Business Development in the field of Low Current Technology at Cegelec Le Mans

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Abstract – The purpose of this study is to suggest improvements in the field of low current technology for the office of Cegelec which is located in the French town of Le Mans. Cegelec is an international technological service company.

First, this master’s thesis report draws the current situation of Cegelec Le Mans thanks to enterprise architecture models, and the study of a specific project as well as different previous projects. The current state is then confronted to the theoretical model lean product development in order to suggest improvements and future scenarios.

Keywords: Enterprise Architecture, EA, Lean Product Development, LPD, Improvements, Cegelec, Low Current Technology
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I would also like to thank my two supervisors at KTH, Evelina Ericsson and Markus Buschle for their help, advices and support during this project.

Then I would like to show my gratitude to the employees of Cegelec who accepted to spend time for me by answering my questions. I would like particularly thank Daniel Carême who helped me a lot with questions both about low current technology and models for enterprise architecture.
<table>
<thead>
<tr>
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<th>Write-out</th>
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<tbody>
<tr>
<td>BMS</td>
<td>Building Management System</td>
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<tr>
<td>BPMN</td>
<td>Business Process Modeling Notation</td>
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<tr>
<td>CCTV</td>
<td>Closed-Circuit TeleVision</td>
</tr>
<tr>
<td>CE</td>
<td>Concurrent Engineering</td>
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<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>CIO</td>
<td>Chief Information Officer</td>
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<tr>
<td>DFSS</td>
<td>Design For Six Sigma</td>
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<tr>
<td>EA</td>
<td>Enterprise Architecture</td>
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<tr>
<td>ERP</td>
<td>Enterprise Resource Planning</td>
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<tr>
<td>HVAC</td>
<td>High Voltage Alternative Current</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
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<td>IIS</td>
<td>Internet Information Services</td>
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<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>LAN</td>
<td>Local Area Network</td>
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<td>LCT</td>
<td>Low Current Technology</td>
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<tr>
<td>LDAP</td>
<td>Lightweight Directory Access Protocol</td>
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<tr>
<td>LPD</td>
<td>Lean Product Development</td>
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<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
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<tr>
<td>MPLS</td>
<td>MultiProtocol Label Switching</td>
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<tr>
<td>OF</td>
<td>Optical Fiber</td>
</tr>
<tr>
<td>PABX</td>
<td>Private Automatic Branch eXchange</td>
</tr>
<tr>
<td>SAP</td>
<td>Systems, Applications and Products for data processing</td>
</tr>
<tr>
<td>SQL</td>
<td>Structured Query Language</td>
</tr>
<tr>
<td>TOGAF</td>
<td>The Open Group Architecture Framework</td>
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<tr>
<td>UML</td>
<td>Unified Modeling Language</td>
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<td>VSM</td>
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1. Background

Developing business is crucial for companies in order to increase benefits. Having different market positions is an important issue which is efficient to develop business. To do so, companies have to adapt themselves to the market evolution so that they can stay at a competitive level.

1.1. Background on the enterprise

Cegelec is an integrated international group providing technological services to companies, public and local authorities. Cegelec provides a complete service cycle to the client, from design to installation and maintenance, working with its own specialized teams. In 2009 the revenues of company was 2.8 billion Euros. The company was created in 1913 but its name “Cegelec” was given for the first time in 1989. The Group employs 25,000 people and is present in 30 countries (mainly in Europe), through a network of 200 agencies and over 1,200 offices which are autonomous. Cegelec's activities are centered on five core businesses [1]:

- Energy and electricity
- Automation, instrumentation and control
- Information and communication technologies
- HVAC, Mechanics
- Maintenance and services

The office of Le Mans is situated in the West of France. This office was created in 1974. The work range of the projects is about 100 km around Le Mans. All offices are connected together but they work independently and do not deal with the same business. For example in Le Mans, the projects focus more on the energy and electricity field whereas other offices focus more on information and communication technologies and so on. There are 57 employees in Le Mans’ office: there is one head manager, project managers, designers, administrative employees and workers who physically build the projects. In order to have a general overview of the work done in the office, some examples of previous works done during the last years are listed: a) renovation of the electricity network of the hospital of Le Mans (2007, 1700K€), b) installation of the electricity network for the tram of Le Mans (2007, 2380K€), c) installation of a fire safety system for a printing house in Saint Hilaire Le Châtel (2009, 54K€) [2].

The group Cegelec is composed of different divisions. The whole group is divided into different countries. The French subdivision is divided into 6 counties: West, Paris, North-East, South-West, South-East and Mid-East. The county subdivision is divided into agencies and agencies into offices. The office of Le Mans is included into the agency “Portes de Bretagne” which is a part of the Western county of France [2].
1.2. Background on Low Current Technology

Energy and electricity can be divided into two main parts: high current and low current technology. High current technology includes all the technologies that produce or carry energy (power plants, transmission/distribution lines, electricity networks, etc). The renovation of the electricity network of the hospital and the installation of the electricity network for the tram are two examples of projects dealing with high current technology. Low current technology is an important expanding field of business which includes all the technologies that carry information thanks to electricity, e.g. the installation of a fire safety system for the printing house. These technologies are numerous and can be divided into 11 subparts: fire safety, fire extinction, sound emission/transmission, video surveillance (CCTV=Closed-Circuit Television), access control, intrusion, telephone switch, intercom, computer network, nurse call and BMS (Building Management System). Every day these technologies are evolving and it is important to have a good knowledge on these before starting any business. In order to understand this field better, all of these 11 subparts of low current technology are explained more precisely in the next page [3][4][5].
Fire safety deals with the detection of fire. The fire systems are composed of detectors, alarm, etc.

Extinction is composed of the technologies which aim to extinguish a fire like sprinklers. When a fire has been detected thanks to a fire safety system the extinction system tries to extinguish it.

Sound is composed of all the systems which can be used to broadcast sound for music like in concert room but also the systems used to broadcast emergency signals when there are problems like a fire.

Video surveillance is used for the surveillance of specific areas: banks, military areas, industries, etc. The main goal is to protect areas against crimes but it can also be used for observation of processes in industry plants. The videos can be recorded.

Access control is a system which allows controlling access to areas or resources thanks to physical facilities or computer-based information system. Cegelec do projects with automatic access control (for example, access by magnetic cards).

Intrusion is composed of all the systems that aim to avoid not-allowed individuals to enter a private space. The systems are for example alarms and detectors.

Telephone switch is a system which connects the phone calls. It is mainly used for internal calls in a company.

Intercom is a stand-alone electronic communication system used for limited or private dialogue.

Computer network deals with the lines to carry information through the Internet (optical fiber for example).

Nurse call is composed of all the systems which allow the patients to call the nurse when they have a problem or need something. It is also composed of all the warning signals which inform the nurses that a patient needs help.

BMS (Building Management System) is a system that controls the building’s electrical and mechanical equipment. For example it can control lighting, fire safety systems, access control, power systems, heating and so on.
1.3. Background on projects in low current technology at Cegelec

Different data on 72 previous projects realized between 1997 and 2009 have been collected. Relevant information are represented through the following figures. Data are shown in annex 1 [6][7].

![Figure 2](image2.png)

**Figure 2 Evolution of the number of projects in the field of low current technology at Cegelec**

![Figure 3](image3.png)

**Figure 3 Evolution of the budget in the field of low current technology at Cegelec**

The Figure 2 and Figure 3 enable to say that Cegelec had a prolific time in the field of low current technology. Between 1998 and 2003 they had many projects (Figure 2) and the budget was significant (Figure 3). After a drop between 2003 and 2008, the numbers have increased since 2008. Interviews with employees lead to know that around 2003 a department of the company which worked exclusively in low current technology had stopped. The main reason was an economic one.
The Figure 4 and Figure 5 show that the situation has been modified. Before 2003, there were several projects in telephone switch, whereas after few of these projects have been done since the demand in this field decreased. However the demand in fire safety and sound systems seem to increase. It can be explained by the fact that before 2017 all the fire safety systems will have to be changed because of a recent law. Indeed in the past detectors were ionic and used radioactive material. Now they are forbidden and have to be replaced by optic detectors [27]. Since sound systems are often linked to fire safety systems, the demand in sound systems increase as well.

The people who worked with telephone switch were highly qualified in this field. That is the main reason why Cegelec did so many projects: employees were highly qualified, which
guaranteed customer’s satisfaction. But telephone switch is now less attractive than fire safety, but most of the workers are the same, so they are not as qualified in fire safety as in telephone switch. Therefore some training is needed.

**The reasons of the golden years in Low Current Technology**

Different reasons can explain the golden years at Cegelec Le Mans in the field of LCT. Information of this section comes from interviews with employees and data collected from previous project.

First, the market was prolific mainly in telephone switch.

Moreover, employees were highly skilled in telephone switch and a department worked exclusively in low current technology.

Furthermore, Cegelec worked with one main supplier: Alcatel (for telephone switch). Employees knew the equipment of this manufacturer well, so it was easier to install and to repair it when there were problems. Furthermore, a strong link between the company and the supplier was established.

The main reason of the end of these golden years is the evolution of the market. The demand in telephone switch decreased and employees did not update their skills or were fired (or resigned). Finally, the concurrence in the LCT increased.

However Cegelec would like to increase its business in LCT and come back to prolific years. This is one of the main reasons which motivated this study.
2. Goals

2.1. Problem description

Cegelec wants to develop business in the field of low current technology. The aim of this study is to suggest improvements based on the enterprise architecture of Cegelec. Consequently, Cegelec will evaluate the establishment of the suggested improvements.

2.2. Goals description

The first goal of this project is to develop an enterprise architecture model of Cegelec focusing on the field of low current technology. Based on a meta-model and using concepts developed by ArchiMate, a business architecture is created to show the business processes and the organizational structure of the enterprise. This provides a global overview on how the company works. Subsequently, information architecture is mapped. Information is an important aspect for all the companies and to describe the information architecture is necessary and shows the most important data and data structures in the company. Linked to information which is used in the company, information application architecture is drawn and shows the link between the applications used in the company. And finally the infrastructure architecture is developed to show what kind of hardware, networks, and so on, are used for the information system.

The second goal is to describe the way how projects are done and handed in Cegelec. The way how a project is managed is presented and a specific example of project is shown (all the processes from the beginning to the end of the project will be covered). This specific project is one which was realized during this study. This point is a practical and particular example of the first goal which is more general. It uses the language developed in the first goal.

The third goal starts with a study of the theoretical model lean product development (LPD) shows how development projects should be done idealistically. The concepts and main principles of LPD are presented. Then a comparison between the models of Cegelec and LPD points out some possible improvements. These suggestions of improvements are presented and the modifications on the current state are drawn (new models).
3. Methods

In this chapter the different methods which are used in order to fulfill the goals are described. The workflow that has been carried out is represented in the following figure:

![Figure 6 Master's thesis workflow]

#### 3.1. Data collection

Data of this study have been collected from different sources as shown in the following table:

<table>
<thead>
<tr>
<th>Data Collection</th>
<th>Sources of information</th>
</tr>
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<tbody>
<tr>
<td>Interviews</td>
<td>Project managers</td>
</tr>
<tr>
<td></td>
<td>Project designers</td>
</tr>
<tr>
<td></td>
<td>Foremen</td>
</tr>
<tr>
<td></td>
<td>Workers</td>
</tr>
<tr>
<td></td>
<td>One employee of the purchase department</td>
</tr>
<tr>
<td></td>
<td>One employee of the financial department</td>
</tr>
<tr>
<td></td>
<td>CEO</td>
</tr>
<tr>
<td></td>
<td>Secretary</td>
</tr>
<tr>
<td>Email exchanges</td>
<td>One employee of the IT department</td>
</tr>
<tr>
<td>Archival records</td>
<td>Data from previous projects</td>
</tr>
<tr>
<td>Direct observations</td>
<td>Different processes</td>
</tr>
<tr>
<td>Documentation</td>
<td>See chapter 9 References</td>
</tr>
</tbody>
</table>

Figure 7 Sources of information

The choice of the studied project corresponds to a project which starts a few weeks before the beginning of this master’s thesis and which finished during the second half of this master’s thesis. Documentation linked to the project, direct observations and interviews with the people who worked on the project (the foreman D. Derouet, the worker W. Sylvestre, the project manager N. Vallée, the project designer D. Carême, the employee of the purchase department S. Porte, and the secretary V. Croissant) are the main sources of information.
3.2. Literature review

Different kinds of literature are used for this study. First, scientific books and articles from student library, personal library or the internet are the sources of information of the theory part. Chapters about enterprise architecture and lean product development are built on scientific papers (references [8] to [25]).

Then, documentation which comes from Cegelec is used in order to create the models (general architectures and specific project). General documentation on the projects such as ‘Infrastructure SI Cegelec’ [29] and ‘Quality Management Handbook of the Enterprise’ [28] are good sources of information. ‘Quality Management Handbook of the Enterprise’ is a paper written in 2006 which explain how projects should be done, but there is a gap between what is written and the way actual reality presents itself. Archival documentation linked to specific projects (and especially the project which is studied precisely in chapter 6) such as needs, technical and administrative documentation [30], offers [31], certificates done at the end of the projects [7] are also used. It is not an easy work to find relevant information in the archival records since information is not saved or deleted because it was too old. Furthermore information from low current and high current technology are mixed whereas the study focuses on low current technology.

Finally, the presentation of Cegelec and low current technology is built on documentation downloaded on the intranet of Cegelec or on the internet (references [1] to [5]).

3.3. Modeling

In this study, models aim to represent the enterprise architecture of Cegelec (see chapters 5 and 6). The whole enterprise is represented. The meta-model is built on literature and adapted to the case of Cegelec.

The models are done using a language based on ArchiMate concepts. There are some variances in order to have more understandable models. For example, in the organization architecture (Figure 26) positions which belong to Cegelec but are not located in Le Mans have another color (red and dark green). The main source of information in order to do the models is the observation of the processes. In order to have a better knowledge on how the company works, being involved in processes seems to be the best way. Different processes have been studied by being involved in them. Complementary information comes from interviews.

Since there were no models established before and it was the first time this kind of study was done in Cegelec Le Mans, it was important that data were checked. It was the goal of regular meetings done with the CEO, S. Kemel. These meetings occurred at least once a month. The project designer specialized in low current technology D. Carême was sometimes present. Models have been improved and modified many times until to obtain satisfactory models validated by the CEO.
This study considers the whole company but it could focus on one department. The study could then produce more accurate models with attributes which could be analyzed in a second time. But since it was not expected to do that and since it would need much more time, it has not been done.

3.4. Analysis

The comparison between the models of the company and the theoretical model LPD highlights potential improvements of the current state of the company. If a concept or principle advocated by LPD is applied at Cegelec, the situation could be regarded as good. However, if it is not the case it leads to an improvement’s suggestion. Different suggestions of improvements are thereby presented. Some of these improvements lead to new enterprise architecture models.

It is able that the comparison with LPD would lead to other suggestions of improvements since there are not concrete tools with the current state as incoming data and the improvements as an outcome but most of them would be similar or close.

3.5. Discussions and conclusion

The results are then discussed and the problems which could have to face Cegelec to implement the suggestions of improvements are presented. A conclusion is set on how the future can be for Cegelec in the field of low current technology.
4. Theory

In this chapter the theory useful for the next chapters is described. Theory about enterprise architecture and lean product development is developed in the following pages.

4.1. Enterprise architecture

Introduction to enterprise architecture

Enterprise architecture has become an indispensable field at companies and in academia. The MIT Center for information systems research has established a formal definition of enterprise architecture: “Enterprise architecture is the organizing logic for business processes and IT infrastructure reflecting the integration and standardization requirements of the firm’s operating model”. M. Lankhorst defines it as “a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise’s organizational structure, business processes, information systems, and infrastructure” [8]. This means that enterprise architecture uses models in order to help the communication between the stakeholders (individual, team or organization with concerns relative to a system [8]) and to facilitate the understanding of the properties of the complex systems they represent [15]. Moreover, it provides a holistic view of the enterprise [8].

Enterprise architecture focuses on modeling. Models are specified as graphical models or drawings over how various things and phenomena are related and influenced. They could be about the representation of real things and their properties, but it could also be a description of abstract notions. Models are powerful tools mainly for two reasons: “Firstly, they help us to focus on the important issues when contemplating a certain problem”, and secondly, “models provide different people with a common view of an issue. Models both provide a common language that helps us to communicate with each other and also guide us to focus on the same issue” [9].

Modeling

Enterprise architecture uses frameworks which define how to organize the structure and views associated with the enterprise architecture. Common enterprise architecture frameworks are Zachman framework [10] or TOGAF (The Open Group Architecture Framework) [11]. These frameworks offer structures for the models.

Understanding here models as abstractions or simplifications of the real world. The essence of modeling is to capture interesting phenomena in the real world in order to underline or identify interesting properties about the phenomenon. So, modeling can be seen at the end as a filter of the real world [9], as in the following illustration:
The choice of the filter which will enable to draw relevant models is determined by the meta-model. The meta-model is “the language in which we describe the phenomena of the real world” [9]. This means that the meta-model defines the modeling language and how the enterprise architecture models have to be instantiated. Basically a meta-model is made up of entities and relations between the entities. An example of a meta-model for a general company is illustrated with the following figure:

![Figure 8 Conceptual picture of modeling; ([9], p214)](image)

![Figure 9 Example of a meta-model of an enterprise](image)

The meta-model gives the rules in order to instantiate models. The models are more suitable to the real aspect they describe, and they correspond to an inferior degree of abstraction than the meta-model. However the instantiation of the whole meta-model would result in a very complex and huge instantiated model. Therefore, models result from subsets...
of the meta-model which are called viewpoints [9]. In this case, the models are also called views. The IEEE 1471 standard defines view as “a representation of a system from the perspective of a related set of concerns” and viewpoint as “a specification of the conventions for constructing and using a view; a pattern or template from which to develop individual views by establishing the purposes and audience for a view and the techniques for its creation and analysis”. For instance, a viewpoint of the previous meta-model could be the following one if what is of interest is the infrastructure of the enterprise:

Figure 10: Viewpoint focusing on infrastructure
**Viewpoints developed in this study**

A good viewpoint is one that helps stakeholders with their concerns. Many different viewpoints can be created. In this study five viewpoints: organizational, business process, information, application and infrastructure are used. The instantiation of these viewpoints leads to views, which are also called architectures in this study (organizational architecture, information architecture, etc.)

**Organizational viewpoint:** It depicts the formal structure of an enterprise [9]. This viewpoint is presented in Figure 11. Organization units are departments, divisions of the enterprise but can also be used to represent other actors such as customers [9]. This viewpoint gives an overview of how the enterprise is organized and how people are related.

![Figure 11 Organizational viewpoint](image)

**Business process viewpoint:** The process is the core of this viewpoint which describes the dynamic behavior of the enterprise. Processes can be broken down into sub-processes [9]. They generate, and are affected by, events. A process can be performed by a position (filled by persons) and can create business objects. The Figure 12 represents this viewpoint.

![Figure 12 Business process viewpoint](image)
**Information viewpoint:** It is often considered as the bridge between the business and the information system [9]. It focuses on modeling the structure among information objects [9]. As shown in the following figure information is related to other information, and realizes business objects which can be related to one another.

![Figure 13 Information viewpoint](image1)

**Application viewpoint:** This viewpoint describes which applications communicate with others (which applications are related to each other) [9]. The basic form of this viewpoint is shown in the following figure:

![Figure 14 Application viewpoint](image2)

**Infrastructure viewpoint:** It is a technical-oriented viewpoint. Devices that realize software and networks are the components of it, such as shown in Figure 15. Hardware is the servers, the computers etc. executing instructions for software. Application software is all types of software and networks are the connections and protocols used to connect devices and software. [9]

![Figure 15 Infrastructure viewpoint](image3)
As a complement of the previous viewpoints, and in order to have better understanding of the enterprise architecture, alignments which link the different views can be used. Different alignments are possible but three are done later in this study: Information-Application, Business-Application and Application-Infrastructure alignments. Viewpoint-alignments are parts of the meta-model which bridge the previous viewpoints. Alignments are the instantiation of these viewpoint-alignments which are presented in the three next figures.

**Information-Application alignment:** It is the bridge between information and application views. It links information to the applications which use or create information as shown in the following figure.

![Information-Application alignment](image)

**Business-Application alignment:** This alignment shows which application that supports the different processes.

![Business-Application alignment](image)

**Application-Infrastructure alignment:** It links application and infrastructure views and describes software, devices and networks which are necessary so that applications can run.

![Application-Infrastructure alignment](image)

**The modeling language**

There are many different modeling languages as for instance UML (Unified Modeling Language) or BPMN (Business Process Modeling Notation). The modeling language used in this study is based on concepts developed by ArchiMate modeling language. ArchiMate has been developed by the Open Group. This organization defines itself as “a vendor- and technology-neutral consortium, whose vision of Boundaryless Information Flow™ will enable access to integrated information within and between enterprises based on open standards and global interoperability” [12].

The architectural framework used in Archimate is shown in Figure 19. This framework consists of three layers made up of three aspects of the enterprise architecture [8].
The three layers can be defined as following:

**Business layer:** it is basically what the company does, the products and services it delivers to customers. It describes also how the company is organized, and who is in charge of each task or process.

**Application layer:** this layer helps and supports the first one using software applications

**Technology layer:** the applications need some infrastructure to be run. The technology layer is for example made up of computers, networks or servers.

Then these layers are divided into three structures:

**Passive structure:** it represents information and all the aspects that can be changed but that are not evolving continuously.

**Behavior structure:** it represents the dynamic things such as business processes for example.

**Active structure:** all the components that perform the behavior structure.
The following figure summarizes the representation and the meaning of the main entities used by ArchiMate. Some of these are used in the chapter 5 Enterprise architecture of this study.

![Summary of language notation](image)

The goal here is to give some definitions and clues about key entities. Most of the definitions are inspired by those given by Open Group and M. Lankhorst.

**Business process:** It represents a set of actions that are performed in order to achieve one or several goals. Some of the processes are directly linked to the activity of the company (production of goods or services) and others are related to the administration, finances, marketing, and so on. One business process can trigger one or several others [14].

**Business event:** A business event is defined as something that happens (internally or externally) and influences behavior (business process) [13].

**Business actor:** A business actor is defined as an organizational entity capable of (actively) performing behavior [13].

**Business Object:** It is a passive component directly related to the business processes. A business process can create, modify, delete or simply use one or several business objects. A business object is realized by two different entities: a representation or a data object [14].

**Product:** A product is defined as a coherent collection of services, accompanied by a contract/set of agreements, which is offered as a whole to (internal or external) customers.
[13]. In this study, the product is considered as representation which is the perceptible form of the information carried by a business object [13].

**Application service:** It is usually software or a part of it which is designed in order to perform some tasks useful for a process. It is quite easy to understand that a manufacturing process for example uses an application in order to run some machines. A process in a research and development department uses different applications of design [14].

**Data object:** A data object is defined as a coherent, self-contained piece of information suitable for automated processing [13]. In this study, information corresponds to data object.

**Device:** A device is defined as a physical computational resource [13].

**Network:** A network is defined as a physical communication medium between two or more devices [13].

The following figures summarize the representation and the meaning of the main relations used by ArchiMate. Some of these are used in the part 5 (Enterprise architecture) of this study [13].

<table>
<thead>
<tr>
<th>Relation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Association</td>
<td>Models a relation between objects that is not covered by another, more specific relationship.</td>
</tr>
<tr>
<td>Access</td>
<td>The access relation models the access of behavioural concepts to business or data objects.</td>
</tr>
<tr>
<td>Used by</td>
<td>The used by relation models the use of services by processes, functions, or interactions and the access to interfaces by roles, components, or collaborations.</td>
</tr>
<tr>
<td>Specialisation</td>
<td>The specialisation relation indicates that an object is a specialisation of another object.</td>
</tr>
<tr>
<td>Realisation</td>
<td>The realisation relation links a logical entity with a more concrete entity that realises it.</td>
</tr>
<tr>
<td>Assignment</td>
<td>The assignment relation links units of behaviour with active elements (e.g. roles, components) that perform them, roles with actors that fulfill them, or artifacts that are deployed on nodes.</td>
</tr>
<tr>
<td>Aggregation</td>
<td>The aggregation relation indicates that an object groups a number of other objects.</td>
</tr>
<tr>
<td>Composition</td>
<td>The composition relation indicates that an object consists of a number of other objects.</td>
</tr>
<tr>
<td>Grouping</td>
<td>The grouping relation indicates that objects belong together based on some common characteristic.</td>
</tr>
</tbody>
</table>

*Figure 21 Structural relations ([8] p 106)*
| **Triggers** | The “triggering” relation describes the temporal or causal relations between behavioural elements, interactions, and events. |
| **Flow** | The “flow” relation describes the exchange or transfer of, for example, information, goods, or value between processes, functions, interactions, and events. |
| **Junction** | A “junction” is used to connect dynamic relations of the same type. It can be used to model splits or joins of triggering or flow relations. |

The following figure summarizes the entities which are used later in this study. Moreover, they are classified in the ArchiMate framework. The entities which are involved in the different viewpoints and alignments appear.

![Figure 22 Behavioural relations (p. 108)](image)

**Figure 22 Behavioural relations (p. 108)**

The following figure summarizes the entities which are used later in this study. Moreover, they are classified in the ArchiMate framework. The entities which are involved in the different viewpoints and alignments appear.

![Figure 23 Summary of main concepts used in this study](image)

**Figure 23 Summary of main concepts used in this study**
4.2. Lean Product Development

The origin and the meaning of lean

Before describing lean product development it seems important to explain the signification of lean and its origin. Lean comes from “lean production” or “lean manufacturing” which was a revolutionary approach to manufacture and was contrasted with mass production. Toyota is considered as the founder of this method. Eiji Toyoda (a manager of Toyota) with the help of Taiichi Ohno (a production manager) developed a new way to manufacture cars focusing on the quality to reduce production costs and increase customers’ satisfaction. To increase the quality, Toyoda’s family set changes: they trained their employees, gave more money to older employees in order to keep them, organized workers into teams, included the suppliers as a member of the production system. [16]

Lean Concepts

The basic purpose of lean production is to reduce waste production or non value adding activity and to maximize profits. Six of the main lean concepts: Waste, Value, Value Stream, Flow, Pull and Perfection are defined in this chapter.

Waste: There are seven kinds of waste that lean aims at avoiding: overproduction, waiting, transportation, unnecessary inventory, inappropriate processing, unnecessary motion and defects (sometimes there is an additional one called the 7+1 one which is the underutilization of human resources) [17].

Value: Womack defines Value in [18] as “a capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer”. Defining accurately the value of a product and the way to produce it effectively (low cost and quick time) is a major challenge of lean.

Value Stream: Womack describes Value Stream in [18] as “the specific activities required to design, order, and provide a specific product, from concept to launch, order to delivery, raw materials into the hands of the customer.” Lean method aims at identifying the value stream in the enterprise which means knowing the value added in each process and detecting waste [19].

Flow: Flow is defined in [18] as “the progressive achievement of tasks along the value stream so that a product proceeds from design to launch, order to delivery, and raw materials into the hands of the customer with no stoppages, scrap or backflows.” Ensuring the continuous flow of the value by deleting obstacles is an issue of lean [19].

Pull: Pull is described in [18] as “a system of cascading production and delivery instructions from downstream to upstream activities in which nothing is produced by the upstream supplier until the downstream customer signals a need.”

Perfection: Lean aims at obtaining perfection thanks to continuous improvement. It is obvious perfection is impossible but imperfections can be deleted so that the results are better
and better. However if the benefits of an improvement are not good compared to the time and the money spent, the improvement might not be taken into account [19].

**Lean in product development**

Lean could be applied in many different areas. The area which is under interest in this study is product development. Product development is defined as “a set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product” by Ulrich in [20].

Applying lean in product development implies to adapt the definition of the previous wastes. In [22] Walton summarizes the list of wastes that LPD aims at avoiding.

**Overproduction**
- Too Much Detail
- Unnecessary Information
- Redundant Development (Reuse not practiced)

**Transportation**
- Information/Software Incompatibility
- Communications Failure
- Not Standards Based
- Multiple Sources
- Incompatible destinations requiring multiple transports

**Waiting**
- Information Created Too Early
- Late Delivery of Information
- Unavailable Information
- Quality Suspect

**Inappropriate Processing**
- Unnecessary Serial Processing
- Lack of Needed Information
- Poor/Bad decisions affecting future
- Excess/Custom Processing
- Not processed per process
- Too Many Iterations/Cycles

**Unnecessary Data Conversions**
- Excessive Verification
- No Transformation Instructions
- Decision Criteria Unclear
- Working With Wrong Level of Detail
- Propagation of Bad Decisions
- Processing of Defective Information
- Multiple Tasking When Not Required

**Unnecessary Inventory**
- Too Much Information
- Incomplete Content
- Poor Configuration Management

**Unnecessary Motion**
- Information User Not Connected to Sources Requiring Manual Intervention
- Information Pushed to Wrong People

**Defects**
- Quality Lacking or Suspect
- Conversion Error
- Wrong Level of Information
- Incomplete Information
- Ambiguous Information
- Inaccurate Information
- Tolerance Exceeded
- Poor Configuration Management
LPD Principles

The following section describes different principles of LPD. They aim at avoiding or deleting any waste and have their fundamentals on the lean concepts.

- **Understanding the customer’s needs**

The customer is the arbiter who decides what he wants and how much he can pay for it. The customer’s needs are the central point of LPD. Understanding as well as possible the customer is necessary to avoid many unnecessary costs during the development phase. To do so, a close relation with the customer has to be created since he decided what value for the product is. Questions such as “will the customer pay more for this improvement?” are the kind of questions development team has to wonder before doing anything [21].

- **Human organization: skilled people involved in a project managed by one engineer in a cross functional integration**

Skilled people: Employees have to be highly skilled and to keep a high level thanks to trainings or meetings with other employees, with suppliers, etc. Continuous and applied learning enables to start every new project with a higher knowledge than the previous one and saves time (deleting waste) by using solutions already developed [25]. LPD promotes continuing education of the employees and learning from each other within a project [19]. Doing regularly meetings with the whole project team is a key to avoid problems or to delete them.

Involved people: Everybody in the company, from the worker to the board of directors, have to integrate the LPD philosophy. Furthermore every member of a project’s team can give his point of view, has to feel himself as an important member of the project and have responsibility. The members’ communication is determinant [23].

One project manager: A project leader is designated to manage the project during the whole development life: from the design to the production. The choice of this chief engineer is consequential and depends on the kind of project (a huge and complicated project and an innovative project are not managed in the same way) [21]

Cross functional integration: The units which are involved in the project (design, purchase, manufacture, and so on) work together and have regular meetings. The goal of this organization is to exchange skills, avoid problems and also create a team spirit. [21]

- **Suppliers as a part of the company**

Suppliers are considered as a part of the company in the LPD philosophy. If they do not apply the lean philosophy they are trained in this method. Suppliers intervene at the early steps of each project in order to give advices on it and to present the technological solutions that they are able to develop. LPD imposes high expectations from the suppliers but it is important to respect them and to help them to improve. However it is also important to
challenge them because it is a way for them to improve themselves and a way for the company to save money. LPD leads to strong links with the suppliers [24].

- **Learning from the past**

  Every product development gives lessons which have to be useful for the future. For example a defect which occurred during the development of a product will not occur anymore. Furthermore, a solution developed in order to solve a problem will be stored so that it can be used for a future project. The time spent to develop this solution will be reinvested for future projects. Feedbacks of every project are a way to solve many future problems.

- **Process**

  Every process has to focus on the main goal: the customer’s needs. Processes have to add value to the product. An efficient tool to detect non value adding processes is value stream mapping (see chapter Tools and Techniques). LPD aims to standardize the processes thanks to check lists and schedules. They are created with the feedbacks of the previous projects (it is consequential to learn from the past). Standardization enables to notice easily and quickly any problems and new employees can quickly be integrated in the processes [21].

- **Digging the root cause of every problem**

  LPD urges to dig every problem to its root cause to find a durable solution and to avoid having the same problem over and over again for every new product [25]

**LPD Tools and Techniques**

There are different tools and techniques which are used within LPD, however only two will be described in this chapter: Value Stream Mapping (VSM) and Concurrent Engineering (CE).

- **Value Stream Mapping (VSM)**

  VSM is a process mapping technique which aims to delete non value adding activities which are considered as waste. This technique is performed in three stages: the current state is drawn (flow of processes), then the desired state is drafted and finally the two states are compared (non value adding activities are detected) and the way to go from the current state to the desired state is defined [25].

- **Concurrent Engineering (CE)**

  CE is also well known under the name simultaneous engineering. It can have two applications. First, different activities are performed in parallel in order to save time [25]. Then a second application is to concept the same product in the same time by several teams. The best solution will be selected but other solutions can be combined with the selected one in order to have an optimized solution. Moreover they are stored and could be useful for future projects [19].
5. Enterprise architecture

In this section enterprise architecture models of Cegelec focusing on the field of low current technology are shown. Based on a meta-model done by using concepts developed by ArchiMate, the business, the organizational, the information, the application and the infrastructure architectures are presented.

5.1. Meta-model

Based on [9][11], a meta-model which aims at modeling the company thanks to ArchiMate concepts can be done:

A process can contain or interact with one or several processes. It can generate or be affected by events. It can generate business objects which are realized by product or information. A process can be performed by positions filled by persons.

Application support processes and can communicate together. It can use/create information. An application is realized by system software which is realized by devices which can be connected to networks.

![Figure 24 Meta-model](image-url)
5.2. Organizational Architecture

The viewpoint which leads to the organizational architecture [2] is the following one:

![Organizational Architecture Diagram]

Figure 25 Viewpoint 1 - Organizational Architecture

![Organizational Architecture Diagram]

Figure 26 Organizational Architecture
In order to avoid having too many pieces of information on the Figure 26 the organization units do not appear. The following table gives the organization unit for each position:

<table>
<thead>
<tr>
<th>Position</th>
<th>Organization unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEO</td>
<td>Board of directors</td>
</tr>
<tr>
<td>CIO</td>
<td></td>
</tr>
<tr>
<td>Local CEO</td>
<td></td>
</tr>
<tr>
<td>IT manager</td>
<td>IT department</td>
</tr>
<tr>
<td>Project Manager</td>
<td></td>
</tr>
<tr>
<td>Project Designer</td>
<td></td>
</tr>
<tr>
<td>Foreman</td>
<td>Operational unit</td>
</tr>
<tr>
<td>Worker</td>
<td></td>
</tr>
<tr>
<td>Warehouse</td>
<td></td>
</tr>
<tr>
<td>Purchase</td>
<td>Purchase department</td>
</tr>
<tr>
<td>Marketing</td>
<td>Marketing department</td>
</tr>
<tr>
<td>Administrative</td>
<td>Administrative department</td>
</tr>
<tr>
<td>Secretary</td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>Financial department</td>
</tr>
<tr>
<td>Quality and safety</td>
<td>Quality department</td>
</tr>
</tbody>
</table>

There is a local CEO who manages the office of Le Mans. The CEO manages two offices, the office of Le Mans and the office of Laval. The board of directors is composed of directors who manage the different subdivisions of the group Cegelec. The IT department and the CIO are the same for the whole group and are located in Paris (that is the reason why they are in red). Purchase, marketing, quality and safety departments are common for all the offices of the agency (that is the reason why they are in a different green).

The project manager is the central point of the project. He is the link between the customer, the suppliers and internal positions (projects designers, foremen, purchase).
5.3. Business Architecture

The viewpoint which leads to the business architecture [28] is the following one:

![Diagram of Business Architecture]

Figure 27 Viewpoint Business Architecture
Figure 28 Business Architecture
The starting point is the needs which will lead to trade action. This process consists on finding needs of customers or prospects mainly by meeting them or reading press. Based on the needs it is possible to do and deliver an offer. Trade talks will lead to modifications of this offer if it does not fit exactly to the customer needs.

Then the offer can be accepted or refused. If it is refused the information will be saved and it will be the end of the project. If the offer is accepted, the project is registered with a project number.

The project can be designed. The project is theoretically created. Based on the previous process, it is possible to purchase the equipment. Then the project can be realized concretely.

When the realization is finished, tests are done to check if all is ok. During the reception tests and checks are done by the customer and final documentations are delivered to the customer. At the end of the project information regarding to this project are stored.

The customer service starts at the end of the project if there are problems or to do other projects linked to the previous one.
The most important business processes are detailed more precisely.

**Offer**

The needs of a customer or a prospect (prospect means someone who never worked with Cegelec previously) can come from a direct request or a public request. These public requests are available on the internet or on press. In order to get them, it is important to monitor all the requests which are published and to update them. The difficulty is to define which requests will be chosen to be answered. The CEO and the local CEO decide which requests will be answered.

Then the request is registered with a serial number. After that the customer’s specifications are studied by the project manager or a project designer to know exactly what he wants and what will be provided to him. A technical paper is created to explain the solutions which will be provided. Suppliers are contacted to know the price of their products for this project.

Based on this study, it is possible to do a quotation to define the price the customer will have to pay. This is a delicate point because it is very difficult to guess exactly how long it will be necessary to do this action; you cannot guess the difficulties which can occur and so on. The quality of the quotation is mainly based on the knowledge of the project designer/manager. If the quotation is not accurate, some problems will be presented: if it is too low, the company is likely to lose money, if it is too high, the company might not be chosen to do the project.

When it is validated by the CEO, the offer is delivered to the customer. A classical offer is composed by the quotation, the technical documentation and administrative documentation.

![Figure 29 Process “Offer”](image-url)
Design of the project

When the offer is accepted by the customer and registered as a new project, it is designed. The project is done theoretically. It is designed on a computer with CAD software and then it is printed on paper. All the equipments are set on site plans so that the workers will be able to know where and how he will set it concretely. Synoptic are also done. A time plan is defined to know exactly how long the project will last, when it will start and finish. A resource plan is done to know how many people are necessary. The plans and the technical documentation are checked and validated by the customer. If he is not satisfied, modifications are done until he is satisfied.

![Design of the project](image)

Figure 30 Process “Design of the project”

Purchase equipment

When the project has been designed precisely it is possible to know what equipment will be needed. The project manager can do a purchase request that will be studied by the purchase department. They will request and evaluate the price options with other suppliers. After validation the purchase department attempts to negotiate a price reduction with suppliers. When the order is signed, the equipment will be received at the warehouse or directly on the site, it will be checked and then the bill will have to be paid by the financial department. So, it is important to get the equipment not too late to avoid the delay on the project but not too early to avoid stock and expenses on equipment not immediately required.

![Purchase equipment](image)

Figure 31 Process "Purchase equipment"
Realization of the project

The people who will work on the project have been defined previously by the project manager. At the starting day, the foreman creates work teams and shares the work between teams. After that, the work is done concretely. In the same time resources (work time and equipment) are checked to monitor if the project is going according to plans. Furthermore there are meetings to check if everything is going well.

Figure 32 Process "Realization of the project"
5.4. Information Architecture

The information architecture [6] can be represented by the Figure 34 which is based on the viewpoint Figure 33:

As it is the case for all companies, the extent of information is numerous, and therefore representations can be complex. In this model only the main pieces of information are represented and mainly those directly linked to the projects.

Needs are realized by the request of a customer. These needs are related to an offer which is realized by administrative documentation (insurance, certificates of the company and so on), the quotation of the project and technical documentation regarding to the technological solutions which are proposed.

Maps, plans and equipment lists are related to this offer. Maps are realized by site plans which locate the place where the equipment is installed and synoptic. Information about the supplier and the equipment realize the equipment list.

Information entitled “Final documentation” is related to “Technical documentation” established for the offer.
5.5. Application Architecture

The main applications [6] used in the company and their links are described by the Figure 36 which is based on this viewpoint:

![Figure 35 Viewpoint Application Architecture]

![Figure 36 Application Architecture]

**WORD 2003**: It is a word processor. In Cegelec, it is used for different uses but mainly in order to write documents for the customers or prospects.

**EXCEL 2003**: It is a spreadsheet application. There are many uses of it in Cegelec: manage the planning of projects, the budget, store information and so on.

**LOTUS NOTES 8.5**: It is an email application but not only. It is also a calendar and can also be useful for other applications; it is a personal information manager. In Cegelec they also used it to save and share easily information like quality processes. Moreover, employees upload their work time on it.

**INTERNET EXPLORER v7**: This application aims at connecting to the Internet.
**SAP:** It is an ERP (Enterprise Resource Planning) which is very useful to manage the customers, the bills, the sales, the resources and so on.

**OPTIMA v9:** It is a billing application.

**AUTOCAD:** It is a CAD (Computer Aided Design) application. At Cegelec, it is used to design virtually the projects.

**CANECO:** It is another CAD application but it is specially used for electrical representation. For example you can design and calculate the length of a cable regarding to the voltage and the current which have to go through this cable.

**DIALUX:** It is an application, which aims to calculate the power of lights depending on different parameters.

**ADOBE READER/PDF CREATOR:** These applications aim at reading and creating pdf files.
5.6. Infrastructure Architecture

The infrastructure architecture [29] can be represented by Figure 38 which is based on the viewpoint Figure 37:

Figure 37 Viewpoint Infrastructure Architecture

The infrastructure of the office of Le Mans is composed by computers which are connected together thanks to a LAN. The operating system is Windows XP. There are two local file servers to store data, which are useful for the office of Le Mans and not for the others. The networks of other offices are in the same way.

The local network of Le Mans is connected to a datacenter through a MPLS network (orange is an internet supplier in France). This datacenter is composed by four servers: Notes 8.5 server (for the personal information manager Lotus Note 8.5), LDAP server, SAP server, Workplace server.

This datacenter is connected to the Internet through a firewall and to another datacenter which is not situated in the same city. This datacenter is composed of five servers: Navision server, Citrix server, BSQL, IIS Webinterface and another LDAP server.
5.7. Alignments

In order to have a better understanding of the previous models and to create bridges between them three alignments are drawn in this chapter. The first one mixes information and applications the second one is a mix between business model and applications, and the last one is a combination of applications and infrastructure.

For all the alignments it has been chosen that the applications Internet Explorer, Adobe Reader and Pdf Creator would not appear in order to have more understandable alignments.

Alignment 1: Information - Application alignment

![Information - Application alignment diagram](image-url)
Alignment 2: Business - Application alignment

Needs

Trade Action

Trade Talks

Accepted offer

Register the project

Design of the project

Purchase equipment

Realization of the project

Tests

Reception

Save Information

Send bill

End of the project

Customer service

LOTUS NOTES 8.5

WORD 2003

SAP

EXCEL 2003

AUTOCAD

OPTIMA VB

DIALUX

CANECO

Figure 40 Business - Application alignment
Alignment 3: Application – Infrastructure

For this alignment, only the example of the application Lotus Notes is represented. However for the other applications the representation would be similar.

![Diagram of Application - Infrastructure alignment](image-url)

Figure 41 Application - Infrastructure alignment
6. Study of a specific project

The previous chapter showed how the company works in general cases. In this chapter a specific and concrete project is presented. The processes, the applications, the people involved in and information which go through the processes are described.

6.1. Presentation of the specific project

The customer is the County Council of Sarthe which is a county located in the West of France. The project consists in installing a new fire safety system in a school situated in Le Mans. The school is composed of four buildings: two buildings for classes and two for student’s rooms [30][31].

The project can be divided into three steps:

6.2. Step 1: From the needs to the offer

On 20\textsuperscript{th} April 2010 the County Council published its needs. The CEO S.Kemel decided that the company would answer to this request. V.Croissant who is the secretary downloaded the main pieces of information and registered this request through the software SAP (“Register the request” Figure 42).

The customer’s specifications were studied based on downloaded information. To read it Adobe Reader has been used. Equipment documentation from suppliers is very important in order to choose the good product. To get more information internet explorer was necessary; to communicate with the customer and the suppliers, Lotus Notes has been used. The technical documentation has been created thanks to Word 2003 and Pdf Creator. The quotation has been done through Optima v9 (“Study of the customer’s specifications” and “Realization of the quotation” Figure 42).

When the offer (quotation and technical documentation) was validated by the CEO, the offer was delivered by V.Croissant who attached administrative documentation (insurance, standards and so on) on 14\textsuperscript{th} May which was the deadline. (“Deliver the offer” Figure 42)

On 31\textsuperscript{st} May, Cegelec was chosen in order to realize the project [30][31].
Figure 42 From the needs to the offer
6.3. Step 2: From the offer to the start of the realization

Upon the customer’s acceptance of the project, it was registered through SAP by the project manager. Then the project designers realized it virtually. Based on the offer delivered to the customer and to the needs, the project designer D. Carême did this work on the paper and then the project designer H. Berthelot did the site plan and the synoptic through the software Autocad (“Realization of the plans, drawings, technical documentation” Figure 43).

The project manager, N. Vallee realized precise time plan and resource plan on Excel. Thanks to a link between Excel and SAP he could download it directly on SAP. Thanks to that, the forecasted plans were available on SAP and N. Vallee was able to check and monitor the project (“Realization of time and resource plan” Figure 43).

The customer checked and validated the project (“Check and validation” Figure 43).

After that, purchasing the equipment was able. The project designer did the order through SAP (“Purchase request” Figure 43); the purchase responsible, M.Kermagoret studied the request validated it and negotiated with suppliers (“Validation and negotiation” Figure 43). The final equipment was slightly different from the order that is why there is a new equipment list (“Equipment List 2” Figure 43). After few days equipment arrived at the warehouse. They were checked by the warehouseman P.Marchand.

Then, the bill of the equipment has been paid (“Payment” Figure 43) and everything was ready to start the realization of the project.
Figure 43 From the offer to the start of realization
6.4. Step 3: From the realization of the project to the end

Before starting the concrete part of the project, a meeting was held with the project manager, one project designer and the foreman. The goal of this meeting was to explain the project to the foreman and to answer his questions in order to avoid future problems. The project manager explained the time to do the project and the workers he would work with (“Start Meeting” Figure 44). Then the foreman created work teams and dealt the work.

Thanks to synoptic and site plans, workers and foreman started to install cables on the 28th of June. Then the fire safety system was installed. During the installation which lasted two months there were meetings to know if there were problems or not (they are not represented in Figure 44 in order to have a clearer figure).

After that, the final steps started: tests, inspections with the customer to check if everything was going well. When the customer was satisfied, information was saved by the project manager through SAP and by the secretary through Excel (general information on the project) (“Save information” Figure 44).

Subsequently, the financial employee, S.Porte, sent the bill, and the project was considered as finished. From the start meeting to the end of the project, the project manager did resource management (time and equipment management). He managed the time spent for the project to be sure that they were on time and did not waste time. He managed equipment to be sure that they did not use more material than what was planned. He put data about equipment in SAP (“resource data” Figure 44). Data come from the foreman. Data about time are put through Lotus Notes and they are automatically uploaded to SAP thanks to a bridge between Lotus Notes and SAP.

Since the end of the project, the manager has been available to the customer for problems assistance or for possible future projects (“Customer Service” Figure 44).
Figure 44 From the realization of the project to the end
7. Improvements

7.1. Suggestions of improvements and future scenarios

Based on the situation described in the previous part, some suggestions of improvements appeared, and are presented in the following pages. These suggestions are inspired from the comparison between the theoretical model LPD and the current state of Cegelec (Enterprise architecture and Study of a specific project).

- Suggestion 1: Close link with the customer to understand well the needs

When a customer launches a request for a project, its needs are not always clear and easy to understand. For a public request (Figure 42), needs are formal and written on paper but in other cases (Figure 28 and Figure 29) they can also be a verbal exchange. In both cases (more in the second one than in the first one) the issue is to understand well and accurately these needs. Indeed, the content or information can be incomplete. This waste (page 29) has to be deleted in order to avoid creating others. A good communication founded on intense exchanges with the customer will delete every lack of information and understanding. A close link with the customer will have a double consequence: this one knows the company and sees the competences and the seriousness of the employees who look for to propose an accurate offer and then he has confidence on the company since he knows his needs are understood.

This improvement modifies the two processes “Offer” and “Design of the project”. The modifications appear in red in the following figures.
- **Suggestion 2: Suppliers as a part of the company**

A strong link with the suppliers is a crucial area of improvement. A faithful relation has to be created. They have the knowledge on their technologies and on the innovations. In order to fulfill exactly what the customer wants, suppliers are the key. Furthermore they can propose innovations which can save time or money during the realization process (Figure 28 and Figure 32). To do so, suppliers have to be selected and informed of the new philosophy of the company. Regular exchanges and meetings with suppliers are necessary. They are collaborators of the project. Exchanges have to be quick to delete waste as “late delivery of information” (page 28). Moreover, suppliers have to indicate the time necessary between the order and the reception of their products, respect it and reduce it wherever possible. It enables to avoid waste of time and to master the time and the transportation.

This improvement modifies the two processes “Offer” and “Design of the project”. The modifications appear in red in the following figures.

---

**Figure 47 Process "Offer" modified by suggestions 1 - 2**

**Figure 48 Process "Design of the project" modified by suggestion 1 - 2**
- **Suggestion 3: Continuous learning by trainings and meetings**

Employees are skilled and know perfectly their work. However the problem is, with the evolution of the market of low current technology (Figure 4 and Figure 5), the qualification of employees is not always adapted to the new type of projects. Indeed, for example some workers are skilled for telephone switch and few for fire safety whereas there are few projects in the first field and more and more in the second one. It is not a fatality. Internal and external (done by specialized organisms or suppliers) trainings can bring remedy to this problem. Moreover meetings between employees, with the suppliers are a way to exchange knowledge and to update skills and to develop new ones. For instance a project designer who masters application software can show and explain the functioning to another one so that in case of absence others are able to go on working. Training and updating skills in the field of low current technology is even more important than this field evolves quickly (the technical knowledge has to be often updated) and is governed by many standards which evolve as well.

- **Suggestion 4: Cross Functional Integration**

The different units of the company work together as it appears on Figure 26 with the project manager as center of projects. Each department seems to be involved in the project as described in the study of a specific project (chapter 6) or in the business architecture (Figure 28). However, as all the departments are not located in Le Mans (Figure 26) it is not easy to have regular meetings which can be a way of improvements. The team spirit cannot be created without these meetings.

- **Suggestion 5: A well defined project manager**

Because of the fact that there are not a project manager specialized in low current technology but a project designer specialized in this field (Figure 26), some responsibilities and activities which should be done by the project manager are done by the project designer. For example the purchase request has been done for the specific project by the project designer (Figure 43) whereas it should be done by the project manager (Figure 28). This mix between the two positions leads to problems since they are two interlocutors (waste of time, lack of communication) and the authority of the project manager decreases. For people who are linked to the project (employees of Cegelec but also external people as suppliers, customer and so on) it is important to have only one interlocutor.
- **Suggestion 6: Dematerialization of the offers**

  The offers are paper folders composed of administrative documentation (insurance, certificates of the company and so on), the quotation of the project and technical documentation about the technological solutions which are proposed (Figure 34). However, new legislation [26] allows to deliver the offer digitally. This method enables to save paper (and money), time (the offer can be delivered few minutes before the deadline) and transportation (which means save of time and money).

  This improvement modifies the process “Offer”. The modifications appear in red in the following figure.

  ![Figure 49 Process "Offer" modified by suggestions 1 – 2 – 6](image-url)
- Suggestion 7: Learning from the past – feedbacks and closing meeting

At the end of every project, feedbacks can be done and analyzed. These feedbacks would contain the good and the bad points which occurred during the project. The problems and the developed solutions have to be described so that they can be easily reused for future projects. A closing meeting during which these feedbacks would be discussed would enable to dig the root causes of problems and to avoid having the same problems over and over again. The closing meeting would be similar to the start meeting (Figure 44) and would aim at improving the situation for future projects.

This improvement modifies the business and information architectures. The modifications appear in red in the following figures:

![Figure 50 Business architecture (end) modified by suggestion 7](image)

![Figure 51 Information architecture modified by suggestion 7](image)
- **Suggestion 8: Standardization**

Standardizing some processes seems to be an interesting field of improvement. Checklists and schedules can be created for most of the processes but are mainly useful for the three processes: offer (Figure 29), design of the project (Figure 30) and realization of the project (Figure 32) since small mistakes or omissions can have huge consequences. However, as monitoring with time and resource plan is already done during the realization process, this suggestion would be more adapted for the processes offer and design of the project. For example, for the process offer two checklists can be created. One for checking all the main pieces of information before starting the process (to be sure the project is viable for the company before wasting time) and one before delivering the offer (to be sure not forget anything and everything is good). A schedule with the deadlines and the steps until the offer can be done, but it has to be adapted for every new project. For the process design of the project, similar checklists and schedule can be created. The people involved in the processes as well as the project manager would be the authors of the checklists and schedules.

This improvement modifies the business and information architectures. The modifications appear in red in the following figures:

![Figure 52 Business architecture (beginning) modified by suggestion 8](image)

![Figure 53 Information architecture modified by suggestions 7–8](image)
- **Suggestion 9: A summary to reduce redundant development between the two processes offer and design of the project**

After the offer has been delivered, it can take a long time before designing the project (chapter 6). Most of the work done for the offer has to be reworked because employees forgot and an offer is not as accurate as a design study. It is a waste of time to rework the same thing but an offer cannot be too much detailed because it can also be a waste of time if the offer would not be chosen by the customer. However a summary of every offer can be done. The goal is to have a bridge between the offer and the design study. It would remind the main points of the offer. This summary can be a standard paper containing the proposed solutions with synoptic, the contacts of suppliers, the particularities of the offer and the difficulties to know.

This improvement modifies the process “Offer” and the information architecture. The modifications appear in red in the following figures:
All these suggestions would significantly affect the way Cegelec do projects. The different modifications on the business architecture are shown in Figure 56. First, before answering to a customer request a prestudy would be done by the project designer. This prestudy uses a checklist and aim to ensure the project is viable for the company (is there enough time to create the offer?, are the required skills available at the company? and so on). As an outcome of this new process, a schedule would be created with the main deadlines of the projects.

Then, the process offer would change as shown in Figure 54. Exchanges with the customer and the suppliers would lead to a more accurate offer which would be sent to the customer as a digital file. Moreover, this offer would be checked one more time just before delivering it to the customer. At the end of the process a summary of the offer is created.

The next steps until the reception would be similar. A new process would appear, just after this reception. The project manager, the project designer and the foreman would discuss on the good and the bad points which occurred during the project. The goal is to reuse the solutions developed for this project and to avoid doing the same kind of errors for future projects. For example, for the specific project described in chapter 6 the feedback would explain how the project designer created evacuation plans whereas he never did that before. It could be useful for future projects because there are more and more projects in the field of fire safety systems as explained in part 1.3.
Figure 56 Modified Business Architecture
7.2. Discussions on the improvements

It is not a simple task to apply suggestions of improvements. Here are presented some constraints that can set obstacles to the previous suggestions.

- **For the improvements it is necessary to spend time which is a scarce resource:**

  In order to implement the previous suggestions it is necessary to spend time. This time will not be wasted but reinvested for the future. However it is not easy to find time because of the market pressure: there are always work to do. Moreover, the suggestions advocate more meetings between employees or with external actors such as the suppliers or the customers. The problem of lack of time is the same for all the actors since everybody is busy and the difficulty is to make them understand the benefits of these meetings for the future.

- **Trainings for employees are an investment:**

  Suggestion 3 supposed to offer trainings to employees. The trainings are an investment for companies and this investment expects to obtain results. However the danger is that nowadays employees change more often the company where they work. The challenge is to convince them to stay.

- **Projects do not have the same size:**

  Another constraint is the fact that the projects are numerous and do not have the same size. A huge project cannot be managed in the same way as a small one. The suggestions of improvements must be adapted to the projects. Perhaps it is not necessary to have a closing meeting for a small project (a feedback can be sufficient) whereas it seems to be necessary for a big project.

- **Until the offer the projects are not attributed**

  It is not easy to work on a project when it is not sure to obtain it. Some of the suggestions (for instance suggestion 9 and suggestion 6 for the first tries) supposed to spend more time on the offer whereas it is not sure to earn money with this one. However the wasted time will be saved later. The saved time for each obtained project should be higher than the wasted time for non-obtained projects. Moreover, suggestions of improvements should lead to increase the rate: number of obtained projects over number of delivered offers. It is one of the main goals of suggestions 1, 2 and 8.
Selection of the suppliers

There are many suppliers in every subpart of the field of low current technology (see section 1.2). Suggestion 2 advises to select suppliers. The criteria of selection, the numbers of suppliers are two questions which have to be answered. Furthermore, it is also important to challenge them: it is a way for them to improve themselves and a way for the Cegelec to save money.
8. Conclusion

8.1. Goal fulfillment

Goal 1: Create enterprise architecture models focusing on the field of low current technology

This goal is fulfilled by the chapter 5 Enterprise architecture. The models could be done with a higher or a lower level of accuracy or could focus more on a department of the company, but the choice has been done to represent the whole company.

Goal 2: Presentation and models of a specific project (from the beginning to the end of the project)

The chapter 6 Study of a specific project fulfills this goal. The choice of this project is not totally random. The project is one which happened during this study and it is a fire safety project which is the subpart of LCT which is developing nowadays.

Goal 3: Study of the theoretical model LPD and suggestions of improvements

This goal is fulfilled thanks to the subchapter 4.2 Lean Product Development which describes the main concepts and principles of LPD and the chapter 7 Improvements which presents suggestions of improvements. There are the result of a comparison between the current state of Cegelec and the theoretical model lean product development. The suggestions can be visualized in new models which have been created.
8.2. Future work

The main concern which is the logical continuation of this study is the way to implement the different suggestions of improvements so that the suggestions can become real.

However some of them have already been studied and have started to be implemented. Indeed, during regular meetings (with the CEO of Cegelec) which aimed at checking and supervising this study some suggestions had been evocated and the way to implement them discussed.

First, the suggestion 2 which suggests to consider the suppliers as a part of the company has been started to be applied. To do so, some suppliers have been selected and meetings with them have been organized. However it is still necessary to go on strengthening the link with the suppliers and to choose the good ones.

Then, an internal training has been organized as suggested by suggestion 3. This training was about fire safety and directed by D. Carême, project designer and specialized in low current technology. It enables to employees to update their skills in fire safety. However, other trainings are still necessary since LCT is composed of 11 subparts, but it is only the beginning.

It is interesting to see that suggestions have already been taken into account by the company, but the road is still long before the end of the study of each suggestion (is it necessary to implement it or not?, how to implement it?, what will be the consequences? and so on).
Conclusion – This paper sums up the work done within Cegelec Le Mans in order to state the situation in the field of low current technology and then to define possible suggestions of improvements. In a first time the enterprise has been modeled thanks to concepts inspired by ArchiMate. A focus has been done on a specific project to know exactly how the company works. Finally, the current situation has been confronted to principles and concepts developed in lean product development and led to suggestions of improvements. The implementation of these suggestions is now a new field of work.
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Annex 1: Data collected from previous projects

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* The star means that the given price is for the whole project and the division among the subparts of this project is unknown.