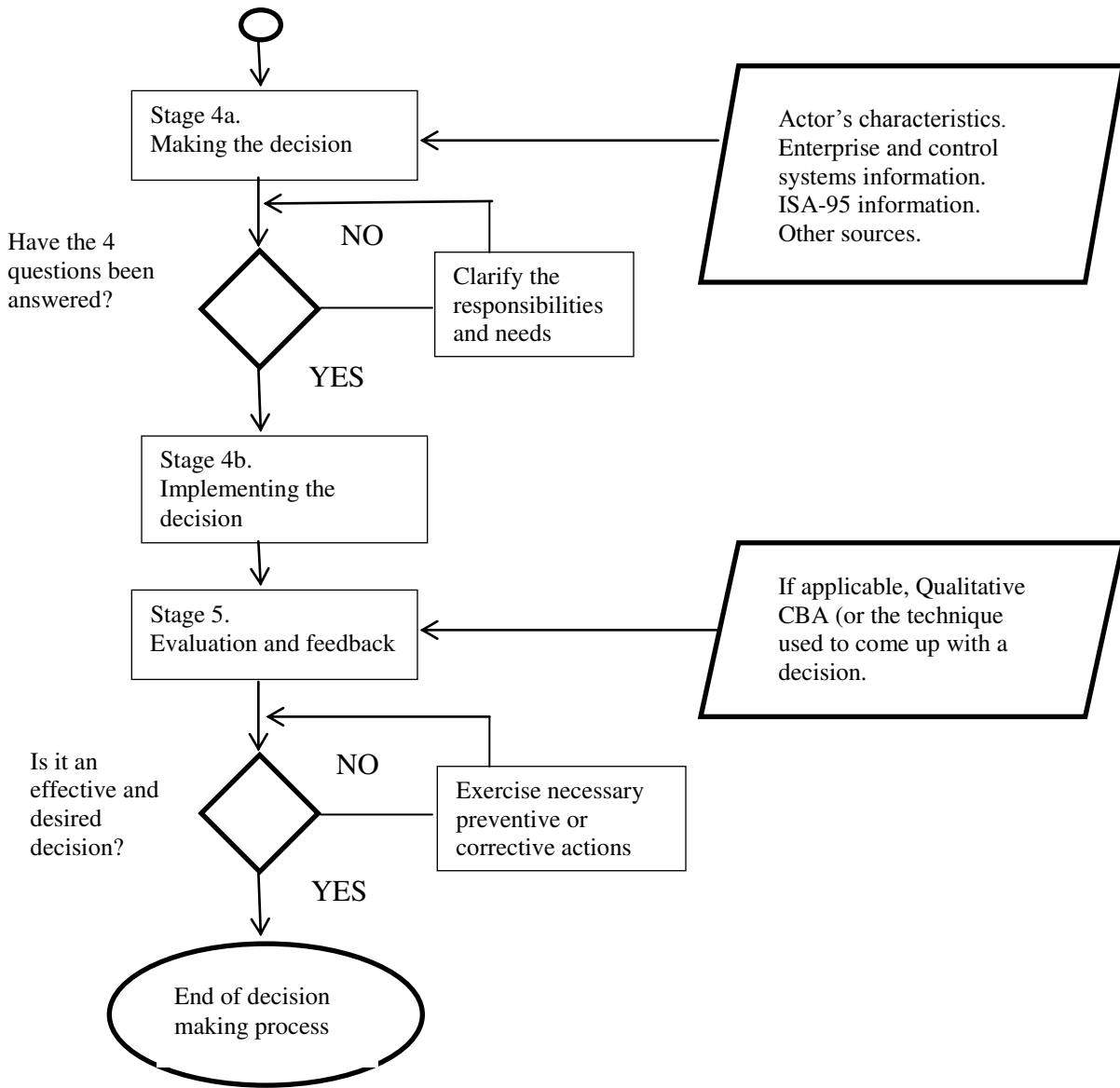


Data input to the process



Indicates the flow and sequence of the process.





**Diagram 1. Flowchart diagram of the framework process.**

## C2. Classification list of usable techniques

Table c.1 provides an overview of the different techniques and their classification from where the decision maker can select the desired or most appropriate techniques. In bold, the techniques that the researcher suggests to use throughout the different stages. As a note of clarification, techniques are aimed with a primary objective but also have secondary ones that are filled; this is why several techniques fall under several different types. The primary focus is marked with an “X” while secondary focus is represented with an “S”. Moreover, “√” is used to refer as how the specific technique will aid the decision making process: top-down or bottom-up. Certain techniques can be used under the two kinds of processes as for example, what-if analysis. It can be classified as a top-down multi-actor decision making process if the decision maker pretends to have the responsibility of the outcome and involve, in less weight, the participation of other actors. This would mean that the process would favor a semi-autocratic or a participatory decision making practice. On the other hand, it can be classified as a bottom-up decision making process if the decision maker is willing to involve at a higher level other actors and let the group be heavily involved in the result of this technique, meaning an inclination towards, for example, consensus decision making practice.

Techniques	Process		Dependencies	Intangibles		
	Top-Down	Bottom-up		Values	Resources	Perceptions
<b>Multi-actor techniques</b>						
Social network analysis		√	X			
Configuration analysis		√	X			S
DANA		√		S	S	X
Multi-attribute assessment		√		X		
<b>Stakeholder analysis</b>		√	S	S	X	S
Analysis of options		√		S	X	
Meta-game analysis		√		S	X	
GMCR		√		S	X	
Drama theory & conflict analysis		√		S	X	S
Transactional process models		√		S	X	S
Dynamic access models		√	S	S	X	S
ALLAS	√	√				
MASAM	√	√				
<b>Decision-making techniques</b>						
<i>Choosing among alternatives</i>						
Grid analysis	√					S
Paired comparison analysis	√					S
AHP	√	√		S		S
Pareto analysis	√					
Decision trees	√	√				S
QSPM	√					S
The future’s wheel		√				S
<i>Assessing future options</i>						
Go/No Go	√	√				S
Risk analysis	√					
PMI		√		S		S

<b>What-if analysis</b>	√	√				S
Change impact analysis		√				S
<b>Qualitative CBA</b>		√			S	
Multi-voting decision making		√		S		S
<b>Nominal group</b>		√		S		S
<b>Stepladder</b>	√	√				S
<i>Additional techniques</i>						
<b>6 thinking hats</b> <sup>a</sup>		√				S
<b>Brainstorming</b> <sup>b</sup>						S

**Table c.1 Classification of suggested multi-actor and decision making techniques.**

a. This technique does not fall under the previous classification as its objective is to help decision making process if stalled or halted.

b. This technique is used within plenty of techniques in the list as their first steps.

<b>Technique</b>	<b>Purpose</b>
Social network analysis	Represents network structure by analyzing relations.
Configuration analysis	Relates actors' similarities in perceptions and frames. Combines a network perspective with a focus on the perceptions of actors.
DANA	Mentions actors' perceptions and characteristics.
Multi-attribute assessment	Ranks outcome alternatives based on actors' points of view.
Stakeholder analysis	Structures information on actors which results in specific participation strategies for each group found.
Analysis of options	Identifies control options and preferences of actors.
Meta-game analysis	Identifies actors' opinions, preferences and feasible outcomes of actors. Analyze the strategic power of actors in a decision-making situation.
Graph model for conflict resolution	Identifies actors' risk strategies, options, and preferences of actors.
Drama theory and confrontation analysis	Identifies dilemmas based on issues of actors.
Transactional process models	Assesses actor dependencies based on interests and control over issues.
Dynamic access models	Assesses influence of relationships on decision outcomes.
Causal maps comparison	Constructs cognitive maps for each actor regarding their views on problems and assumed causality.
Allas	Helps negotiators understand how the different actors can bargain on issues and conceive good negotiation strategies.
MASAM	Gives a general and comprehensive view of the problem based on aggregating values and specific strategies of actors.

**Table c.2. Potential list of Multi-actor techniques**

<b>Technique</b>	<b>Purpose</b>
Grid Analysis	Helps to decide between several options, where you need to take many different factors into account.
Paired Comparison Analysis	Weighs up the relative importance of different courses of

	action. Useful when priorities are not clear or competing.
AHP	Combines different types of tangible and intangible, quantitative and qualitative factors.
Pareto Analysis	Prioritizes problem solving by showing which are the most important aspects to solve and showing how severe they are.
Decision Trees	Helps visualize multi stage decision problems while addressing uncertainty outcomes.
QSPM	Evaluates the relative attractiveness of different strategies
Future's Wheel	Brainstorms direct and indirect consequences of a decision.

**Table c.3 List of Decision Making techniques complementing a multi-actor analysis approach that enable choosing between options**

<b>Technique</b>	<b>Purpose</b>
Go/No Go Decision Matrix or Trees	Helps to decide whether to go ahead or not with plans of actions based on decision criteria and rating of different actors.
Risk Analysis	Within manufacturing activities, anticipate potential problems and planning for changes.
PMI	Helps revise if the courses of action and decisions taken will improve the situation at hand or not.
What if Analysis	Helps brainstorm risks and explore solutions.
Change Impact Analysis	Brainstorm the negative effects, impacts or consequences of a proposed change.
Qualitative Cost-Benefit Analysis	Provides the estimated cost of developing and following an alternative and the benefits derived from each of them.

**Table c.4 List of Decision Making techniques complementing a multi-actor analysis approach that assess future options.**

<b>Technique</b>	<b>Purpose</b>
Multi-voting decision making	Allows a group to narrow their list or options into a manageable size for sincere study. However, it will not help the group make a decision
Nominal group	A structured technique for group brainstorming that encourages contributions from everyone.
Stapladder	Encourages individual participation in group decision making. It manages how members enter the decision making group. Encourages all actors to contribute individually before being influenced by others.
6 thinking hats	Used to look at decision from a number of important perspectives, forcing actors to move out of their habitual style of thinking.
Brainstorming	Gather a list of ideas from the actors involved to help address specific situations.

**Table c.5. List of additional decision making techniques.**

### **C3. Potential strategies to be used when a halt in the decision making process occurs**

#### **In semi-autocratic or participatory decision making practices.**

The decision maker will analyze the information and proceed with the decision he/she thinks provides the best chances of effectiveness and support. This can cause alienation or more blocking power but with the complementary techniques like 6 thinking hats, actors may better understand the different angles of the situation allowing for better comprehension on the why of the decisions and stands of other actors. Furthermore, certain strategies (written in the following paragraphs) can be employed to favor the position of the decision maker in which he/she has the final saying.

One strategy might be that of the decision maker, if he/she has the power to do so, to threaten unilateral action to influence what the other actors see as gain or loss. This threat can provoke that actors that are resisting, change their perception based on what more they would lose if they don't cooperate and thus, start cooperating.

Another interesting strategy is that of taking into the group's advantage, if applicable, the hierarchical structure of the company. With this, a superior's position could be used in order to put pressure on the "core group" in order to reach a cooperative resolution. The superior position then can threaten to impose actions or give more power to the decision maker to go pass the blockage point of the process. Involving a superior will certainly cause other actors to respect the line of command in companies with large power distance cultures.

The benefit of having a unilateral decision after actors have tried to cooperate is that the actors themselves will see that it was the last option and it was because of their differences that an unilateral decision had to be made to try as opposed of a perception that their interest were not heard in the process. This then will prompt actors at other decision making processes to try and be more receptive for collaboration.

#### **In consensus or democratic decision making practices**

Because in these practices there is no room, in principle, for univocal decisions, the "core group" should refer to the criteria in order to prompt the actors to cooperate by sharing and explaining on how the decision will benefit the overall objective of the company; thus, making the actors see that this is an effort to benefit the overall objective, even if individual ones could not benefit from this decision.

Likewise, recall that just as this time individual objectives may not go into desired direction, the accomplishment of the overall objective will secure that later decision making processes can happen, where it could be that then, their individual objectives can benefit. In short, the "core group" should recall that this is not a one-shot operation but that they will certainly come across with each other in later decision processes. This can boost cooperation efforts and minimize potential presence of strategic behavior.

Moreover, it should be reminded that if no cooperation is made, at later processes those actors not cooperating with a considerable reason may not be taken into account. This could make them vulnerable to decisions without being heard.



A more subtle strategy is that of opening up the process to give place to trade-offs from the actors and to allow that the actors feel more involved. The opening of the process can include, for example, broadening the goals of the decision. It is not suggested, however, to make changes to the definition of the problem nor its boundaries since this have already been defined by the “core group” and this will be a signal of a defeat in the process. This strategy is more aimed at providing, if applicable, additional benefits which can attract different actors to cooperate. In other words: opening the process to see if it is possible to compensate elsewhere.

A last and radical strategy if no decision is being made is turning the practice into that of a semi-autocratic or participatory, allowing the decision maker the chance to have a univocal say in the decision. The idea of using a unilateral take is that this can promote the progress of the decision but always within a multi-actor decision making process.

## C4. Box score for client satisfaction evaluation

The researcher suggested MEEIN to use a box score to evaluate where they qualify each of their clients regarding “client satisfaction” after weighing different factors. With a simple formula, they can evaluate the estimated client satisfaction based on these factors. The formula is as follows:

Client satisfaction grade = [1]

$$[(f_1 + f_2 + \dots + f_n) / K] / n * 10,$$

where: K = total number of projects done for that client  
 n = total number of factors, and  
 f<sub>n</sub> = successful projects regarding factor *n*

For example, if MEEIN has had made 10 projects for Client A, they could evaluate this client A satisfaction score. Assuming two factors, project on time, and project without functional problems, MEEIN would need to see how many of the projects complied with each factor. In this example, an assumption can be made that at least 90% of the projects were on time and without functional problems. Having said this and using formula [1]:

Client A satisfaction grade =

$$[(9+10) / 10 / 2] * 10 = 9.5;$$

Client A is at acceptable levels under the satisfaction grade

For MEEIN, customer satisfaction must be at least 8 to be acceptable, meaning that at the most 20% of the total projects do not comply with a score of 8 or above on any of the different factors. The complete perception of MEEIN towards the client’s satisfaction score is as follows:

Score	
10	Optimal. Desired situation
9	Acceptable
8	Acceptable
7	Not acceptable but can be taken for a short period of time
6	Not acceptable under any situation
5	Not acceptable under any situation
4	Not acceptable under any situation
3	Not acceptable under any situation
2	Not acceptable under any situation
1	Not acceptable under any situation
0	Not acceptable under any situation

Table c.6 MEEIN’s box score of client satisfaction

**Annex D.**

**Complementary information on the empirical studies**

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**D1. MEEIN case study**

**Stage 0**

**Stakeholder analysis**

<b>Actor</b>	<b>Interest</b>	<b>Desired situation</b>	<b>What do you want from this actor?</b>	<b>How could this actor halt the effectiveness of the decision?</b>	<b>Influence on decision</b>
<b>Design</b>	Function-ality	Have a budget that allows for a correct and complete design without restrictions.	-Design on time. -Flexibility on designs. -Agile, reasoned quick decisions. -Evaluation between design and cost. -Feedback about expected design times and about the concept prior accepting and starting the project.	Not designing correctly or not on time. Not taking into account costs	Very High
<b>Fabrication</b>	Time	Have a budget that allows them to produce on time and with quality.	-Decision about how and when to use available internal or external resources. Correct resource distribution. -Criteria to evaluate product quality. Quality assurance despite time or resource limits. -Feedback on production times and indirect production costs	Wrong fabrication or not on time. Deviating from the design and making corrections. Machine damage	High
<b>Purchasing</b>	Low costs	Budget is as low as possible while meeting with the requirements of the client	-Control and organization of materials. -Real budget of the necessary materials before purchasing materials. -Feedback on status of material delivery.	Purchasing non-quality material or not on time. Purchasing wrong material	Very High
<b>Client</b>	Low costs, function-ality, time.	Final product meeting final budget.	Detailed, on time, and complete description of the requirements.	Giving wrong or incomplete description of product to produce.	Very High
<b>Project Manager</b>	Profit, customer satisfaction , quality, time,	That the budget meets execution while accounting for quality, time and functionality	-Detailed description from client. -Client confirmation of budget	-Wrong quotation of product. -Not involving other actor	Very High

	function-ality.	aspects. Profitability of the project			
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**Table d.1 Initial Stakeholder analysis for Stage 0 of MEEIN’s case study.**

**Stage 1**

**Nominal Group Technique**

<b>S1</b>	<b>Introduction and explanation</b>		
The purpose is to classify the given situation from the 4 proposed categories: generic, unique, generic yet unique to the company, and generic yet start of a new trend.			
<b>S2</b>	<b>Generation of ideas</b>		
The participants wrote down the ideas concerning the classification. The participants did not consult or discuss with the other actors on their ideas. Approximate duration:5 min.			
<b>S3</b>	<b>Group discussion</b>		
Participants shared the ideas they wrote down and their reasoning. The round finished after all ideas have been presented. There is no debate of ideas at this stage. Approximate duration: 6 min			
<b>Round</b>	<b>Actor</b>	<b>Classification</b>	<b>Reasoning</b>
1	Project Manager	Generic yet unique	It is a procedure that is done on a regular basis but I am confronted with new variables all the time. I rely on previous procedures but the decisions rarely are the same, even the procedure changes because of the different factors.
	Design	Generic yet unique	I am always given designs that, holds true they are for the same industry and can hold resemblance with previous projects, but there is hardly an exact same project I need to do.
	Purchasing	Generic yet unique	Each project is unique in the sense that they are composed of different parts. It is generic in the sense that most of them involve the same “families” of materials and I follow mostly the same procedure but with different variables. From time to time, I come across new materials and requirements.
<b>S4</b>	<b>Group Discussion</b>		
The participants exchanged points of view and clarification upon the reasoning of each actor. No ideas were eliminated and all actors were given a chance to discuss, if needed, on each other’s contributions. Approximate duration: 3 min			
<b>S5</b>	<b>Voting and ranking</b>		
The participants, following a consensus decision making practice, agree that the situation will be classified as: <b>generic yet unique to the situation.</b>			

**Table d.2 Situation classification using a nominal group technique**

**Stage 2**

### Stepladder Technique

Round		Actor	Input
1	ENTER	Project Manager	Order in work, facilitate tools for the other actors to work with to improve control on the process, make use of human resources based on their strengths and weaknesses.
	ENTER	Design	A standardized design process, constant capacitation on personnel to be able to have the necessary resources to work with when having different projects at the same time.
	At this point, design and project manager discuss their ideas.		
2	ENTER	Purchasing	Improvement on purchasing procedures and a plan for supplier development
	After this, the 2 actors from the previous round present their “agreed” common views to Purchasing, the entering actor. After this, a discussion is set and the 3 give once again their views.		
		Project Manager	To identify available resources and make better use of them. A constant revision of strengths, weaknesses, opportunities and threats can help. Facilitate tools and respect workloads
		Purchasing	Involving the actors so that all information is present. Better assignments.
		Design	Knowing if there are resources available to do the different tasks. A more orderly and standardized process
3	The means that is found most important is selected. This is: <i>To know better the availability of the different resources.</i>		

Table d.3. Stepladder technique to come up with means to achieve the desired objective between 3 actors.

Round		Actor	Input
1	ENTER	Project Manager	Inefficient and incomplete management
	ENTER	Purchasing	Poor purchasing analysis
	At this point, design and project manager discuss their ideas but cannot agree on problems. For them, both ideas are critical		
2	ENTER	Design	Bad distribution of work among the resources. Lack of leadership to make use of resources talent or strengths.
	After this, the 2 actors from the previous round present their views on the problem to Design, the entering actor. After this, a discussion is set and the 3 give once again their views.		
		Project Manager	Bad management in assigning tasks to resources without knowing availability or strengths
		Design	Bad management, wrong understanding of availability of resources
		Purchasing	Lack of perception in what is needed, who will do it and how will it do it. Lack of understanding in materials.
3	A discussion is set in order to come up with the problems that actors feel are most critical for reaching the objective. This are: <i>Bad management of resource distribution and assignment</i> <i>Wrong or incomplete analysis of the project</i>		

Table d.4 Stepladder technique to come up with problems to reach the desired objective based on selected means.

### Assessing information completeness of problem definition

	<b>Project Manager</b>	<b>Design</b>	<b>Purchasing</b>
<b>Current Information</b>	-Client specs -Concept from client -Information from similar past project, including estimated cost and time	-Delivery times on current projects -Profile on available resources (abilities and capabilities)	-List of current suppliers -“Common” materials costs
<b>Needed information</b>	-Resource availability -Reliable budget of the unknown or different materials -Feedback of work distribution from design	Workload information of new project	-Costs of additional materials. -Estimated budget -List of materials
<b>Information missing?</b>	Yes	Yes	Yes
<b>Who provides this information?</b>	Resource availability from Fabrication. A reliable budget from suppliers. Feedback from Design	Project Manager	All come from Project Manager
<b>Risks</b>	Wrong or not on time information from suppliers. Suppliers not knowing about materials. Incomplete or unknown information from Fabrication Wrong evaluation of workload	Wrong evaluation of workload towards and from Project Manager	-Wrong material selection. - Wrong cost evaluations -Wrong estimation of material load.

Table d.5 Overview of current and missing information upon the problem and which risks are present.

### Stage 3

#### Stakeholder Analysis

	<b>Project Manager</b>	<b>Design</b>	<b>Purchasing</b>	<b>Fabrication</b>
<b>Interest</b>	Profit, customer satisfaction, quality, time, functionality.	Functionality	Low costs	Time
<b>Desired situation</b>	-That the budget meets execution while accounting for quality, time and functionality aspects. -Profitability of the project	Have a budget that allows for a correct and complete design without restrictions.	Budget is as low as possible while meeting with the requirements of the client	Have a budget that allows them to produce on time and with quality.
<b>What do you want from this actor?</b>	-Detailed description from client. -Client confirmation of budget	-Design on time. -Flexibility on designs. -Feedback about expected design times	-Control and organization of materials. -Real budget of the necessary materials	-Correct resource distribution. -Feedback on production times and indirect

		and about the concept prior accepting and starting the project.	before purchasing materials. -Feedback on status of material delivery.	production costs
<b>How could this actor halt the effectiveness of the decision?</b>	-Wrong quotation of product.	Not designing correctly or not on time. Not taking into account costs	Purchasing non-quality material or not on time. Purchasing wrong material	Wrong fabrication or not on time. Deviating from the design. Machine damage
<b>Influence on decision</b>	Very High	Very High	Very High	High
<b>Dedicated actor?</b>	Yes	Maybe	No	Maybe
<b>Network link</b>	Information from Fabrication, Design and Suppliers is needed. It can be seen that is indirectly dependent on Purchasing due to this. On the other hand, it gives information to all these actors.	Their information has a direct effect on what Project Manager does. In order to give correct information, they first need Project Management input.	Their information has a direct effect on what Project Manager does. In order to give correct information, they first need Project Management input.	Their information has a direct effect on what Project Manager does.
<b>Resources</b>	Process and knowledge	Knowledge	Process and knowledge	Knowledge
<b>Power</b>	High	Medium	High	Medium

Table d.6 Updated Stakeholder analysis for Stage 3 of MEEIN's case study.

### Nominal Group Technique

<b>S1</b>	<b>Introduction and explanation</b>		
The purpose is to come up with the criteria that will be used to evaluate if the decision taken was successful or not. Successful in the sense that it allows reaching or closing the gap towards the desired objective and situation.			
<b>S2</b>	<b>Generation of ideas</b>		
The participants wrote down the ideas concerning the possible set of criteria based on: a) Variables that can be affected by correct decisions b) Variables that can be affected by incorrect decisions The participants did not consult or discuss with the other actors on their ideas. Approximate duration:6 min.			
<b>S3</b>	<b>Group discussion</b>		
Participants shared the ideas they wrote down and their reasoning. The round finished after all ideas have been presented. There is no debate of ideas at this stage. Approximate duration: 7 min			
<b>Round</b>	<b>Actor</b>	<b>Criteria</b>	<b>Reasoning</b>
1	Project Manager	Project time	The time and cost of the Project is critical

		Final cost Client satisfaction	because this is what makes the project be or not on budget. It involves also a correct assessment on these in order for the budget to be as close as possible to the execution to maximize resource utilization. Client satisfaction is imperative since we depend on Clients for more projects.
	Design	Client satisfaction Design time	Client satisfaction is important because it dictates if we continue on business or not. We need the trust from the client. The design time should be evaluated to see if the budget process accounted correctly for the human and tool resources needed for a correct and complete design that can guarantee reaching all of the client's requirements.
	Purchasing	Cost	Cost is the most critical variable we should look at because after all, a budget is made in reference to money. It is made to not incur in higher costs than what is needed to fulfill the client's requirements.
	Fabrication	Re-work Fabrication time Design time	Re-work should be assessed because this means that more money will be spent on labor, machinery and materials. Fabrication time is a good evaluator to see if the process went accordingly to the projection. The same goes for the design time.
<b>S4</b>	<b>Group Discussion</b>		
<p>The participants exchanged points of view and clarification upon the reasoning of each actor. No ideas were eliminated and all actors were given a chance to discuss, if needed, on each other's contributions.</p> <p>The criteria that should be selected are those that affects the most the performance of actors and the situation, and those that are affected the most (and be influenced) by a correct/incorrect decision and good/bad performance of actors.</p> <p>Approximate duration: 12 min</p>			
<b>S5</b>	<b>Voting and ranking</b>		
<p>The participants, following a consensus decision making practice, agree that the criteria that will be used to evaluate the decision are:</p> <ul style="list-style-type: none"> <li>- Cost of the project</li> <li>- Client's satisfaction</li> <li>- Duration of the project</li> </ul>			

**Table d.7 Nominal group technique to assess criteria of interest for MEEIN's case study**

### What if analysis

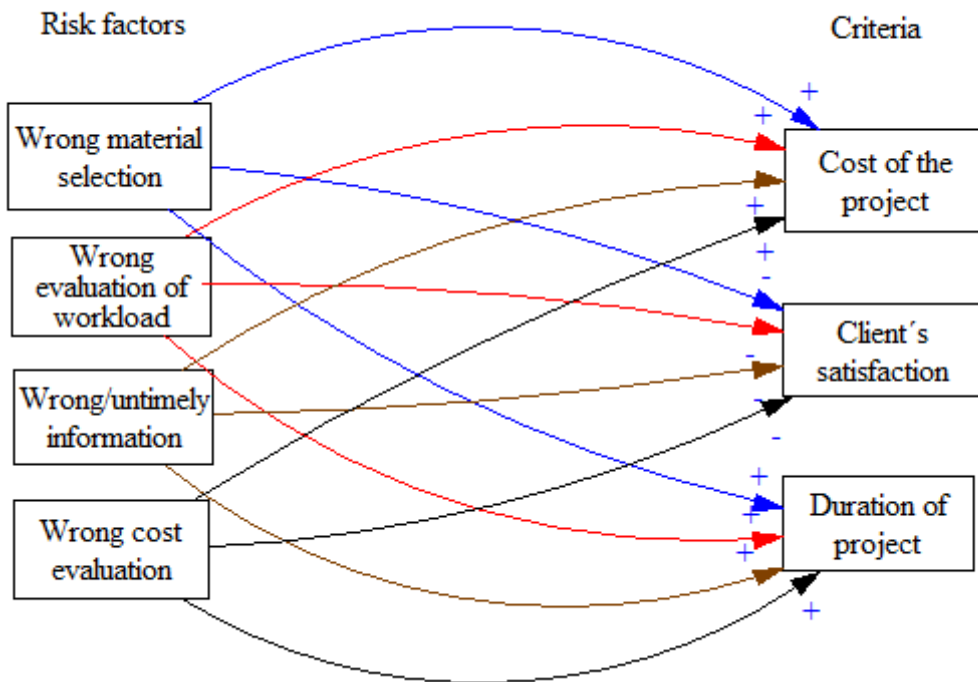
<b>S1</b>	<b>Purpose of this analysis</b>
<p>The purpose of this analysis is to conduct a scenario study of how the risk factors could change and have an effect on the established criteria, in order to draw general plans of action and be prepared in case these scenarios occur.</p>	
<b>S2</b>	<b>Brainstorm of options for decision based on the problem and situation</b>
<p>The "core group" actors give ideas on which possible decision could be made (i.e. options) in order</p>	



to reach the desired objectives based on the defined problem.  
 After the brainstorming session and discussion on which options are most feasible to implement in terms of time, resources, logistics and practicability, the following options are selected:

1. *Improvisation*
2. *Don't do project*
3. *Outsource the project*
4. *Negotiate on times with client*

**S3 Causal map and identification of cause/effect on criteria by risk factor changes**



With this, it can be seen that indeed the risk factors, if present, have an effect on the criteria. However, the inverse causal dependency is non-existent: criteria cannot influence the risk factors since the criteria is measuring the whole project outcome and not the budget making process as opposed to the risk factors that have a direct influence on the budget making process.

From this, the following is seen clearly:

Risk factor	Criteria	Effect
Wrong material selection	Cost of project	Materials will have to be bought again and there will be waste material. This increases cost so most probable that budget is not met but is under the actual costs.
	Client's satisfaction	With wrong material on the product, the functionality and performance suffers.
	Duration of project	By having to re-purchase materials or re-work the project due to wrong materials, there is a delay in the project.
Wrong evaluation of workload	Cost of project	A bad evaluation of workload makes, most probably, resources being under-assigned which later on, on practice, extra resources will need to be assigned.
	Client's	The project will most probably be out of time

	satisfaction	
	Duration of project	The project will most probably be out of time. Accorded times are not respected.
Wrong/untimely information	Cost of project	The budget can be either over or under estimated which is not optimal for the objective of wanting it to be as close as possible to the actual execution.
	Client's satisfaction	The client will not receive what it asked for.
	Duration of project	Can delay the project
Wrong cost evaluation	Cost of project	The impact is a direct one. A bad evaluation of costs results in an incorrect budget and most probably an overrun of costs.
	Client's satisfaction	The reputation of MEEIN suffers due to an incorrect evaluation of costs that is transmitted to the client. The client will not be paying what first agreed on.
	Duration of project	A delay occurs given a negotiation with the client.

The “core group” analyzes this and chooses out of these risk factors the one that is most probable to happen and is most critical to simplify the process of identifying scenarios. It can be that in other processes, this simplification is not made and a wider range of scenarios are analyzed. The “core group” believes that a *wrong cost evaluation* is the risk factor that presents the worst effects on MEEIN and is feasible to occur. In other words, when evaluating the risk factors that are most probable to occur, the “core group” evaluate the impact of such factors to choose the one that had the highest impact on the established criteria, and therefore, on the objective attainment.

**S4 Identification of Scenarios**

The “core group”, taking into account the risk factors and the defined options, identify and name 4 possible scenarios.

**Scenario A – “Improvised Nightmare”**

= It is decided that the process will be improvised; this is, that MEEIN will see what actions to do as the project goes on. On top of that, a wrong evaluation of costs occurs which impacts cost of the project, client's satisfaction and the duration of project. Certainly, the budget will not be even close to the actual execution. Even more, because the process has been improvising and adapting itself depending on what is happening, there is no actual procedure that was followed to see where the mistake was made.

**Scenario B – “Heavenly Laziness”**

= It is decided that under this situation of no available resources, the project is not done. So, there is no effect on a wrong evaluation of costs.

**Scenario C – “Warm Potato”**

= An outsourcing of the project is decided to be made. However, a wrong evaluation of the costs done by MEEIN occurs. This makes that the negative effects of delay of the project double themselves because it is not MEEIN directly doing the project but another company. This requires the double of negotiations to be made: one with the outsourcing company and one with the client. However, because the project is outsourced, a lot part of the risk is transferred to the outsourcing company and MEEIN can blame the delay on them, minimizing a bit the blame and loss of its reputation to the client.

Scenario D – “Turning Tables”

= The option chosen is that of negotiating with the client with respect on time to handle the problem. This means that an opportunity to safeguard face is present since a wrong evaluation of costs can be “hidden” and included in the negotiation process of time of the project. If negotiation favors MEEIN, the client will not notice this mistake. However, the duration of the process still gets delayed and the cost of the project will still be elevated.

**S5**                                 **Set up general plans of actions for each scenario**

“Improvised nightmare” → Design, Fabrication and Purchasing should give the correct information. Project Manager will negotiate with client about times and costs with an option to decline continuing with the project. This for sure hurts MEEIN’s reputation but not as much as with no taking corrective action.

“Heavenly Laziness” → N/A

“Warm Potato” → Design, Fabrication and Purchasing should give the correct information to the outsourcing company in an urgent matter. Project Manager will negotiate with client and outsourcing company about times and costs with an option to decline continuing with the project. This for sure hurts MEEIN’s reputation but not as much as with no taking corrective action.

“Turning Tables” → Design, Fabrication and Purchasing should give the correct information. Project Manager will negotiate with client about times and costs with an option to decline continuing with the project. As opposed to the previous scenarios, the negotiation process will not be as complex given that negotiations were already in place.

**Table d.8** What-if analysis to assess scenarios for MEEIN’s case study

**Stage 4**

**Qualitative CBA**

	<b>Improvising</b>	<b>Decline the project</b>	<b>Outsourcing</b>	<b>Negotiating time with client</b>
<b>Criteria involving Costs</b>				
Material cost	28,960.80 USD (20% over budget)	0	25,340.70 USD (5% over budget)	24,134 USD (Same amount as budget)
<i>Grade</i>	<b>4</b>	<b>1</b>	<b>3</b>	<b>2</b>
Labor costs	23,051.60 USD (30% over budget)	0	18,618.60 USD (5% over budget)	17,732 USD (Same amount as budget)
<i>Grade</i>	<b>4</b>	<b>1</b>	<b>3</b>	<b>2</b>
Indirect costs	4,220 USD (100% over budget)	0	0	1,266 USD (40 % under budget)
<i>Grade</i>	<b>4</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>Criteria involving Benefits</b>				

Profit	10,554.40 USD (20% less than expected)	0	13,193 USD	11,927 USD
<i>Grade</i>	<b>3</b>	<b>4</b>	<b>1</b>	<b>2</b>
Client satisfaction	8	9	8	8
<i>Grade</i>	<b>2</b>	<b>1</b>	<b>2</b>	<b>2</b>
<b>Other criteria</b>				
Project duration	12 weeks (100% above estimated time)	0 weeks	9 weeks (50% above estimated time)	8 weeks (On time due to negotiation with client)
<i>Grade</i>	<b>4</b>	<b>1</b>	<b>3</b>	<b>1</b>
Budget making process duration	25-30 days	0 days	15-20 days	25-30 days
<i>Grade</i>	<b>3</b>	<b>1</b>	<b>2</b>	<b>3</b>
<b>Total Grade</b>	<b>24</b>	<b>10</b>	<b>15</b>	<b>14</b>
<b>Recommendation</b>	<b>D</b>	<b>A</b>	<b>C</b>	<b>B</b>

Table d.9 Qualitative CBA used at stage 4 for MEEIN's case study.

#### Client satisfaction box score

	Without this project	With this project			
		Option 1	Option 2	Option 3	Option 4
<b>Number of total projects</b>	16	17	16	17	17
<b>Number of factors</b>	3	3	3	3	3
<b>Factor 1 (number of projects w/o functional or quality problems)</b>	14	14	14	14	14
<b>Factor 2 (number of projects on time)</b>	13	13	13	13	13
<b>Factor 3 (number of projects under budget)</b>	15	15	15	15	15
<b>Client satisfaction grade</b>	8.75	8.2	8.75	8.2	8.2

Table d.10 Client's satisfaction box score of MEEIN's case study

#### Stage 5

	Negotiating time with client	Projected outcome
<b>Total Costs</b>	43,132 USD	39,849 USD
<b>Profit</b>	11,927 USD	15,210 USD
<b>Time to realize project</b>	8 weeks	8 weeks
<b>Time of budget making process</b>	25-30 days	18-22 days

Table d.11 Comparison of results from the chosen decision with the projection of the situation with such decision.

## Feedback

1. *What is your opinion about the process that this proposed framework suggests?*

“I think that the process is complete and it explores a lot of different factors that affect making good decisions.”

2. *How much does this framework process differs from the process of decision making that you currently use at MEEIN?*

“It is more specific and it asks to follow standardized rules as well as involving several actors to the process”.

3. *Do you see any additional value in using this framework process?*

“Yes, most definitely; a first added value is that of incorporating a way to make decisions and not merely by intuition. A second one is the effect and now insight of having several actors throughout the process. We liked as well the way to evaluate the client’s satisfaction, although maybe we adapt it to our necessities”.

4. *What would limit MEEIN to follow this framework process?*

“That we are still not familiar with many of the techniques. Also, without your help reviewing the process, it may be probable that we would go into another direction and fall back to what is known to work”.

5. *What are the shortcomings you perceive in the proposed framework process?*

“Perhaps the stages can be reduced a bit to reduce some complexity. Also, maybe not all of the actors would willingly and interestingly be participating”.

6. *Would you include all or parts of the framework into your current decision making processes?*

“Yes, I think we can try to use the process. At least to this kind of situations and then evaluate if we could extend its use to other situations”.

7. *Which benefits do you perceive that using the proposed framework might bring to manufacturing companies?*

“To this kind of situations, it may allow that the budgets are reasonably closer to the execution. It can allow on deciding better on what to do if we face adverse situations like unavailability of resources. I can see more support and having more effective decisions”

8. *Was a decision be more rapidly taken than when your decision making processes?*

“No. It was not decided more rapidly but it did allow taking a decision which met the goals established in a fast way. Taking fast decisions can also be not productive if they do not meet with the established goals”

9. *Was a decision taken with less conflict and more support?*

“Yes, it appears as this is true. Conflict is inevitable but with the process of your framework, the arguments have more reasoning behind it and a common ground is reached faster. This helps to have more support of the decision that is taken”.

10. *Is this framework feasible to use in manufacturing companies in terms of time and resources?*

“Yes”.

11. *Do you think that the suggested techniques are appropriate? If no, why?*

“Yes, it seems this way”.

12. *What is your opinion on the conclusions given throughout the stages? Are they correct and usable?*

“Yes, they are correct. In fact, some of them are the same conclusions that I had. The only difference is that I had to see this thing after everything was finished but with this process divided in stages, you can have data and conclusions helping you to identify strengths, weakness, opportunities and risks; all before actually taking a decision”.

**Table d.12 Feedback from Mr. Treviño for MEEIN’s case study**

## D2. DSM case study

### Stage 0

#### Stakeholder analysis

Actor	Interest	Desired situation	What do you want from this actor?	How could this actor halt the effectiveness of the decision?	Influence on decision
Operations	Costs	Have a schedule that minimizes costs and can assure that production can be done at the right time.	Information on capabilities and realization of products based on availability, cost capacity, etc.	Failing to reach the production schedule. Failing to give information on their true capabilities. Failing to allocate capacity costs.	High
Sales	Profit	Have a schedule that gives the most profit while accounting for external factors such as change of demand, priorities, etc.	Information on sales prospect. Provide financial information and priorities.	Wrong assumptions on the sales prospects leading to misleading information.	High
Quality	Quality assurance	Products are of right quality, meeting with customer's demands with any given changes in schedules.	Information on specifications for products. Involvement in production schedule to anticipate tension zones due to bottlenecks or change-over.	Failure to observe possible tension zones that could lead to damage in quality.	Medium

Table d.13 Initial Stakeholder analysis for Stage 0 of DSM's case study.

### Stage 1

#### Nominal Group Technique

<b>S1</b>	<b>Introduction and explanation</b>
	The purpose is to classify the given situation from the 4 proposed categories: generic, unique, generic yet unique to the company, and generic yet start of a new trend.
<b>S2</b>	<b>Generation of ideas</b>
	The participants will write down the ideas concerning the classification. In this stage, the participants should not consult or discuss with the other actors.
<b>S3</b>	<b>Group discussion</b>

Round	Actor	Classification	Reasoning
1	Mr. van Delft	Generic yet unique	Done periodically but it involved different variables. Previews parameters and procedures are available but actual decisions may be different based on current factors.
	Researcher	Generic yet unique	It is a situation that often occurs and for which a certain procedure is in place to deal with this. However, the variables and parameters change from one situation to another so the process cannot rely on previous information.
<b>S4</b>	<b>Group Discussion</b>		
The participants exchange points of view and clarification upon the reasoning of each actor. No ideas should be eliminated and all actors should be given a chance to contribute and that discussion on all reasoning is made.			
<b>S5</b>	<b>Voting and ranking</b>		
The participants vote upon the classification, prioritizing the reasoning from the different actors. Immediate results are given. The results should respect the decision making practice which was defined earlier in this stage. In this case, the result was quick and unanimous: <i>the classification is that of generic yet unique to the situation.</i>			

Table d.14 Situation classification using a nominal group technique

## Stage 2

### Adapted Stepladder technique

Round		Actor	Input
1	ENTER	Mr. van Delft	Want to have a schedule that is profitable, so a decision should be made on staying with the current schedule or using a schedule with modifications according to external influences.
	ENTER	Researcher	That explains the situation. The problem is yet broad.
2		Mr. van Delft	In order to have a correct schedule we need certain information from the involved actors: Operations and Sales. Having the wrong information or at wrong times hurts the situation.
		Researcher	Taking a step ahead, what is the information that is available when developing a schedule normally, and what is the information that is needed and what is missing?
3		Mr. van Delft	The problem lies in being able to match the costs and profits of the current schedule in order to see if it is profitable even with external influences.

Table d.15 Stepladder technique to come up with a problem definition between 2 actors.

### Assessing information completeness of problem definition

	Operations	Sales	Quality
<b>Current Information</b>	Production capacity Run-time information → Estimation on needed time for	Product characteristics Financial information	Specifications Quality targets Tolerance levels



	<p>production</p> <p>Raw material figures</p> <ul style="list-style-type: none"> <li>→ Indicate additional costs and means of raw materials.</li> <li>→ Indicate estimate time delivery to have raw materials</li> </ul>		
<b>Needed information</b>	<p>Real time capacities</p> <p>Extra production costs</p> <ul style="list-style-type: none"> <li>→ Change-over costs</li> <li>→ Production installation costs</li> </ul> <p>Scenario analysis of how the capacities and costs can change depending on external factors</p>	<p>Sales prospects</p> <ul style="list-style-type: none"> <li>→ Priorities</li> <li>→ Demand</li> </ul> <p>Rush orders</p> <p>Changes in sales prospects</p>	<p>Specifications</p> <p>Quality targets</p> <p>Tolerance levels</p>
<b>Information missing?</b>	Yes	Yes	No
<b>Who provides this information ?</b>	<ul style="list-style-type: none"> <li>- Real time capacities can be obtained via a control system.</li> <li>- Extra production costs are obtained within Operations Department but depend on knowing the current schedule.</li> <li>- Scenario analysis information depends on Sales to know external factors.</li> </ul>	<ul style="list-style-type: none"> <li>- Sales prospects can be obtained within Sales department but depend on the market.</li> <li>- Rush orders and changes in sales prospects depend also on market. Therefore, information can be based on assumptions</li> </ul>	N/A
<b>Risks</b>	<ul style="list-style-type: none"> <li>- MES information is wrong</li> <li>- Not knowing the schedule with time/ Working figures of wrong schedule</li> <li>- Sales providing wrong/untimely information</li> </ul>	<ul style="list-style-type: none"> <li>- Market variability</li> <li>- Wrong/Untimely information from Operations regarding production costs</li> <li>- Wrong information from assumptions</li> </ul>	The quality study is done with faulty information from the other actors.

Table d.16 Overview of current and missing information upon the problem and which risks are present.

### Stage 3

#### Stakeholder analysis

	<b>Operation</b>	<b>Sales</b>	<b>Quality</b>
<b>Interest</b>	Costs	Profit	Quality assurance
<b>Desired situation</b>	Have a schedule that minimizes costs and can assure that production can be done at the right time.	Have a schedule that gives the most profit while accounting for external factors such as change of demand, priorities, etc.	Products are of right quality, meeting with customer's demands no matter changes in schedules.

<b>What do you want from this actor?</b>	Information on capabilities and realization of products based on availability, cost capacity, etc.	Information on sales prospect. Provide financial information and priorities.	Information on specifications for products. Involvement in production schedule to anticipate tension zones due to bottlenecks or change-over.
<b>How could this actor halt the effectiveness of the decision?</b>	Failing to reach the production schedule. Failing to give information on their true capabilities. Failing to allocate capacity costs.	Wrong assumptions on the sales prospects leading to misleading information.	Failure to observe possible tension zones that could lead to damage in quality.
<b>Influence on decision</b>	High	High	Medium
<b>Dedicated actor?</b>	Yes	Yes	No
<b>Network link</b>	Information from Sales is needed to produce. Production can be affected by Quality actions	Their information have a direct effect on what Production does.	The functions of this department can halt production and sales interests.
<b>Resources</b>	Process and information	Information	Process
<b>Power</b>	High	High	Medium

Table d.17 Updated Stakeholder analysis for Stage 3 of DSM's case study.

#### Stage 4

#### Qualitative CBA suggestion

	<b>Option 1</b> Keep current schedule without making adjustments		<b>Option 2</b> Modify current schedule accounting for changes in external factors	
<b>Criteria involving Costs</b>				
Installation costs				
<i>Grade</i>				
Change-over costs				
<i>Grade</i>				
Raw material cost				
<i>Grade</i>				
Maintenance cost				
<i>Grade</i>				

<b>Criteria involving Benefits</b>				
Client satisfaction				
<i>Grade</i>				
Total product value				
<i>Grade</i>				
<b>Other criteria</b>				
OEE				
<i>Grade</i>				
Run time				
<i>Grade</i>				
<b>Total Grade</b>				
<b>Recommendation</b>				

Table d.18 Example of proposed Qualitative CBA to be used at stage 4 for DSM's case.

### Feedback

1. *What is your opinion about the process that this proposed framework suggests?*

“To me it looks very comprehensive and complete. I am not sure whether the example provided gives enough validation to the framework since not all stages haven been examined”.

2. *How much does this framework process differs from the process of decision making that you currently use at DSM?*

“In a sense, things are being made more explicit than is normally done”.

3. *Do you see any additional value in using this framework process?*

“Possibly; implicit assumptions are being challenged or prevented. However the approach looks quite elaborate and complicated”.

4. *What would limit DSM to follow this framework process?*

“See comments above”.

5. *What are the shortcomings you perceive in the proposed framework process?*

“Difficult to answer since the framework is not compared with other frameworks like rational decision making (at least not in the reading materials I got)”.

6. *Would you include all or parts of the framework into your current decision making processes?*

“We will think about this, I see some advantages in making stages more explicit”.

7. *Which benefits do you perceive that using the proposed framework might bring to manufacturing companies?*

“Quicker and more effective decision making; capturing more business opportunities”.

8. *Speaking specifically of DSM, by following the proposed framework process in this case situation, which results would you expect to have?*

“See answer 7”.

*Would a decision be more rapidly taken?*

“Most probably”.

*Would a decision be taken with less conflict and more support?*

“Doubtful, since people in general don’t like frameworks”.

9. *Is this framework feasible to use in manufacturing companies in terms of time and resources?*

“Yes”.

10. *Do you think that the suggested techniques are appropriate? If no, why?*

“Yes, although not clear about alternatives”.

11. *What is your opinion on the conclusions given throughout the first stages? Are they correct and usable?*

“In general I agree. However, for stage 2 conclusions, important to signal that having production power is something different than having power overall. Therefore, not entirely true that Production holds the highest level of power”.

12. *What is your opinion on the suggestions drawn for the last 2 stages? Are these usable, of value and true? Do they bring new facts? Could they help achieve better results?*

“This is difficult for me to assess since we have not been through this”.

**Table d.19 Feedback from Mr. van Delft for DSM’s case study**

### D3. Radial case study

#### Stage 0

#### Stakeholder Analysis

Actor	Interest	Desired situation	What do you want from this actor?	How could this actor halt the effectiveness of the decision?	Influence on decision
<b>AV</b>	Production efficiency	Comply with the 30% increase while minimizing costs, risks to security of personnel and machine, securing quality and on-time delivery.	-Information on production capacities -Information on production times -Information on extra personnel costs -Agile, reasoned quick decisions on-line	-Wrong capacities and projections. -Bad estimation of machinery status -Wrong personnel assignment -Deviation from correct product	High
<b>Planning</b>	Costs	Comply with the 30% increase securing material delivery while analyzing why this increase was not detected before and with time.	-Information on material costs -Information on extra personnel costs -Information on specification of material (i.e. model, quantity, etc.)	-Wrong information on specification of material -Materials not on time -Wrong delivered material	High
<b>Quality</b>	Quality Assurance	Comply with the 30% increase while securing that the quality of the product is kept high. No rejections or customer complaints.	-Information on specification of material given by Planning -Information on quality tests to be done -Information on extra personnel costs -Information on specialized quality inspectors (if needed)	-Not optimal disposal of instrument or specialized personnel	High
<b>Human Resources</b>	Secure qualified personnel availability	Comply with the 30% increase assuring that no laws or regulations are violated	-Availability of human resources -Costs of new personnel -Extra time costs -Coordinate extra hours of personnel or new hiring and capacitation	-Not having human resources available in time -Violations on regulations and laws.	High
<b>Plant Manager</b>	Profit, client satisfaction, security, social and environment resp.	Comply with the 30% increase while securing social, security, quality, functional, and client resp.	-Support and authority to decision maker to have resources to work with	-No involvement on situation	High

Table d.20 Initial Stakeholder analysis for Stage 0 of Radial's case study.

## Stage 1

### Nominal Group Technique

<b>S1</b>	<b>Introduction and explanation</b>		
The purpose is to classify the given situation from the 4 proposed categories: generic, unique, generic yet unique to the company, and generic yet start of a new trend.			
<b>S2</b>	<b>Generation of ideas</b>		
The participants will write down the ideas concerning the classification. In this stage, the participants should not consult or discuss with the other actors. Approximate duration:.			
<b>S3</b>	<b>Group discussion</b>		
Participants share the ideas they wrote down and their reasoning. The round continues until all ideas have been presented. There is no debate of ideas at this stage. Approximate duration:			
<b>Round</b>	<b>Actor</b>	<b>Classification</b>	<b>Reasoning</b>
1	Mr. Yepis	-	It is a unique situation given that this situation is not normal, occurring perhaps 1 or 2 times per year at the most. However, the main characteristics of the process are kept.
	Researcher	Generic yet unique	It is generic in the sense that the production is nothing new and is always done, yet it is unique given that this situations are atypical and bring new variables in the table (i.e. time constraints and extra production demand)
<b>S4</b>	<b>Group Discussion</b>		
The participants exchange points of view and clarification upon the reasoning of each actor. No ideas should be eliminated and all actors should be given a chance to contribute and that discussion on all reasoning is made.			
<b>S5</b>	<b>Voting and ranking</b>		
The participants vote upon the classification, prioritizing the reasoning from the different actors. Immediate results are given. The process should respect the decision making practice which was defined earlier in this stage. In this case, the result is proposed by the researcher: <b>the classification is that of generic yet unique to the situation.</b>			

Table d.21 Situation classification using a nominal group technique

## Stage 2

### Stepladder Technique

Round	Actor	Input
1	AV	Having in optimal state machinery and human resources
	Planning	A trusty procedure so that the correct material is given and all elements are correctly assigned
	Quality	Ensuring that qualified personnel are used in the process
	Plant Manager	To identify available resources and make best use of them. Facilitate support and resources.

		Perhaps negotiating with client
	Human Resources	Good assignation of resources.
2	The means that is found most important is selected. In this case, this could be: <i>To correctly assure the availability of the correct resources.</i>	

**Table d.22 Stepladder Technique to come up with means to achieve the desired objective between 5 actors.**

Round	Actor	Input
1	AV	Wrong maintenance schedule. Wrong information on resource capacities.
	Planning	Wrong information on resource capacities.
	Quality	Wrong evaluation on resources capabilities as to have wrong qualified personnel and tools.
	Plant Manager	Overstepping regulations and law requirements when assigning and using different resources.
	Human Resources	Not complying with labor regulations and laws. Not complying with environmental and social aspects.
2	The problems that may be most critical for reaching the objective are selected. This are: <i>Bad management of resource distribution and assignment</i> <i>Not complying with law and environmental regulations</i>	

**Table d.23 Stepladder Technique to come up with problems to reach the desired objective based on selected means.**

### Assessing information completeness of problem definition

	AV	Planning	Quality
<b>Current Information</b>	-Production capacities -Machinery status and availability -Information from similar past production, including estimated cost and time -Labor status, qualification and availability	-Material requirements -Capacity to deliver material -Product description -Planning department resource availability and qualifications	-Quality specifications -Tools and tests required for product
<b>Needed information</b>	-Resources availability -Resource qualifications -Production capacity	-Product description -Status on material delivery and information on material requirements -Resource availability	-Results from tests/inspections -Resource capacity for inspection
<b>Information missing?</b>	No	Yes	Yes
<b>Who provides this information?</b>	The information can be gotten from AV and other actors.	Planning and maybe suppliers	-Planning must give product description -The rest from Quality
<b>Risks</b>	-Wrong capacities and projections. -Bad evaluation of status and qualifications of resources	-Wrong information on specification of material -Materials not on time -Wrong delivered material	-Not optimal disposal of instrument -Not specialized personnel during inspections

	-Wrong resource assignment -Deviation from correct product	-Wrong resource assignment	-Inspections not made on time/correctly
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Table d.24 Overview of current and missing information upon the problem and which risks are present.

	<b>Human Resources</b>	<b>Plant Manager</b>
<b>Current Information</b>	-Costs of new personnel -General Labor Laws -Environmental and Safety Regulations	-Client requirements
<b>Needed information</b>	-Resource requirements by AV -Labor laws, environmental and safety regulations	-Status of production -Cause of the problem
<b>Information missing?</b>	Yes	Yes
<b>Who provides this information?</b>	Resource requirements from AV	AV, Quality, Human Resources, Planning
<b>Risks</b>	-Not complying with laws and regulations -Not having required resources in time -Not having correct resource requirements	Wrong information

Table d.24 Overview of current and missing information upon the problem and which risks are present.

### Stage 3

#### Stakeholder Analysis

	<b>AV</b>	<b>Planning</b>	<b>Quality</b>	<b>H.R</b>	<b>Plant Manager</b>
<b>Interest</b>	Production Efficiency	Costs	Quality Assurance	Secure qualified personnel availability	Profit, client satisfaction, security, social and environment responsibility
<b>Desired situation</b>	Comply with the 30% increase while minimizing costs, risks to security of personnel and machine, securing quality and on-time delivery.	Comply with the 30% increase securing material delivery while analyzing why this increase was not detected before and with time.	Comply with the 30% increase while securing that the quality of the product is kept high. No rejections or customer complaints.	Comply with the 30% increase assuring that no laws or regulations are violated	Comply with the 30% increase while securing social, security, quality, functional, and client responsibilities.



<b>What do you want from this actor?</b>	-Information on production capacities -Information on production times -Information on extra personnel costs -Agile, reasoned quick decisions on-line	-Information on material costs -Information on extra personnel costs -Information on specification of material (i.e. model, quantity, etc.)	-Information on specification of material given by Planning -Information on quality tests to be done -Information on extra personnel costs -Information on specialized quality inspectors (if needed)	-Availability of human resources -Costs of new personnel -Extra time costs -Coordinate extra hours of personnel or new hiring and capacitation	-Support and authority to decision maker to have resources to work with.
<b>How could this actor halt the effectiveness of the decision?</b>	-Wrong capacities and projections. -Bad estimation of machinery status -Wrong personnel assignment -Deviation from correct product	-Wrong information on specification of material -Materials not on time -Wrong delivered material	-Not optimal disposal of instrument or specialized personnel	-Not having human resources available in time -Violations on regulations and laws.	-No involvement on situation
<b>Influence on decision</b>	High	High	High	High	High
<b>Dedicated actor?</b>	Yes	Yes	Yes	Most probable	Yes
<b>Network link</b>	-Information from Planning. -Mutually dependent on function by Human Resources. -Their reach can depend on the involvement of the Plant Manager. -Its action influence what Quality can do	Their information has a direct effect on what AV does.	Dependent on production process efficiency and punctuality to allow a correct inspection of products	Mutually dependent on the information AV gives to them	AV is dependent on his involvement
<b>Resources</b>	Process and knowledge	Process and knowledge	Process and knowledge	Knowledge	Knowledge
<b>Power</b>	High	High	High	High	High

Table d.25 Updated Stakeholder analysis for Stage 3 of Radiall's case study.

**Stage 4**

**Suggested Qualitative CBA**

	<b>Option 1 – Hire extra personnel</b>	<b>Option 2 – Habilitate second shift</b>	<b>Option 3 – Break personnel schedules</b>
<b>Costs and Others</b>			
Process capacity			
Maximum Volume capacity			
Legal costs			
Environmental costs			
Security risks			
<b>Benefits</b>			
Profit			
Client’s satisfaction			
Total product value			
<b>Benefits minus Costs</b>			

Table d.26 Example of proposed Qualitative CBA to be used at stage 4 for the Radiall’s case.

**Feedback**

1. *What is your opinion about the process that this proposed framework suggests?*  

The proposal is very workable and amiable to the current culture of problem-solving. It brings to light some elements not normally considered in our site, such as risk analysis and the potential elements of dysfunction that an actor can bring to the table.
2. *How much does this framework process differs from the process of decision making that you currently use at Radiall?*  

Not much, as we consider our site to be atypical in that sense. Team Problem Solving is common, and alignment to customer satisfaction is clear and non-debatable.
3. *Do you see any additional value in using this framework process?*  

Yes, as it follows some of the current management tools derived from the scientific approach, like doing 5 why analysis and cause-effect evaluation.
4. *What would limit Radiall to follow this framework process?*  

Nothing, it is very much in alignment with current management style.
5. *What are the shortcomings you perceive in the proposed framework process?*  

Potentially over-analytical, or subject to power debating.

6. *Would you include all or parts of the framework into your current decision making processes?*

Yes, in fact we will follow current case outcome to see if any learning can be made for problem solving.

7. *Which benefits do you perceive that using the proposed framework might bring to manufacturing companies?*

Many; we are very performance accountable based on the industry sector we serve, which is aerospace manufacturing, and we see opportunity for any company that applies scientific method problem solving.

8. *Speaking specifically of Radiall, by following the proposed framework process in this case situation, which results would you expect to have? Would a decision be more rapidly taken? Would a decision be taken with less conflict and more support? What would be the impact on the various criteria?*

We feel a more accurate permanent corrective action & system improvement will be achieved.

9. *Is this framework feasible to use in manufacturing companies in terms of time and resources?*

Yes

10. *Do you think that the suggested techniques are appropriate? If not, why?*

Very appropriate since it is practical, logical and simple.

11. *What is your opinion on the conclusions given throughout the first stages? Are they correct and usable?*

There are more variables to consider per actor, but yes, it touches the main items

12. *What is your opinion on the suggestions drawn for the last 2 stages? Are these usable, of value and true? Do they bring new facts? Could they help achieve better results?*

Yes, as the analysis of each actor is being discussed, it bring organized exposure of the point of view of each player, giving the work group a digestive capacity of the issue from each actor's angle.

13. *Comparing this process to the one you currently are taken, do you consider there is an added value if this framework process is used? Do you consider that the results would differ greatly from the ones using your current decision making process?*

They do not differ, but there is certainly a clear lesson on improvement and broad analysis capability that we can learn and implement.

**Table d.27 Feedback from Mr. Yepis for Radiall's case study**

## Annex E

### **Multi-actor and decision making techniques explanation**

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The purpose of this Annex is to explain in general terms those techniques that are suggested by the researcher to be used at the different stages of the proposed framework. This is to help the reader know about these techniques, their use, and the way to utilize them. Furthermore, it will help the reader know how the information used on the practical cases was gotten from and why.

#### **E1. Stakeholder analysis**

A stakeholder or actor analysis provides a structured inventory of the parties and their interests to get an overview of the situation. Therefore, stakeholder analysis is an analysis of all relevant actors. We refer to actors instead of parties which include both individuals and groups like institutions. All these actors can change an existing situation by their priorities or characteristics (i.e. interests, value systems). A stakeholder analysis is the process of identifying the actors that are likely to affect or be affected by a decision or action, and sorting them according to their impact on the action and the impact the action will have on them. This information is used to assess how the interests of those actors should be managed.

Stakeholder analysis is frequently used during the preparation phase of a process to assess the attitudes of the actors regarding the potential changes. Stakeholder analysis can be done once or on a regular basis to track changes in stakeholder attitudes over time. In this framework, a stakeholder analysis is suggested to be used at the preparatory phase of the process and during the process. It is also suggested to be done on a periodical basis.

Stakeholder analysis has the goal of developing cooperation between the actors and, ultimately, assuring successful outcomes. It is important to identify all relevant actors for the purpose of identifying their success criteria and turning these into quality goals.

Based on all the different ways for actor mapping that are available, the researcher employs in this framework a mapping of actors that go along with the purpose of the research. This is, that explores variables that are of high interest in the decision making process. Normally, the most commonly used dimensions to study include: power (high, medium, low), influence (high, low), need (high, medium, weak), potential for threat and/or cooperation (high, medium, weak), dependency (high, low), among others.

Stakeholder analysis helps with the identification of actor's characteristics such as interests, networks, resources, dependencies, objectives and values. Furthermore, it helps identifying mechanisms to influence other actors and gain insight into potential risks. It identifies key and critical actors to involve in the process, as well as negative actors.

During the framework, the following tables could be used. The first one, used in the empirical cases, shows a matrix with different variables under study of relevant actors: it is an inventory of actors. The second table is called an actor matrix after Enserink et al (2001) and it shows the level of dedication and importance of actors towards the decision in order to visualize potential threats or support and possible coalition forming. This is done by dividing the actors based on their joint or opposed interests and perceptions.

	Interest	Desired situation	Influence on decision	Dedicated actor?	Network link	Resources	Power	Other factors of interest
Actor 1								
Actor 2..								
:								
..Actor n								

Table e.1 Simple inventory of actors matrix

	Dedicated actors		Non-dedicated actors	
	Critical Actors	Non-critical actors	Critical Actors	Non-critical actors
<b>Joint perceptions and objectives (to the effectiveness of decision in decision-maker's view)</b>	Probable participant, potential allies <i>(Powerful allies)</i>	Possible participant and potential allies <i>(Allies)</i>	Indispensable allies but hard to engage	Actors not to be involved (in first instance)
<b>Opposed perceptions and objectives</b>	Probable participant, potential opponents <i>(Biting dogs)</i>	Possible critics <i>(Barking dogs)</i>	Potential enemy but not active <i>(Sleeping dogs)</i>	Actors that do not need attention (in first instance)

Table e.2 Actor matrix

## E2. Nominal group technique

The nominal group technique (NGT) is a decision making technique to use within multiple size groups, who want to make their decision quickly, as by a vote, but want everyone's opinions taken into account. This differs from traditional voting where only the largest group is considered. The method of tallying is the difference. First, every actor of the group gives their view of the situation, with a short explanation. Then, as a tweak to the original process, the actors discuss on any doubt about the explanation and reasoning about that explanation. Originally, duplicate solutions are eliminated from the list of solutions; however, this technique is suggested to be used in this framework as a way to select a classification for the situation at hand, and criteria to be evaluated upon, so what is wanted would be duplicate ideas. At the end, the actors proceed to rank the selections and select upon this.

For the original purpose of this technique, some facilitators encourage the sharing and discussion of reasons for the choices made by each actor, as to identify common ground, and a plurality of ideas. In the basic method, the numbers each solution receives are totaled, and the solution with the highest (i.e. most favored) total ranking is selected as the final decision. But as stated, there are variations on how this technique is used. For example, it can also identify strengths versus areas in need of development, rather than be used as a decision-making voting alternative. Also, options do not always have to be ranked, but may be evaluated more subjectively as it occurs within this proposed framework.

As compared to interacting groups the NGT groups provide more unique ideas, more balanced participation between actors, increased feelings of accomplishment, and greater satisfaction with idea quality and group efficiency.

NGT is particularly useful: when some group members are much more vocal than others, when some group members think better in silence, when there is concern about some members not participating, when the group does not easily generate quantities of ideas, when all or some actors are new to the team, when the issue is controversial or there is conflict, and when there is power imbalance amongst the actors.

One major advantage of NGT is that it persuades actor participation since some actors may be reluctant to suggest ideas because they are concerned about being criticized. Second, some actors are reluctant to create conflict in groups. NGT has the clear advantage of minimizing differences and ensuring relatively equal participation. It may also, in many cases be a time-saving technique. Another advantage includes producing a large number of ideas. A major disadvantage of NGT is that it lacks flexibility by being able to deal with only one problem at a time.

The following table presents how the technique is used in the proposed framework.

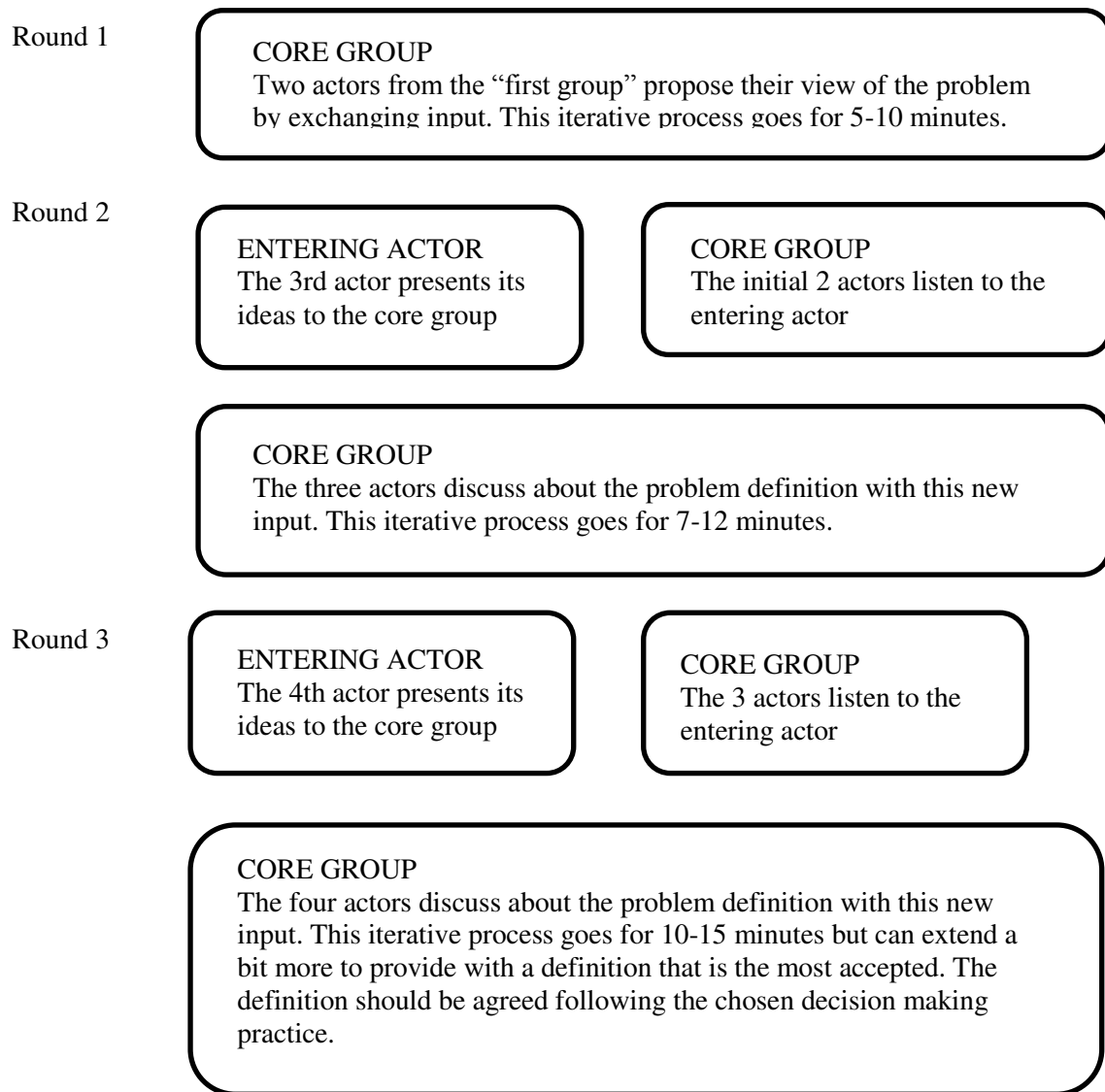
<b>S1</b>	<b>Introduction and explanation</b>		
The purpose is to ....			
<b>S2</b>	<b>Generation of ideas</b>		
The participants will write down the ideas concerning the purpose. In this stage, the participants should not consult or discuss with the other actors. Approximate duration:5 min.			
<b>S3</b>	<b>Group discussion</b>		
	Participants share the ideas they wrote down and their reasoning. The round continues until all ideas have been presented. There is no debate of ideas at this stage. Approximate duration: 5-10 min		
<b>Round</b>	<b>Actor</b>	<b>Classification</b>	<b>Reasoning</b>
1	Actor 1		
	Actor 2		
<b>S4</b>	<b>Group Discussion</b>		
The participants exchange points of view and clarification upon the reasoning of each actor. No ideas should be eliminated and all actors should be given a chance to contribute and that discussion on all reasoning is made. Approximate duration: 10-15 min			
<b>S5</b>	<b>Voting and ranking</b>		
The participants vote upon the classification, prioritizing the reasoning from the different actors. Immediate results are given. The results should respect the decision making practice which was defined earlier in this stage.			

**Table e.3 A nominal group technique process**

### **E3. Stepladder technique**

The stepladder technique is intended to facilitate group effectiveness by structuring the entry of the actors into the decision making process. The first step of this technique involves having a 2 actor sub-group that begins with the discussion on the task at hand. After a fixed time interval, another actor joins the group and presents his or her ideas concerning the task without any prior influence from other actors. This three-person group then discusses the ideas. Again, after a fixed time interval, another actor joins the discussion process by first presenting his or her ideas with no prior influence. The process continues in steps until all actors have systematically joined the group. When

this occurs, the group arrives at a final choice. Figure 10 displays the stepladder technique as applied to a four-person group.



**Figure 12. Simple stepladder technique for a problem definition between 4 actors**

The technique has four requirements: First, each actor is given sufficient time to think about the task before entering the group. Second, the new member must make a preliminary solution presentation before hearing the group's ideas. Third, sufficient time is allocated to discuss the problem as each person is added. Fourth, the final decision occurs only after the entire group is formed. These steps make for all actors to participate and contribute.

Research on the effectiveness of the stepladder technique has shown that stepladder groups produce higher-quality decisions than conventional groups. The number of studies that have tried to test the stepladder technique empirically is limited, but the results are encouraging (Orpen, 1995).

The table below presents how this technique has been used in the framework of this framework. The word Enter refers to when a new actor enters into the process. This actor presents his input to the rest of the actors already in the process without debate from them. After input presentation, a discussion starts involving now all members already present in the group.

Round		Actor	Input
1	ENTER	Actor 1	
	ENTER	Actor 2	
	At this point, these 2 actors discuss their ideas.		
2	ENTER	Actor 3	
	After this, the 2 actors from the previous round present their “agreed” common views to the entering actor. After this, a discussion is set and the 3 give once again their views.		
		Actor 1	
		Actor 2	
		Actor 3	
3	The agreed choice is made		

Table e.4 A presentation on the use of the stepladder technique

## E4. Qualitative CBA

Cost–benefit analysis (CBA) is a systematic process for calculating and comparing benefits and costs of a certain project, or in this case, of scenarios to come up with a decision. In this paper, the researcher refers to a qualitative CBA to express that often intangible variables will be used and thus, sometimes monetary values will not be the center of attention. For example, if one benefit or criteria is customer satisfaction, a value could be given based on the box score of client satisfaction as shown in Annex C3. A cost- benefit analysis is done to determine how well, or how poorly, a planned action will turn out. CBA has two purposes:

1. To determine if it is a sound decision (justification/feasibility),
2. To provide a basis for comparing plan of actions. It involves comparing the total expected cost of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.

Therefore, CBA is used to evaluate the desirability of a decision. A cost benefit analysis finds, quantifies, and adds all the positive factors (i.e. benefits). Then it identifies, quantifies, and subtracts all the negative ones (i.e. the costs). The difference between the two indicates whether the planned action is advisable. In this framework, the options are compared through the criteria defined within the decision making process. Therefore, it may be that no costs are present in one evaluation or no benefits in another one. As it was expressed in earlier lines, because monetary values are not the main focus since intangible criteria can be present, there needs to be a way to establish which the best option on paper is. To help with this, the researcher proposes to use a grading system for each criterion among the available options. Suppose a criterion is time and the decision maker values higher that time is minimized; then, the different options will give a different value of time depending on the information brought by the “core group”. After putting down all the values from all the options, a grading system is made where 1 should be given to the most preferred option based on the value. Following this example of “time” as a criterion, having higher value a minimal time value, and supposing 2 options, of score 30 days and 90 days respectively, the grade “1” will be given to option 1 (30 days) while the grade “2” will be given to option 2 (90 days). This process of grading will continue until all criteria are evaluated like this. At the end, the best option should



be that option which scores the *lowest sum out of all the criteria*. In other words, for each option, a sum will be made on that same column of all the criteria grades concerning that option and the option with the lowest sum is the best option on paper, considering the value the “core group” gives to each criteria and among the options. However, this is the best option on paper since the “core group” could base their decision on intangible factors to still prefer another option. Therefore, the Qualitative CBA output is a great guideline, but a guideline at the end of the day.

The following is a list of steps that comprise a generic qualitative cost-benefit analysis.

1. List alternative options
2. Include relevant actors (in this framework, “the core group”)
3. Measure all cost and benefits elements (i.e. all the criteria). The “core group” should analyze and agree on the validity of the information of these measurements.
4. Predict outcome of these elements over a relevant time period which should match the time period used when evaluating the decision.
5. For each criterion, grade the different options based on the value of preference where 1 should be the most preferred option according to the measurement.
6. Sum all grades for each option. The option with the lowest sum is the *theoretical best*.

The following table shows how the CBA technique was used in the framework. As a reminder, one option should preferably always include “doing nothing” (staying on current course of action).

	<b>Option 1</b>	<b>Option 2</b>	<b>Option 3</b>	<b>Option 4</b>
<b>Criteria involving Costs</b>				
Cost 1	10	20	30	40
<i>Grade</i>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Cost 2	6	6	8	2
<i>Grade</i>	<b>2</b>	<b>2</b>	<b>4</b>	<b>1</b>
<b>Criteria involving Benefits</b>				
Benefit 1	5	6	3	5
<i>Grade</i>	<b>2</b>	<b>1</b>	<b>4</b>	<b>2</b>
Benefit 2	70	67	45	50
<i>Grade</i>	<b>1</b>	<b>2</b>	<b>4</b>	<b>3</b>
<b>Other criteria</b>				
Criteria n				
<i>Grade</i>				
<b>Total Grade</b>	<b>6</b>	<b>7</b>	<b>15</b>	<b>10</b>
<b>Recommendation</b>	<b>A</b>	<b>B</b>	<b>D</b>	<b>C</b>

Table e.5 An example of a Qualitative CBA as used in the proposed framework.

## E5. What-if analysis

What if analysis is a technique that can help to identify risks and opportunities and, therefore, help making better decisions about the future. A “what if analysis” is planned to be used within this framework at 2 stages: with a explorative focus on the third stage of the framework to assess scenarios and its qualitative consequences; and with a descriptive focus on the 4<sup>th</sup> stage to help assessing future plans of actions to deal with potential scenarios once a decision has been taken.

This type of analysis can help in a variety of ways like:

- Identifying critical assumptions or comparing alternative numerical values.
- Guiding future data collections
- Detect the changes of important criteria and its effects
- Optimizing resources allocation
- Model simplification.

Common disadvantages of this type of analysis lie that it can often be too complex depending on the nature of the study; especially if it involves sophisticated planning, forecasts or new models. Corporate data is complex and the tools at hand, like spreadsheets, for these models can become messy and slow to handle the complexity. Thus, many people run away from using this technique. That is the reason why the technique is meant to be used on its simplest form in this framework.

Further considerations when using this analysis are that variables are often interdependent, which makes examining them each individually unrealistic. Also, often the assumptions upon which the analysis is based are made by using past experience/data which may not hold in the future. Finally, assigning a maximum and minimum value is open to subjective interpretation. This sort of subjectivity can adversely affect the accuracy and overall objectivity of the analysis. However, by using a multi-actor analysis approach this risk of subjectivity presence can be minimized.

The general idea of how this technique can be used within the framework process is as follows:

1. Explain the purpose of this activity
2. Brainstorm on options to be used on the following stage for which a decision will be taken on which of these options to select when considering quantitative and qualitative factors.
3. Discuss about how each set of criteria (benefit, costs, etc.) could be changed or affected based on the following:
  - a. How the criteria could be changed, specially by the risk factors
  - b. How the criteria could change the risk factors
  - c. Which other things could the criteria changeThese will serve as the basis for the identification of scenarios. Develop a causal map to facilitate the view on the previous discussion.
4. Discuss what-if these previous scenarios were to happen. Name these events to facilitate identification.
5. Set up general plans of action for each of these events.

*And at stage 4:*

1. Based on the decision made, assess again plans of actions for the scenarios of interest

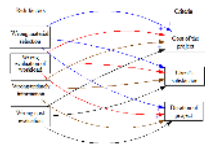
<b>S1</b>	<b>Purpose of this analysis</b>																		
	The purpose of this analysis is to conduct a scenario study of how the risk factors could change and have an effect on the established criteria, in order to draw general plans of action and be prepared in case these scenarios occur.																		
<b>S2</b>	<b>Brainstorm of options for decision based on the problem and situation</b>																		
	The “core group” actors give ideas on which possible decision could be made (i.e. options) in order to reach the desired objectives based on the defined problem based on which options are most feasible to implement in terms of time, resources, logistics and practicability.																		
<b>S3</b>	<b>Causal map and identification of cause/effect on criteria by risk factor changes</b>																		
	 <p>Develop a causal map to help visualization of cause and effect relationships between criteria and risk factors to determine which risk factors are the most critical to analyze under scenario study</p> <p>Make a further assessment of the cause and effects relationships</p> <table border="1"> <thead> <tr> <th>Risk factor</th> <th>Criteria</th> <th>Effect</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Risk factor 1</td> <td>Criteria 1</td> <td></td> </tr> <tr> <td>Criteria 2</td> <td></td> </tr> <tr> <td>Criteria 3</td> <td></td> </tr> <tr> <td rowspan="3">Risk factor 2</td> <td>Criteria 1</td> <td></td> </tr> <tr> <td>Criteria 2</td> <td></td> </tr> <tr> <td>Criteria 3</td> <td></td> </tr> </tbody> </table> <p>The “core group” analyzes this and chooses out of these risk factors the one that is most probable to happen and is most critical to simplify the process of identifying scenarios. In other words, when evaluating the risk factors that are most probable to occur, the “core group” evaluate the impact of such factors to choose the one that had the highest impact on the established criteria, and therefore, on the objective attainment.</p>		Risk factor	Criteria	Effect	Risk factor 1	Criteria 1		Criteria 2		Criteria 3		Risk factor 2	Criteria 1		Criteria 2		Criteria 3	
Risk factor	Criteria	Effect																	
Risk factor 1	Criteria 1																		
	Criteria 2																		
	Criteria 3																		
Risk factor 2	Criteria 1																		
	Criteria 2																		
	Criteria 3																		
<b>S4</b>	<b>Identification of Scenarios</b>																		
<b>S5</b>	<b>Set up general plans of actions for each scenario</b>																		

Table e.6 What if analysis applied in the propped framework