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HOW TO EVALUATE THE SUPPLIERS' PERFORMANCE IN COLLABORATIVE DESIGN?

Le Dain Marie-Anne[1], Calvi Richard[2], and Cheriti Sandra[3]

[1]G-SCOP, Grenoble University, School of Industrial Engineering (ENSGI)
[2]CERAG, Grenoble University, School of Business Administration (IAE)
[3]G-SCOP and Thésame, the Business & Innovation Center of Haute-Savoie

ABSTRACT

An important trend in New Product Development Projects (NPDP) is to involve more and more suppliers in order to enlarge the scope of the firms' competencies. Thus, the focal firms in this design network express a need of methods and tools to manage as well as possible these particular relations of collaborative design. This paper is the first step of an on going research aiming at describing the problematic of supplier performance evaluation in this specific context. The model presented in this paper was built with the collaboration of six industrial manufacturers, partners of the PRAXIS research project (Performance in Relationships Adapted to eXtended Innovation with Supplier).

Keywords: NPDP, collaborative design, supplier performance evaluation.

1 INTRODUCTION

Nowadays, the competitive context can be characterised by two antagonistic phenomena. On the one hand, an increasing complexity of the products, that leads to an integration of various technologies during the product's development. On the other hand, a concentration of the companies on their key competencies, that induced an acceleration of the *Design or Buy Design* policies, which consists in transferring to suppliers the responsibility for the design and the engineering activities of the outsourced component. These two phenomena emphasize the importance of the external resources' management, mobilised in the New Product Development Projects (NPDP). Indeed, in many sectors, as the potential of innovation is beyond the strict boundaries of the customer's company, one of the principal ways to reach a competitive advantage is to generate a *relational rent* [1]. That's why the suppliers are obliged to develop pro-active strategies in order to become a *preferred* partner for their customers in their New Product Development Projects (NPDP). For the customers, they have to develop a specific know-how in term of supplier involvement in such projects.

For that, the supplier selection and the supplier performance evaluation processes are two crucial managerial issues. Indeed, the customer firms have to evaluate not only the supplier's capability to answer their requirements in terms of costs, quality and delivery but also in terms of ability to collaborate on the design activity and to provide the needed technological competencies. However, they have some difficulties to define relevant criteria to assess these expected abilities and also to select the suitable supplier. Furthermore, once the supplier is involved in a specific project, they wonder how to measure the real contribution of the supplier with tangible and objective performance criteria.

The study of both these processes is one of the main goals of the PRAXIS research project developed within the French Competitiveness Cluster "Arve Industries Haute Savoie Mont Blanc"[1].

[1] This project gathers researchers in Engineering Design (G-SCOP) and in Management Science (CERAG and Université de Marne la Vallée), the Business & Innovation Center of Haute-Savoie (Thésame), a professional syndicate (Udimec) and industrial partners (BioMérieux, Bosch RexRoth Fluidtech, Salomon, Schneider Electric, SNR Roulements and Somfy).

In this article, we focus on the evaluation of the supplier's performance in collaborative design. Our objective is to provide a generic model of supplier performance evaluation that takes into account the various situations of collaborative design with suppliers involved in New Product Development Projects. In the first section, the specificities of the evaluation of the supplier's performance in collaborative design and research hypotheses are presented. Subsequently, the research methodology is described. Section 3 presents the developed model and the selected criteria. Section 4 presents the mode of evaluation of the suggested criteria.

2 THE EVALUATION OF THE SUPPLIER'S PERFORMANCE IN COLLABORATIVE DESIGN

Innovation became a crucial axis for customers to face the competition. In industrial sectors where the suppliers contribute towards a large part of the product value, the customer have to implicate their suppliers more and more in this running to the new product.

In this way, for a specific project, customers are used to selecting suitable suppliers not only on their cost, product quality and delivery reliability but also on their *high potential contribution to the innovativeness of the firm* [2]. However, a selected supplier which was judged capable of answering the customer's expected requirements could not prove successful *in situ* during the project. For this reason, customers have to regularly evaluate the effective results of the supplier compared to their expected requirements and that is the aim of a supplier performance evaluation.

For the focal firm, the evaluation of the supplier's performance within the framework of a New Product Development Project (NPDP) may be used in three different ways: (1) on a short-term way, to identify the critical questions and to provide solutions that were co-built with the supplier in order to perform their collective response, (2) on a middle-term way, to improve continuously the performance of the suppliers and (3) on a long-term way, to rationalize the panel of the suppliers for the future projects. For suppliers perspective, such evaluation could enable them to identify clearly the performance criteria expected by the customer thus to create a dynamic improvement within their organisation, in order to evolve from "standard supplier" to "innovative design supplier".

2.1 Evaluation adapted to the moment of integration

According to Le Dain, there is not *one best way* to evaluate the supplier's performance. In facts, the relevance of the modes of evaluation depends on the industrial problems suited to each customer/supplier relationship [3]. As an illustration, one cannot evaluate with the same criteria a subcontractor and an equipment manufacturer, both involved in a project of collaborative design. Indeed, in both cases, the required competencies, the level of autonomy in the development, the expected results and the allotted resources to the relation as well as the coordination mechanisms with the customer must be different. Thus, the measurement of the performance must be adapted in order to take into account the specificities of each situation.

We used the *Supplier Involvement Portfolio* developed out by Calvi and Le Dain [4] to embody each situation (Figure 1). This typology is based on two dimensions, both judged by the two authors as fundamental in the discrimination of the different situations of supplier involvement in collaborative design: the "degree of autonomy" that is contracted out to the supplier in the NPDP and the collaborative "development risk" of the outsourced component or building block.

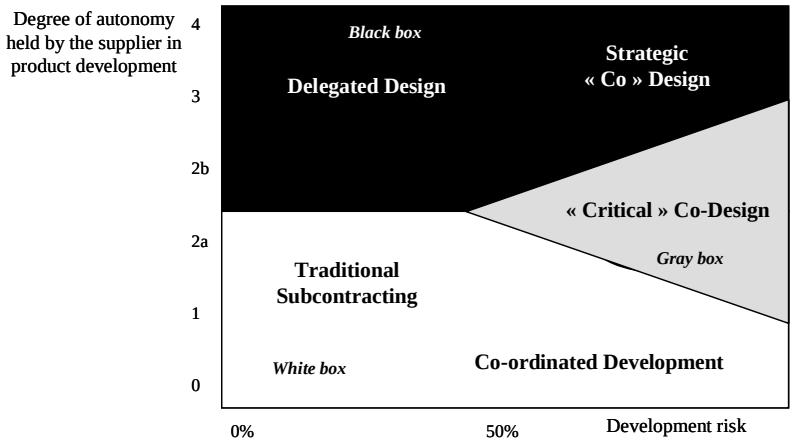

Figure 1. Supplier Involvement Portfolio (Calvi and Le Dain, 2003)

The authors defined five types of customer/supplier involvement in collaborative NPDP associated with different combinations of the two previously identified dimensions.

When the level of autonomy[2] of the supplier is low (levels 0 to 1 on the vertical axis), the relations are generally described as *white box* by [5]. In this case, Calvi and Le Dain [4] defined two types of relation according to the level of development risk[3] associated to the project: ***traditional subcontracting*** characterised by a low development risk and ***co-ordinated development*** characterised by a high *systemic and timeline risk*. In both these situations, the outsourced products are mainly simple parts, whose design remains internalised. But with a ***co-ordinated development***, due to the nature of the development risk, the product design activity realized by the customer and the process design activity realized by the supplier must be coordinated to obtain a genuine product – process integration in the build of the final product solution.

If the autonomy of the supplier is high (*black box*), the results of the exploratory survey carried out by the author invite to distinguish two types of relation, in accordance with the risk related to the development of the delegated product: the ***delegated development*** (levels 2b to 4 on the vertical axis) and ***strategic co-design*** (mainly level 4 on the vertical axis). In both cases, the supplier carries out the concept design and the development of the outsourced component. But in *strategic co-design* situation, the high level of risk requires real communication with the supplier in order to clarify needs and to monitor the evolution throughout the project.

Lastly, the authors qualify as ***critical co-design*** (levels 2a to 3 on the vertical axis and risk greater than 50% on the horizontal axis) the situation where neither the customer nor the supplier possesses the knowledge and the ability to completely execute product design in house. The greater the development risks, the more the customer will try to force and control the collaboration between its own and the

[2]The authors defined 5 levels from (0) to (4):

(0) The supplier is responsible for the setting up the production process. The supplier provides input in customer's product design by sharing information about its equipment and process capabilities and production scheduling,

(1) The supplier is responsible for the setting up the industrialization and production processes based on the drawings supplied by the customer. Supplier provides feedback on customer's design including suggestions for cost or quality improvements,

(2) On the basis of functional specifications, the supplier is responsible for the detailed design, the testing and the setting up the production and assembly processes,

(2a) The customer keeps the intellectual property rights of the component and pays design fees to the supplier,

(2b) The supplier holds the intellectual property rights of the component and is held legally responsible,

(3) The supplier has the full responsibility from concept to manufacture for the design of an entire part,

(4) The supplier is responsible for the global design (concept, feasibility studies, design, supply chain organisation), the detailed design, the testing of global and detailed design and the setting up the production and assembly processes of a complex subsystem.

[3] The authors identified six combinatory types of development risk: (1) Systemic link between supplier component and final product performance, (2) Differentiation Produced by Component, (3) Component Development Timeline, (4) Newness of technology, (5) Weight of component cost for the final product, (6) Internal complexity.

supplier's project team. This reasoning thereby explains the triangular nature of the conceptual matrix that we proposed.
The diversity of these situations of integration responds to a diversity of customer's requirements towards its suppliers, which leads us to state our first assumption as follows:

> H1: The evaluation of the supplier's performance in collaborative design must be adapted to each situation defined in Figure 1.

Unlike the authors who promote *Early Supplier Involvement* [6], we thought that the problematic of the external resources involvement is not a question of *Early* (or *Later*) involvement but a matter of *On Time* involvement using suitable tools. Thus, we agree with Primo and Amumdson [7]: *Firms that develop successful new products involve suppliers in the process when they are needed, involve them at the stage of development needed, and involve them only to the extent needed.*
Thus, our second assumption is the following one:

> H2: The right moment to involve the supplier in NPDP depends on the type of collaboration in design developed with the supplier.

To illustrate this assumption, we attempt to work out in Figure 2 a theoretical link between the typology of involvement and the *On Time* moment of involvement in a NPDP. In that way, we represented the four principal stages and decisional milestones of such a project [8][4]. Then we placed on this NPDP representation the moment of involvement adapted to each situation presented in Figure 1.

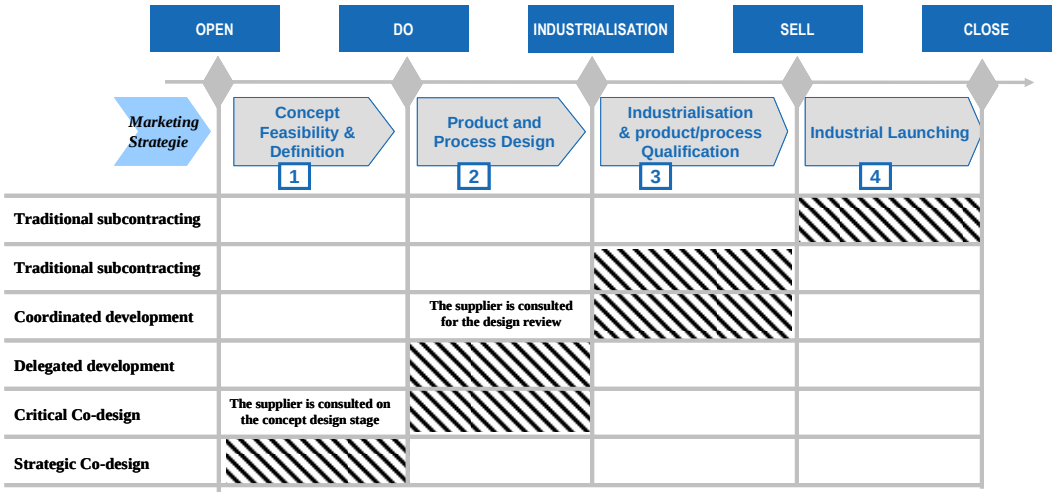

Figure 2. Moment of involvement according to typology

In the case of a *co-ordinated development*, the suppliers will be involved in the *industrialisation and product/process qualification* phase. However, he may be consulted in the *product/process design* phase to provide feedback on customer's design. For *critical co-design*, the same reasoning is applicable between the *architecture* and *product & process design* phases.

2.2 Effectiveness, efficiency and pro-activity

Our third assumption concerns the three dimensions proposed by Le Dain [3] to characterize the notion of supplier's performance:

- Supplier effectiveness: A supplier is considered as effective if its results are in accordance with the objectives fixed by the customer. For example, the respect for the classic customer triptych requirements – cost, product quality and delivery – corresponds to efficiency criteria in order to evaluate the supplier performance.
- Supplier efficiency: A supplier is considered as efficient if he is able to use in a relevant way the

[4] The phase 1 corresponds to the front-end phase defined by Ulrich and Eppinger [9]. This phase aims at studying the relevance of a product concept to make the stop or do decision of its development. The phases 2 to 4 aims at developing the product concept selected during the phase 1.

means that he dedicated to a project in order to reach the expected results. These possible means should be either organisational competencies (project organisation; cross-functional team …) or technical competencies (concurrent engineering tools and techniques as Value Analysis, CAD tools, design for X tools, numerical simulation tools, FMEA ...). For example, when a supplier proves its real mastery of value analysis in proposing a clear splitting up of its product cost and furthermore its ability to reduce it, the customer is convinced that the supplier uses this tool efficiently.

- Supplier pro-activity: We define the supplier pro-activity as its capability to improve by itself and consequently to pull forward the customer. For example, a supplier involved in concept definition stage must be able to challenge the customer specifications and rises up new design solutions, even if it was not explicitly asked by the customer.

Our industrial partners of the project measure primarily the criteria of effectiveness. This observation shows a gap between the practices and the precepts of Ouchi's theory [10]. Indeed, according to this theory, the control of the relation by the only criteria of effectiveness is reserved for situations characterized by a small ambiguity in the performance measurement. Thus, in the case of *traditional subcontracting* (Figure 1), the criteria of effectiveness could be sufficient. However, in the cases of customer/supplier relationships in design stage, it is not enough to define the customer's requirement towards suppliers using the sole criteria of "effectiveness". For example, in the case of a *critical co-design*, one typical requirement of the customer is that its supplier makes itself profit from its expertise in the resolution of problem not identified at the beginning of the project. Thus it seems relevant to couple together this measure of efficiency with the two other dimensions of the performance in accordance with the degree of supplier's implication in the design process.
This leads us to state a new assumption:

> H3: The more the customer/supplier relationships requires a strong collaboration in the design activity, the more the system of performance evaluation will have to take into account the two dimensions of efficiency and pro activity.

3 A SUPPLIERS' PERFORMANCE EVALUATION MODEL IN COLLABORATIVE DESIGN

The performance evaluation model presented in this section stems from an empirical research process started in 2005.

3.1 Research methodology

Since one of the goals of the PRAXIS research project was to investigate how project organisations monitor the supplier's involvement in NPDP, the project purchasing and technical functions were the unit of analysis.

- The first step of our methodology consisted in conducting 15 case studies with project purchasing and technical organisations having a real practice in our topic. So we used a semi-directed interview guide with the aim of describing one experience of collaborative development. The case studies were used to build a theoretical model of performance evaluation in collaborative design adopting a grounded theory approach [11] where "the researcher begins with an area of study and allows the theory to emerge from data" [12]. This study focused on a group of organisations in electronics, electrical appliance, automotive and industrial equipment industries.
- The second step consists in the constitution of a focus group of six enterprises interested in benchmarking and getting practical advices on the topic of "how to evaluate suppliers' performance in collaborative design". With the financial support of these firms, we start a PHD thesis dedicated to the animation of this experts group, the development of a supplier performance evaluation tool and the setting up of this tool in their team project. Collecting their comments, our former model will be adapted to each context using a contingency approach. For that, we adopted a research action approach with the integration of two researchers within the project teams of the each enterprise.
- The last step of this ongoing research must provide an integrated view of the performance evaluation problematic when suppliers are involved in NPDP.

After explaining how we structured our model, we will then present the retained criteria and their mode of evaluation. We will also analyse the remarks about the criteria made by the industrial partners to illustrate the specificities of their practices in collaborative design with suppliers.

3.2 Structure of the model

The model suggested here is intentionally generic and so in accordance with our first assumption, it can be adapted to the various situations of collaborative design identified in figure 1. In that way, we built this model with the two following axes (Figure 3):

- ***Stage of Supplier Involvement in a NPDP*** in order to take into account our second assumption. Thus, the supplier development effort will be evaluated with adapted criteria according to the involvement stages. We considered only the three first stages of the product development process because the expected supplier's performance at the phase of industrial launching is more a classical industrial performance than an engineering performance. This industrial performance may be evaluated by the traditional and already developed supplier performance system.
- ***Type of Customer Requirements expected during the collaboration***. We identified four main classes of requirements expected by the customer in collaborative design with supplier:
    - Know-how on the delegated product,
    - Know-how on the delegated process,
    - Project management skills,
    - Relational skills.

In order to take into account the various situations, we distinguished know-how related with the product from know-how related with the process of manufacture. Indeed, a supplier who is in charge of the development of a component and its process can have different levels of performance on both these types of activities. Otherwise, if a process subcontractor is involved, only its performance on its process development will be evaluated. In addition, the customer actors who will evaluate both these performances are not generally the same ones [3]. Indeed, the criteria related to the product are ordinarily evaluated by the design-team whereas the criteria related to the process are evaluated by the industrialisation-team.

Concerning the requirements in terms of relational quality and project management, these one are often evaluated during the suppliers' selection in collaborative design. Indeed, Spekman and Carraway [13] like Lindgreen et al. [14] affirmed that the organisational competence of the suppliers (ability of being organised in project team, existence of a cross-functional team, reactivity …) is a fundamental criterion of selection because it strongly affects the performance of the co-design activity. According to our industrial partners, it is relevant to evaluate these two aspects because the suppliers can be qualified but non-powerful *in situ*.

For each combination of these two axes, we proposed effectiveness, efficiency and pro-activity criteria to evaluate the supplier performance in collaborative design in order to take into account our third assumption.

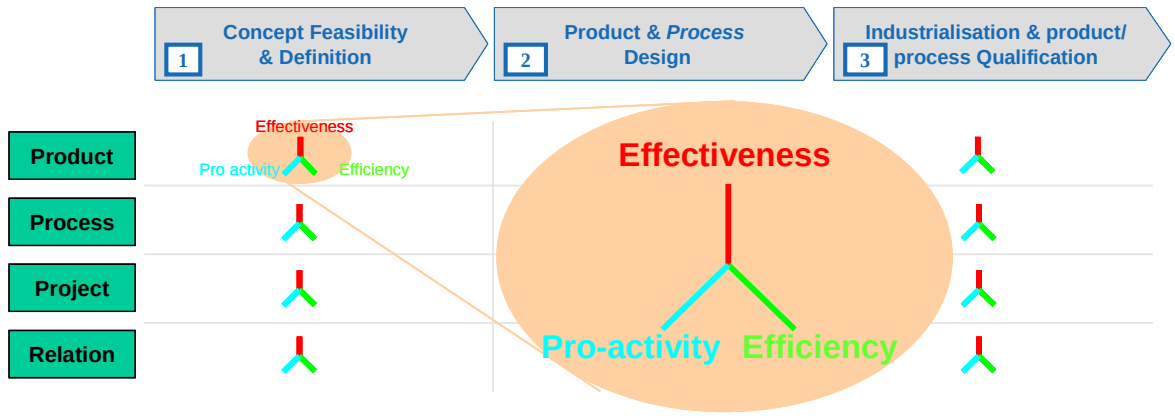

Figure 3. Structure of the Supplier Performance Evaluation model

3.3 Specification of the criteria

Figure 4 presents the criteria suggested in our model of supplier performance evaluation in collaborative design.

Figure 4. Generic model of supplier performance evaluation in collaborative design

The proposed criteria can be specified for each combination of the two axes to adapt the evaluation to the different situation of collaboration. This specificity can be of two types:

- The definition of the same criterion can be declined differently in accordance with the customer's requirements during the project. As an illustration, Figure 5 shows for each phase the variation of the two criteria of effectiveness – product quality and product cost – to fulfil the customer's requirements throughout the NPDP.

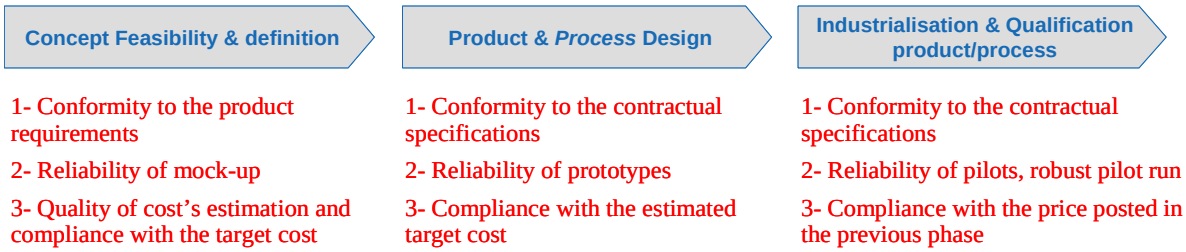

Figure 5. Variation of criteria of effectiveness during the project

- The nature (effectiveness/efficiency/pro-activity) of the same criterion can evolve during the project. As an illustration, Figure 6 presents the evolution of the criterion related to the risk. Thus, a supplier integrated in phase of *feasibility and definition of the concept*, which anticipates the risks from this phase in realising a preliminary risk analysis with an identification of possibly actions of mastery of the risks, will be considered as pro-active. But, in phase of *Product & Process Design*, the supplier is in charge of the risk analysis and so the criterion becomes an efficiency criterion. Finally, in phase of *Industrialisation*, the customer expects the mastery of the risk from its suppliers. Thus, in this case this criterion becomes a criterion of effectiveness.

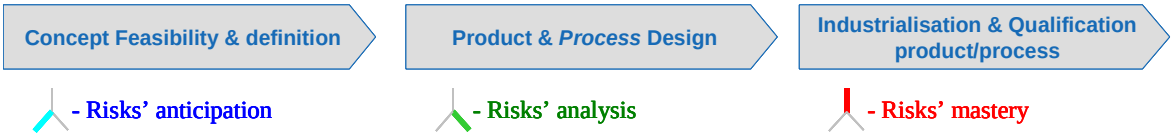

Figure 6. Evolution of the criterion related to the risk

3.4 Presentation of the criteria

In this section, we present the main criteria proposed in the Supplier Performance Evaluation Model and the reason of their choice.

3.4.1 Criteria of effectiveness

For product and process performance items, quality and cost are both the classical effectiveness criteria. As we previously said, the definitions of these criteria evolve along the phases. In a context of New Product Development Project, the delivery reliability is a one aspect of management project performance of the supplier and is evaluated through the ***respect for the due dates for deliverables***.
When a customer involved a supplier at the beginning of the concept feasibility and definition stage, most information is imprecise and the customer expects from the supplier specialist its help to clarify the need. In this case, the ***contribution*** of the supplier ***in the concept definition*** and the ***ability to propose different scenarios*** are considered as effectiveness criteria.
Prahinski and Benton [15] affirmed that *the supplier's commitment should influence the supplier's performance*, even if *empirical research that directly measures the impact of supplier's commitment on performance was not found*. They argue that *when a supplier is committed to a buying firm, the supplier will want to ensure the continued success of the business relationship and therefore, meet and/or exceed the needs of the buying firm.* We declined this commitment in terms of reactivity (***reactivity towards the customer's requests***, ***reactivity towards non-conformities***) and of motivation (***quality and reliability of the exchanges*** as well as the ***quality of the bids responses*** during the project).

3.4.2 Criteria of efficiency

We classify the retained criteria along the two axes of efficiency which seem relevant to evaluate the correct application of the supplier engineering practices necessary to reach the required results [3]:

- Quality of the supplier's expertise.

As advised by De Toni and Nassimbeni [16], this axis covers the contribution to the ***identification of new materials and new product and process technologies***, the ***support in standardisation choices*** and the ***use of archives of element available from supplier***. One of the principal stakes of the New Product Development Projects is to find innovative solutions under cost and time constraint. Indeed, on the one hand, the customer waits from the supplier the access to new functionalities [17], [18]. On the other hand, it also waits *the supplier to increase the use of standard parts* (or process) *as a way to accelerate product development* [19]. Thus, the supplier must be evaluated on its ability to supply "a right innovation". The ***mastery of the methods and tools of the design (value analysis, product FMEA and process FMEA …***) must help the supplier to build this objective and consequently contributes to its efficiency.

- Aptitude for collaborating in project team.

This goes through the ***mastery*** by the supplier ***of its own product development process*** (resources allowed, milestones, mobilisation of cross functional team ...). The supplier and the customer would have to agree on a mode of project management since the beginning of their collaboration and then the supplier would have to respect the commitments. The ***availability of the interlocutors*** in the supplier's team also contributes to the good course of the project.

3.4.3 Criteria of pro-activity

The management of the supply chain of the supplier is an important activity for the success of a project [17]. As *75% of the defects that entailed repairing or substituting a component, concerned parts that had been produced by second tier suppliers* [20], it is relevant to measure the performance of its supplier in terms of ***management of second tier supplier***.

In terms of cost, the supplier's pro-activity consists in a setting up of an approach which aims at remaining under the objective cost fixed by the customer. This consists in ***optimising the study's cost*** in phase of concept, then in seeking how to ***reduce the cost of parts and investments*** in phase 3. The customer also appreciates when the supplier ***commits contractually on a progress plan*** to get a better level of productivity, a secured stocks or reliable deliveries for the extension of the project.

In terms of pro-activity, the customer will also evaluate the ***ability*** of the supplier ***to challenge the contractual specifications***. However, it's necessary not to confuse the skills in challenging the customer's specifications and the non-observance of the specifications. Indeed, this pro-activity criterion must evaluate the supplier's skills to take into account the specifications but more over to propose minor specification modifications that provide convincing reductions of cost or a better product quality for the customer.

4 THE EVALUATION MEASUREMENT

As Le Dain [3] point out the evaluation must remain as objective as possible in order to allow a comparison on the whole suppliers' panel. To reach this objective, we defined for each criterion a scale of marks in order to facilitate the assessment of the realised level of supplier performance. For the setting up of this scale, we followed the methodology recommended by Lindgreen et al. [14]. It consists in identifying first the maximum and minimum levels and then some intermediate levels. These various levels of performance are then translated into a mark. Figure 7 illustrates the levels for the criterion of pro activity related to the ***management of the second tier suppliers***.

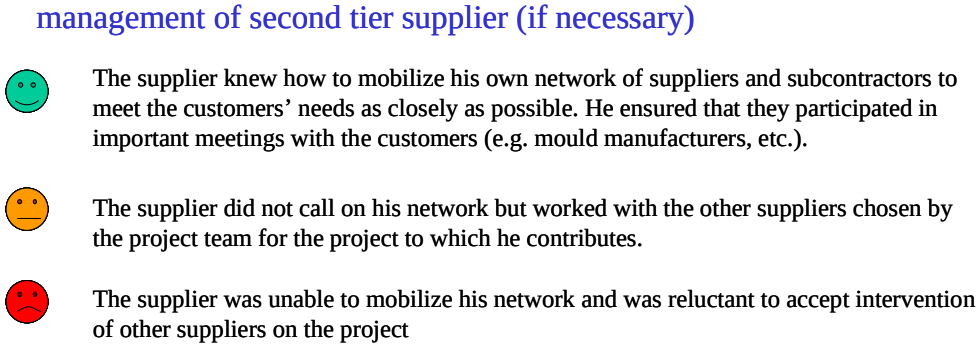

Figure7. Criterion "Management of second tier suppliers"

Finally, the global performance of the supplier will be obtained by an aggregation of the various marks of the criteria used to evaluate the supplier. In order to take into account our third assumption, we recommend to balance the criteria in accordance with the type of supplier involvement in NPDP (Figure 1) according to following methods: the more the relation of the *critical co-design* type is, the more important the criteria relating to the requirements in terms of project management and relational qualities are and the more the relation of *strategic co-design* type is, the more important the dimensions of efficiency and of pro-activity are.

5 CONCLUSION AND PROSPECTS

The suggested model allows the customer to identify where the effort about the development of their suppliers must be focused as recommend by Humphreys et al. [21]. Thus, the results of our model of evaluation can provide throughout the project the zones of failure where improvements of the performance are necessary. In addition, the building of such a tool enables the supplier to clarify what the customer expects from the partner performances. Thus, from the front study, the supplier will be able to turn its efforts in order to answer the requirement of the customer as well as possible. This continuous improvement process is important in explaining the success of the design collaboration.
The model presented in this article is a generic model, i.e. common to all the industrial partners of the PRAXIS research project. The model is evolving throughout our meetings with our industrial partners. In order to test it within the framework of concrete projects, its implementation is soon expecting at two industrial partners. These tests will enable us to refine this model but also to check the relevance of the criteria in accordance with the type of the customer/supplier relationship.
Furthermore, in the case of a relationship marked by a strong collaboration, it is relevant to evaluate, beyond the only performance of the supplier, the performance of the relationship too. For that, we plan to adapt our model to the evaluation of the client and to set up it as a test for the suppliers of our partners.

6 THANKS

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Contact: Marie-Anne Le Dain
INPG, Grenoble University
G-SCOP Laboratory
46, avenue Félix Viallet
38 031 Grenoble Cedex 1 - France
Phone : +33 (0)4 76 57 43 20
Fax : +33 (0)4 76 57 46 95
e-mail : Marie-Anne.Le-Dain@ensgi.inpg.fr