Using GRAIMOD for Improving Performance of Multi-Product Companies

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ABSTRACT

European economies have been deeply affected by different crises. The impact of the economic crisis on enterprises is now recognized by everybody. Enterprises are fighting to pull through the present situation and are seeking to be prepared for the post-crisis phase. Enterprises need to reorganize in order to be better adapted to this situation and to integrate new dimensions in their development. GRAI Methodology is one of the three main methodologies (with PERA and CIMOSA) for enterprise modelling. In this paper, the concepts of GRAIMOD a tool for supporting GRAI Methodology is presented. Then a zoom is made on an example related to multi-product companies for defining a reference model according to enterprises of this activity domain. For improving this enterprise performance, a multi-criteria analysis was used by combining quality, cost, lead time but also carbon management, social societal and environmental dimensions.

1. INTRODUCTION

The special economic situation in Europe is the root cause of many difficulties for enterprises today, creating a downward spiral in performance. Indeed, the prescribed increase in taxation and reduction in government expenditure for correcting the economic situation has had a negative knock-on effect on enterprises and the public in general. Enterprises are fighting to pull through the present situation and are seeking to be prepared for the post-crisis phase.

The enterprise SOLISO is one of those companies trying to take into account the actual changes in terms of the economy, society, environment, energy and industry. It is a multi-product enterprise producing a wide range of blinds and awnings. Its objectives are to have a fundamental look at its organisation in order to not only navigate through difficult times, but also to become stronger and better able to adapt itself to future conditions.

GRAI Methodology is one of the three main methodologies for enterprise modelling. GRAIMOD, a software tool being developed for supporting GRAI methodology, is composed of different modules allowing to improve enterprise performance. An enterprise typology is developed in this frame not only for facilitating the improvements required using different aspects of enterprise performance: quality, cost, lead time (QCD), but also social, societal and environmental aspects. Reference models are being developed for each sub-domain defined by the typology. The elaboration of these reference models needs the acquisition of knowledge of enterprises concerned in a specific domain. The objective is to re-use this knowledge during a new modelling of a company of any particular domain.

In this paper, the concepts of GRAIMOD are presented. Then, according to the different modelling phases of GRAI methodology the example of the enterprise SOLISO is shown. Optimization Objectives were defined such as production, manufacturing lay-out, lean manufacturing and lean management deployment, integration of social and societal aspects in the improvements and energy and carbon reduction. The research team at Icam Vendée is endeavouring to build a reference model for this company. This 'win-win' collaboration is presented in detail and the process of satisfying both parties concerned is developed.

Nowadays an enterprise is a multi-criteria system integrating social, societal and environmental dimensions in addition to QCD for its improvement. The definition of a new sustainable reference model for enterprises integrating these criteria is necessary.

The concept elaborated aims to think about the future needs of manufacturing, the supply chain, enterprises, local authorities etc. The choice made is to define these concepts by introducing sustainable values in the proposed changes.

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2. GRAIMOD

GRAI Methodology is one of the three main methodologies used for analyzing and designing enterprises. The GRAI approach is composed of four phases: An initialization phase to start the study, a modeling phase where the existing system is described, an analysis phase to detect the inconsistencies of the studied system and a design phase during which the inconsistencies detected are corrected and a new system proposed. These concepts could be used to ensure the transformation of enterprises to meet the real market needs (globalization, relocation, capacity to be proactive, cost optimization, lead time, quality, flexibility, etc….) and have to be adapted. An enterprise is completely described according to GRAI Methodology by finding five models: functional (functions of the enterprise and their links), physical (the production system), informational (the net, tools and informational flows), process (series of sequences or tasks), and decisional (structure of orders, hierarchic organisation). Then these models could be improved for increasing enterprise performance.

GRAIMOD is a new tool being developed by ICAM Engineer School for proposing concrete solutions to improve enterprises according to new market evolutions. At present it contains five modules working around three sub modules (figure 2). The tool is divided into two parts: the interface containing modules for modeling enterprises and the analysis & improvement part for changing the existing system and proposing new organizations. The objective is to use reasoning (such as CBR or decomposition), enterprise typology, expert systems, Multi-agents systems, enterprise knowledge for defining a tool (GRAIMOD) destined to improve enterprise performance. This tool will support GRAI Methodology.

The objective of this research is to:

- Allow enterprises to evaluate their performance and to drive the change of their economic model by integrating the social, societal and environmental aspects.

- Aid enterprises to adopt an ecological and energy-aware mindset.

- To improve progressively and sustainably enterprise supply chains.

The structure obtained and the problem solving method associated to this tool are defined by combining different reasoning and acquiring expert knowledge during enterprise improvement. For instance, knowledge is defined as the process which transforms the whole set of known information C_i (stable state) into another C_{i+1}. Knowledge C_{i+1} can be therefore defined as a sum of disjointed information or as a progressive improvement of the whole - C1 implying a restructuring of already acquired information. Explicit and tacit knowledge is defined and three modes of knowledge representation introduced in the concepts of GRAIMOD:

- rules

- cases

- reference models

GRAIXPERT, the expert system of GRAIMOD, contains these different types of knowledge in order to give various kinds of assistance during enterprise performance improvement. The rules were used for analyzing models but also for suggesting design. The old cases were capitalized for reusing them (analogy reasoning) during a new design. Reference models had to be developed for each enterprise activity domain in order to use an ideal model for each new enterprise modeling and to adapt the reference model concerned to the case studied.

Indeed, the classification reasoning was used for elaborating a new enterprise typology. It allows from pertinent criteria cp to elaborate enterprise classes C_i. The first criterion transforms the set of enterprises into intermediate subsets. The second divides these subsets into reduced elements until the obtaining of more elaborated classes. This organization is progressive according to changes of the pertinent criteria of the enterprise. An increase in the amount of criteria improves the typology and increases the number of classes. We define the set S_p of enterprises which is characterized by the vector s_p. We also define for each criterion cp a vector α as the number of columns m corresponding to different attributes (values) associated to the criteria.

$$\alpha = \begin{pmatrix} \alpha_1 & . & \alpha_j & . & \alpha_m \end{pmatrix}^T.$$

The following linear combination is deduced for three criteria corresponding to the associated vectors α, β and γ:

$$S_p = \sum_{j=1}^{m} \alpha_j * \left(\sum_{k=1}^{r} \beta_k * \left(\sum_{i=1}^{n} \gamma_i * c_i \right) \right)$$

(1)

where m, r and n correspond to the number of columns (attributes) of α, β, γ and c_i a class of enterprise. According to this typology, reference models corresponding to each part were defined. Then for each part a base containing studied cases were elaborated. These kinds of knowledge were used for designing a new enterprise model.

This tool is composed of different modules. **GRAIKERN** is a graphic editor, an interface used for representing the different models associated to GRAI methodology. **GRAIWORKER** is the work base elaborated for managing, modifying and capitalising knowledge about the studied case. **GRAITRANS** is a Transfer Interface used for putting the new case in GRAIXPERT in order to improve its Cases Base. The reference model elaborated for each enterprise domain will be improved by the acquisition of this new model in GRAIXPERT between the different modules.
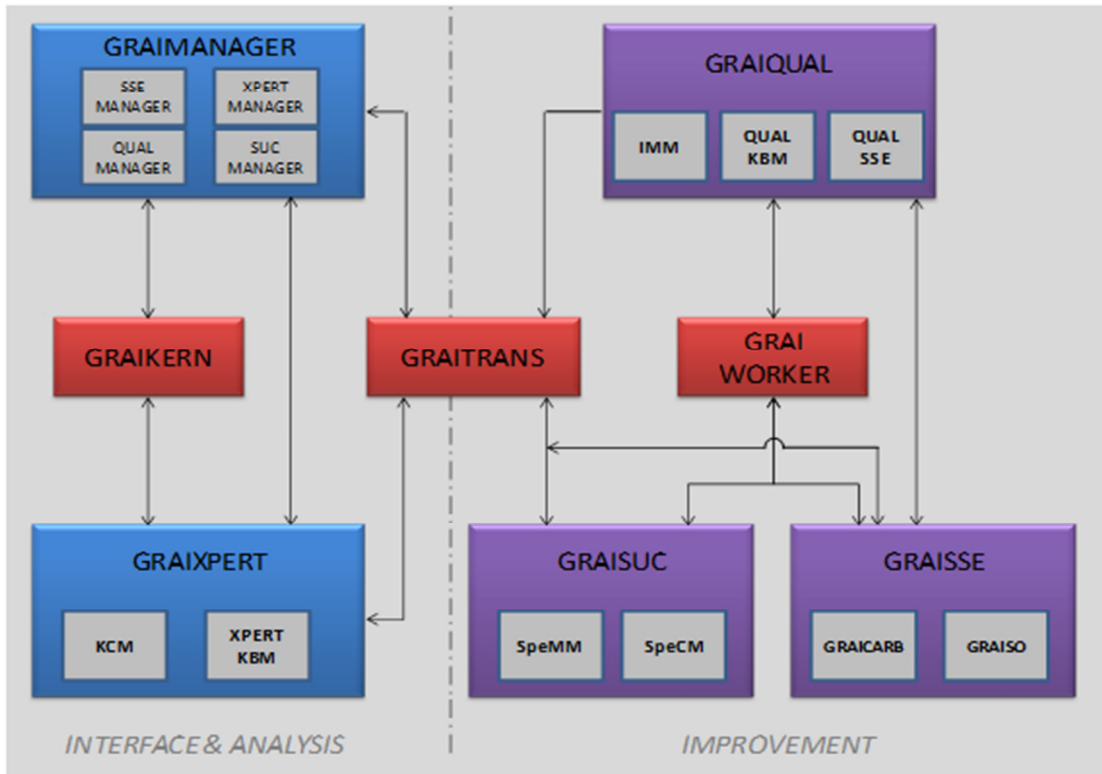

Figure 1. Achitecture of GRAIMOD.

GRAIXPERT is a hybrid expert system for managing the analysis of the existing system and proposing a new system. It is composed of two sub-modules in interaction with GRAIKERN: the Knowledge Capitalization (KCM) and the Knowledge Based System (XPERTKBM). **GRAIMANAGER** is a management module used for organising the different interactions between the modules of GRAIMOD. It controls and manages the system's interactions with the users. **GRAISUC** is a module used for managing the choice of an ERP or SCM tool for an enterprise. It is composed of two sub-modules SpeMM and SpeCM. The Specification Management Module (SpeMM) is used for choosing the appropriate ERP or SCM Tool of an enterprise. The specifications obtained are capitalised in the Specification Capitalisation Module (SpeCM). **GRAIQUAL** is a module used for managing quality approach implementation or quality improvement in an enterprise. It contains two sub-modules IMM and QUALKBM. The Improvements Management Module (IMM) is used for managing the different quality action plans of the enterprise. The Quality Knowledge Base Module (QUALKBM) is being elaborated for containing the rules related to quality certifications in order to use them for improving or elaborating quality in an enterprise.

A new module GRAISSE is being added to GRAIMOD in order to pinpoint the environmental, societal and social dimensions in enterprises. This module would integrate, for example, changes associated to carbon management

(GRAICARB), IS0 26000, ISO 14000 implementations, the impact of social and societal evolution (GRAISO) on both enterprises and local authorities (states, associations, districts, etc.).

Unlike GRAIQUAL whose goal is to improve enterprise performance by using the criteria defined, GRAISSE focuses only on the social, societal and environmental aspects. This module is composed of two sub modules:

- GRAICARB which allows to calculate the enterprise carbon footprint and to propose environmental improvements according to ISO 26000 norm
- GRAISO which focuses on the improvement of social and societal aspects in enterprises. GRAISO is dedicated to social and societal aspects according to concepts of ISO 26000 and Lucie Label. ISO 26000 has no certificate as opposed to Lucie which proposes a validation of the work done by awarding a certificate.

For instance, each supply chain is improved by optimizing the main performance criteria such as quality, cost, lead time, but also by adding environmental and social dimensions. For quality criterion, each vector uk corresponding to a given supply chain sub-part will be composed of vectors qf, qp, qpr, qs associated respectively to the main aspects of quality. The vector qf represents Quality of suppliers, qp Quality of products, qpr Quality of process, and qs global Quality of the system (Dossou & Mitchell, 2009). These vectors are defined for each sub-part and indicate the global state of the sub-part according to the performance criterion Quality. Then it will be possible to measure the state of each sub-part and propose specific tools for improving this part. The following equations (2) and (3) are obtained for sub-parts and for the global supply chain:

$$L_1(u_k) = \sum_{l=1}^{4} (\alpha_l * q_l)$$

(2)

$$L_1(u) = \sum_{k=1}^{n} (\lambda_k * (\sum_{l=1}^{4} \alpha_l * q_l))$$

(3)

Then the step of improvement according to this criterion could be made. In GRAIMOD, a multi-criteria analysis is proposed. It means that this design according to quality criterion is repeated for lead time, cost and also social and environmental dimensions. Both GRAICARB and GRAISO modules are used in combination with GRAIQUAL for establishing a global supply chain performance improvement. The objective is to show to enterprises the advantage of defining in the same way cost reduction, lead time reduction, quality optimization and carbon management, energy management, waste management, and a socially positive organization. This new vision corresponds to the elaboration of future sustainable supply chains. So, three steps of multi-criteria combination are defined:

The first one is the optimization of each supply chain sub-part by using each criterion. For instance, procurement lead time could be optimized by taking into account all the parameters reducing the delivery date.

The second step is integration of the criteria (quality, lead time, cost, environment management and socially positive management) for each part of the supply chain for finding a real optimum corresponding to the particularity of the enterprise.

The last level is about the global supply chain for integrating the different parts and their local optima. The consequence of this step is the creation of a real coherence between the studies of each part. The defined reference models associated to each domain could be extracted during the improvements and adapted to the studied enterprise in order to obtain the best sustainable result possible.

The following examples allows to illustrate this last section and facilitates showing how to make the most appropriate choices using GRAIMOD to make enterprises and their supply chains sustainable.

Reference models are being elaborated according to enterprise activity domains. The enterprise SOLISO is used for acquiring data about the multi-product domain in order to build the reference model concerned. The study also allows to illustrate the concepts of GRAIMOD, and in a win-win context to propose performance improvements to this enterprise. In the following chapter, the different parts of GRAIMOD which will be used according to the improvement process will be shown. Then, the data necessary for building a new reference model adapted to multi-product companies will be summarized.

3. EXAMPLE: THE ENTERPRISE SOLISO

The enterprise SOLISO is specialized in sun protection. The products are numerous and divided in types: blinds, sun blinds, roller blinds, textile frontage, awning and pergola. This enterprise is a SME situated in the west of France near Nantes which was founded in 1947. There are generally about 100 employees reinforced rising to 150 in the high season. The number of customers is extremely high: more than 3000. The surface area is 9000 m^2 divided into two manufacturing workshops. The enterprise has no sales shop but the strategy is to sell the different products to tradesmen, retailers, carpenters, blind manufacturers and specialized hypermarkets. The context of the enterprise is simple: due to the economic crisis and the bad weather, the turnover decreased in 2013. It has meant that SOLISO had to think about how to reduce cost on the supply chain, to improve quality and to respect delivery dates in order to win the loyalty of customers, and to anticipate future improvements by integrating for instance the social, societal and environmental dimensions. The study is for reorganizing the enterprise, by using concepts developed in GRAIMOD. The enterprise accepts to be used as a case in the database of GRAIMOD. The deal being:

- For SOLISO the improvement of its global performance,

- And for ICAM Industrial Organization Research Team the definition of a reference model for multi-product enterprises.

The study started with context acquisition, and then the modeling of the existing system was done. Different formalisms were used for realizing this modeling. A zoom was made on each workshop (decomposition reasoning) in order to study in detail the supply chain. During this phase GRAIKERN, the module of GRAIMOD destined to model representation was used for elaborating models. This module used Object Oriented Design theory, for representing each model of the enterprise (physical, functional, decisional, process and informational models). The formalism actigramme was used for modeling the physical (figure 2) and the functional systems.
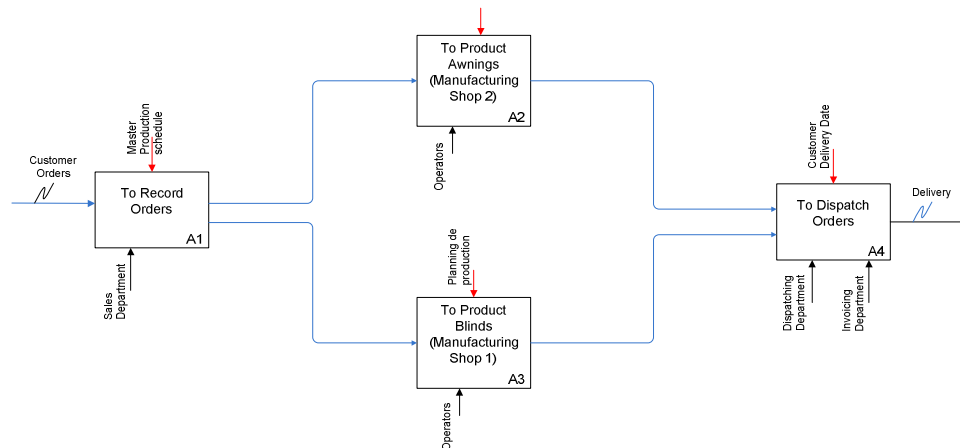

Figure 2. Functional model A0.

Other models have also been elaborated by using this kernel. The module GRAIMANAGER managed not only the elaboration of these models in GRAIKERN but also the use of the different modules of GRAIMOD. For instance, all the decisional structure of the enterprise was studied by establishing the GRAIgrid and the GRAInets of the enterprise. The processes of this enterprise were also elaborated by using extended actigramme and the structure of informational data shown by using UML (Unified Modeling language). For elaborating these models interviews were held with the staff. It was also opportunity to know exactly the desire of operators in terms of ergonomics, their suggestions for improvement, their problems, their expectations. The sub-module GRAISSO was used for acquiring and modeling the positive social and societal expectations of SOLISO. The sub-module GRAICARB was used for managing carbon, energy and waste. In addition to the previous traditional GRAI models, a Value Stream Mapping (VSM) formalism was used for calculating flow times and completing inconsistencies (figure 3). A simulation tool (Flexsim) was also used for modeling the manufacturing implantation and showing bottlenecks and finding inconsistencies (figure 4) on the enterprise manufacturing processes.

The analysis of these models allows to detect inconsistencies in the enterprise. The module GRAIXPERT (containing rules capitalized in a rules base) was used for this task.

Then GRAIXPERT allows to deduce from these inconsistencies, the strengths and weaknesses of the enterprise and presented them to the GRAIQUAL, GRAISUC and GRAISSE modules for improvements. The strengths of SOLISO were shown in order to show employees the advantages of the enterprise. However the weaknesses were also presented so that they could be addressed. The high desire for meaningful improvement and evolution noticed in this enterprise were the basis of the study's success. The following points given by GRAIQUAL, GRAISUC and GRAISSE were immediately taken into account by SOLISO for being improved:

- Storage according to raw materials, semi-products and products

- Process organization

- Quality of product, but also system

- Non respect of delivery date

- Quantity and quality of energy used

- Waste management

- High production cost due to expensive raw materials and existing process organization
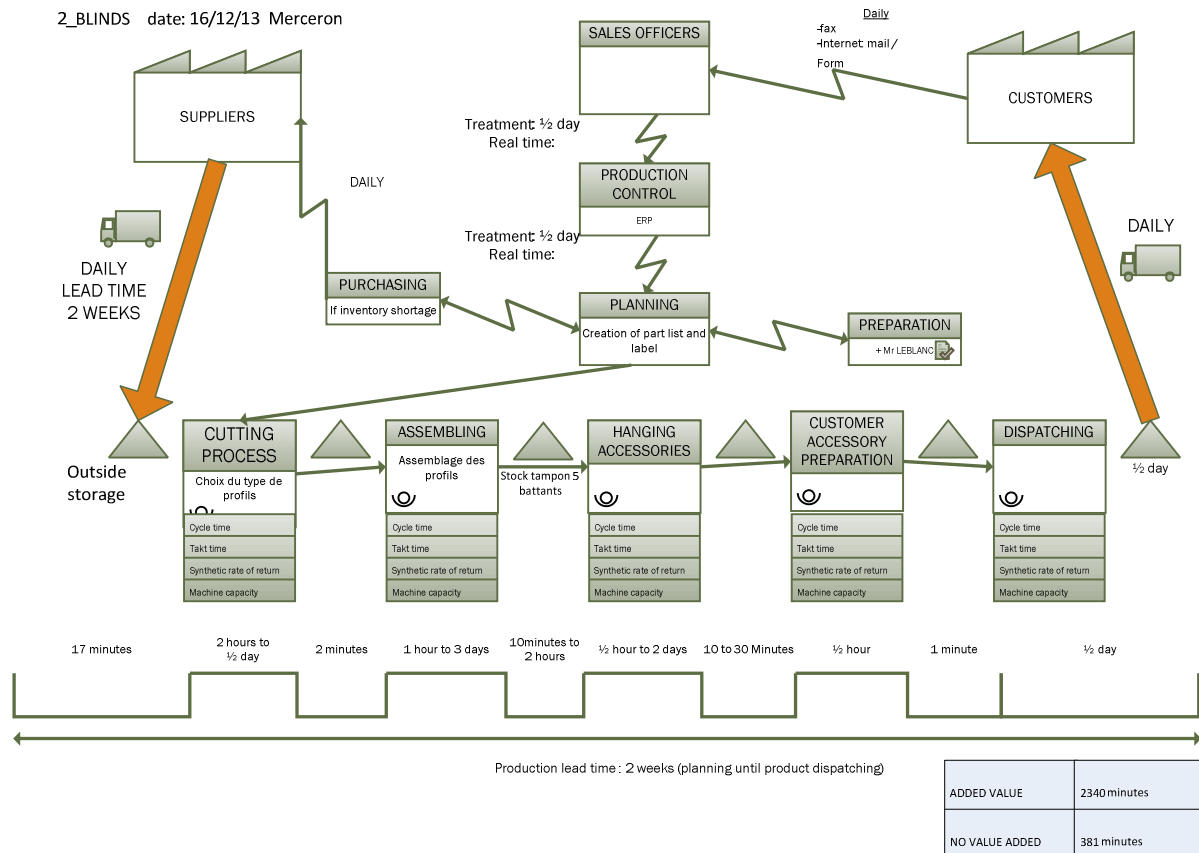

Figure 3. VSM of the supply chain.

After the validation of these points and the authorization to make improvements, the design phase started by elaborating new consistent models and using different tools to meet the expectations of the enterprise.

For instance, FLEXSIM was also used for simulating and redefining processes, then proposing an adapted and optimized new organization. The bottlenecks noticed in the first workshop were corrected by elaborating scenarios and testing them. The previous organization needed more movements of operators for taking raw materials and pieces and bringing them to their machines. Moreover, the use of machines was not consistent and implied a lot of return trips. The non value added tasks were reduced or suppressed by testing different possibilities. This combination of simulation and Value Stream Mapping exploitation proved to be a great success.
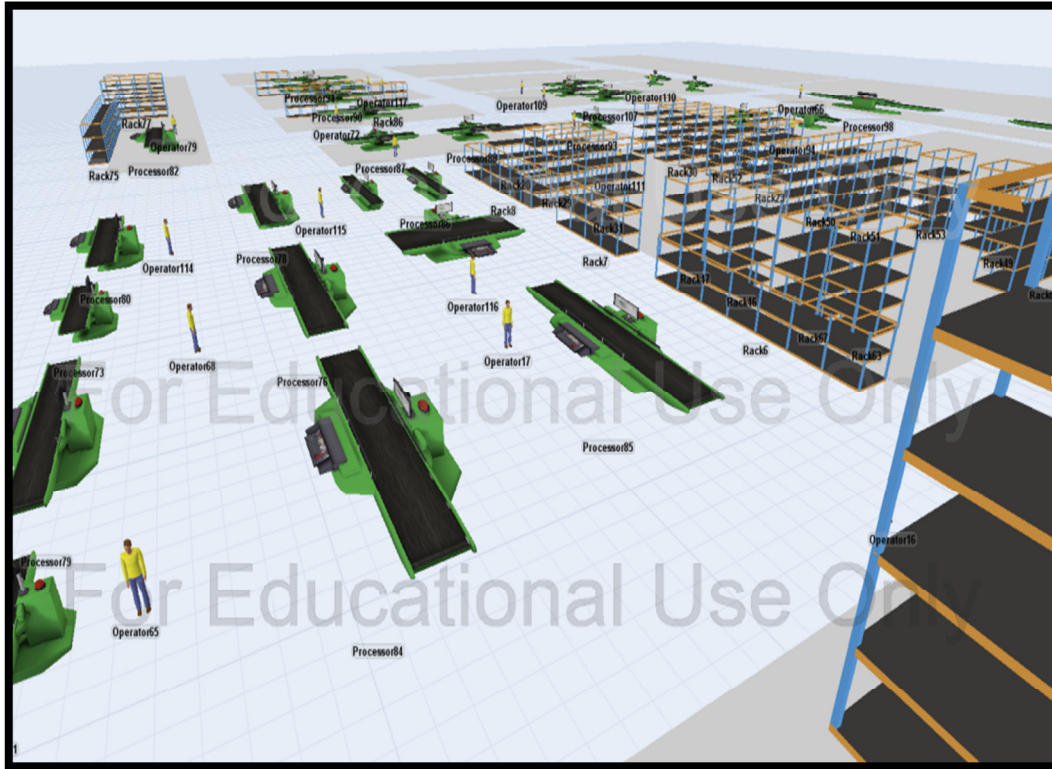
Figure 4. Simulation of the enterprise processes.

The module GRAIQUAL which contains approaches, tools and methods was also used for finding the best way forward to solve the problems detected and to propose suitable solutions. The module GRAISSE was used for proposing improvements according to ISO26000 principles, energy, carbon and waste reduction. GRAISUC was used for managing the implementation of a new tool to manage orders in the enterprise. Indeed, the enterprise already had a software tool for managing manufacturing, sales, account, procurement, purchasing, and dispatch services. But a lot of inconsistencies were detected implying the definition of specifications and handbook for choosing a new adapted tool.

The official study was finished at the end of February 2014 and the managers of the enterprise were keen to make all improvements and pursue the changes in their enterprise. They decided to follow a training course on lean manufacturing and management for being more able to manage future changes and evolutions of processes in the enterprise. The design phase was a great success because of the reactivity of the enterprise for making changes proposed. For instance, the following solutions were proposed and have been implemented very quickly:

- ABC method for storage and use of the enterprise ERP for its management
- Lean manufacturing and lean management
- Definition of supermarket and borderline train for procuring raw materials and pieces to each work station
- Reimplementation of machines and reorganization of physical flows
- Carbon, waste, energy and cost reduction

All the environmental, social and societal dimensions are growing. Indeed, the energy consumption of SOLISO was very high not only because of the machines, but also because of the dilapidation of the roof. The invoice of water consumption was very high despite water not being used in production. The solution proposed was to change the roof and putting a new one which has skylights and alternating these skylights with the installation of solar panels. To reduce water consumption, it was decided to introduce a system for saving rain water and reusing it for cleaning, flushing the toilets etc., reducing consumption considerably. The latest results of the study, the reorganization phase and the transformation of this case into reference model will be presented later (certainly during the FAIM conference). The new elaborated reference model will be introduced in GRAIMOD for being the model of multi-product companies.

4. CONCLUSION/PERSPECTIVES

Enterprise modeling is used for preparing enterprises for the post-crisis period by reorganizing them according to society evolution and globalization rules. It is important to show them how to integrate different new parameters for being adapted to the future. The objective to make enterprises sustainable needs to redefine performance criteria by including environmental, social and societal dimensions in addition to QCD. GRAI Methodology supported by GRAIMOD a new software tool, allows to improve to the global performance of Enterprises and particularly SMEs. A focus is made on GRAISSE and GRAICARB dedicated for managing carbon footprint and social, societal and environmental aspect in enterprise improvement.

In this paper, the concepts of GRAIMOD are presented. An example is used for illustrating the process of reference model elaboration and validating the concept presented. The reactivity and desire to improve of the enterprise SOLISO proved to be exceptional. The availability of both the management and all staff in this enterprise facilitated the collaboration and the result will surely give to SOLISO an advantage in terms of organization and performance. The proximity of Icam Vendee to enterprises will not only allow to enrich the case base of GRAIMOD by making modeling of them but also to improve the reference models and the typology elaborated. The development of GRAIMOD tool is ongoing.

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