

Proposition of a Tool to Evaluate the Customer's Performance in Collaborative Product Development with Suppliers

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Abstract: An important trend in New Product Development Projects (NPDP) is to increase the involvement of suppliers in order to enlarge the scope of the firms' competencies. However, involving suppliers in NPDP requires the development of specific know-how to manage the suppliers in such projects. The success of a project depends on the performance of both partners –supplier and customer. This paper is a new step in an on-going research project aimed at describing the issue of customer performance evaluation in this specific context. The model and the associated tools presented in this paper were built with the collaboration of six French industrial manufacturers, partners of the PRAXIS research project (Performance in Relationships Adapted to eXtended Innovation with Supplier).

Key words: Product Development, Collaborative Design, Early Supplier Involvement, Performance Evaluation.

1- Introduction

Today, in numerous industrial sectors, the competitive context can be characterised by two combined phenomena. On the one hand, product complexity is increasing due to an integration of various technologies during the product development phases. On the other hand, companies are concentrating on their core competencies and are thus choosing the contracting-out solution rather than the in-house one. This decision is not limited to production activities. When firms contract out, they often decide to also transfer responsibility for design and engineering activities of the outsourced component to the supplier. These two phenomena emphasize the importance of what Van Weele calls *Supply Resources Management* [V2]. In this paper, the focus is particularly on the topic of mobilising external capabilities in New Product Development Projects (NPDP). Our objective is to provide a generic model of customer performance evaluation that takes into account the

various situations which arise during the course of collaborative design with suppliers.

Section 2 is devoted to the definition of the scope of collaborative design and a presentation of the state of the art of performance evaluation in NPDP. The research methodology is presented in section 3. Section 4 then presents the model for customer performance evaluation in collaborative design. The model and some criteria are described, followed by a brief presentation of the tool which was developed with the Schneider-Electric Company. Section 5 presents the first findings of the validation phase of our tool. Finally, managerial implications, limitations and future research perspectives are discussed in the conclusion.

2- Relationship Performance Evaluation in Collaborative Design.

2.1 – Collaborative Design in New Product Development: What does it mean?

The Customer Performance Evaluation (CPE) model presented in this paper is dedicated to the different collaborative design situations that occur between a customer and his suppliers in NPDP. Thus, in this section, we present what we mean by collaborative design in NPDP. For that, we distinguish between two exclusive kinds of collaboration with suppliers in NPDP: *Collaborative Design* and *Collaborative Development* [LC4].

Both of these collaborations are exclusive because the role played by the supplier in customer design activities is radically different in each. Figure 1 illustrates a simplified view of these two kinds of collaboration through the various stages of the product development process.

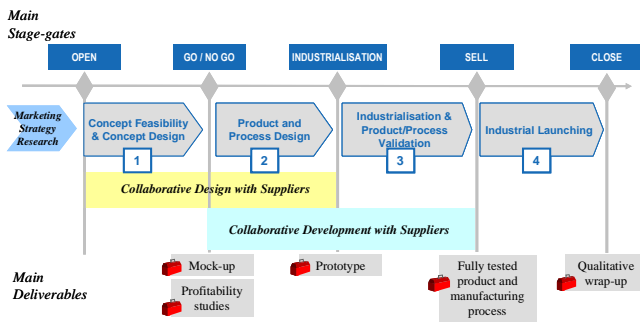


Figure 1: Collaborative Design versus Collaborative Development with Suppliers.

- *Collaborative Development with Suppliers*: In this case, the customer handles all design activities but there is joint development work with suppliers. The supplier may be consulted at the design stage (stage 2 in Figure 1), according to customer need, to provide his process and manufacturing know-how with regard to the dimensions of the part, or the choice of raw material, for instance. Nevertheless, the major role of the supplier does not come into play until the industrialisation stage (stage 3 in Figure 1). Dumas referred to these contributors as *silent designers* [D1]. Thus, in *collaborative development with suppliers*, the timing of the supplier's involvement refers to the two following issues: the stage where the supplier plays an active role i.e. he is responsible for the results of the industrialisation and/or manufacturing process of the supplied part, and the stage where the supplier plays the role of *silent designer* i.e. he only provides informal input to permit his customer to conduct the design activity. In practice, this input often occurs earlier in the process than the contractually designated stage of supplier involvement. This situation called by Calvi and Le Dain *co-ordinated development situation* [CL1] which was experienced by our industrial partners concerning the relationship with their suppliers of plastic injection moulding services. The latter have expertise on how a plastic part can be manufactured. During the *product/process design* phase, they contribute to the customer's design activity by giving their tacit process knowledge, but the drawings are still supplied by the customer.
- *Collaborative Design with Suppliers*: In this case, the supplier has a real responsibility in the design of the customer's product. Indeed, the customer provides functional requirements (performance, interface requirements, space constraints...), and the supplier takes responsibility for the supplied item from design through to the manufacturing ramp-up. A similar concept is the *drawing approved parts* proposed by Asanuma in his classification of outsourced parts in the Japanese automotive industry [A2]. According to Monczka et al., the timing of supplier involvement depends on the complexity and the criticality of the supplied item [MH1]: the supplier of complex and critical items is already integrated during the concept stage and the supplier of simple and less critical items is not involved until the product and process design stage. Thus, in *collaborative design with suppliers*, the timing

of involvement essentially refers to the stage at which the supplier plays an active role in the NPD process.

Within these Collaborative Design situations, relying solely on evaluation of supplier performance is not sufficient. As Araujo et al. highlight, these kinds of relationships require building an *interactive interface*, which is always "*an outcome of decisions made on both sides of a dyad*" [AD1, p506]. Consequently, it seems to be relevant to broaden the topic of performance evaluation to include both partners - the customer and the supplier.

2.2 - From Supplier Evaluation to Collaborative Relationship Evaluation

Several works in literature address the issues of how to manage Early Supplier Involvement [BD1; HR1; WV1] in order to better identify and understand the relevant processes and enabler factors for the success of such involvement. Yet, there is little research which focuses on the *collaborative maturity level* [FF1] and the influence of the competency of the customer's project team on the performance of supplier's involvement in NPD projects [LC5]. This stance fits perfectly with the theory of performance relationship evaluation as presented by Lamming et al. in their RAP (Relationship Assessment Program) model [LC2]. For these authors, when customer and supplier work together in a collaborative way, sole evaluation of the supplier is not sufficient. It is thus necessary to assess the contribution of both parties to improve the performance of the relationship. As Lamming et al. highlighted "*Existing systems still focus upon assessing the 'other' end of the dyad*" [LC2, p174]. Moreover, most of the literature about the evaluation of a relationship takes the customers' point of view [DN1; MC2; EC1]. Johnsen et al. explored the construction of a conceptual relationship evaluation model, which jointly engages both the customer and the supplier in the identification of operational and strategic sources for relationship improvement [JJ2]. Van Echtelt followed the idea of relationship evaluation and claimed that the supplier should "*also evaluate manufacturer's performance*" [V1, p357].

From an industrial point of view, it appears that the use of relationship evaluation models is not common practice across most industries. The RAP model formed a conceptual model rather than a managerial tool [JJ1]. "*More operationalized tools, have since emerged, including the Cranfield Relationship Evaluation Tool (RET), and the 'Supply Chain Relationships in Action' (SCRIA) methodology based on RAP. Practiced in the UK defence and aerospace sectors, they remain inscrutable to anyone who does not operate within these circles*" [JJ2, p3]. According to Johnsen et al., some suppliers now issue evaluation surveys about their customers, identifying areas in which the customer could improve [JJ2].

This is the starting point of the PRAXIS research project which was carried out within the French Cluster "*Arve Industries Haute-Savoie Mont Blanc*"ⁱ. During this project, methods and associated tools were developed to assess the ability of both partners – customer and supplier – to co-design (Working Packages WP1 and WP2 in Figure 2) and to evaluate the performance of both partners throughout a product development project (WP2 and WP3 in Figure 2).

Co-design ability evaluations of both partners were performed prior to establishing the collaboration, and performance evaluations were also performed during and after the collaboration in order to measure the real co-design effort of both partners in a specific project.

This question of how to evaluate the collaborative design relationship is all the more important since our primary interest in the PRAXIS project is not the relationship between OEM (Original Equipment Manufacturer) and first tier suppliers, contrary to the majority of research focus on co-design practices. The industrial partners of the project are mostly firms which, up until now, have retained control of all the design activities of their NPD projects. Their supply networks are composed of SMEs with poor experience and/or limited design activity resources. In this context, our assumption is that all the “working packages” (Figure 2) are highly relevant for leading successful collaborative design relationships.

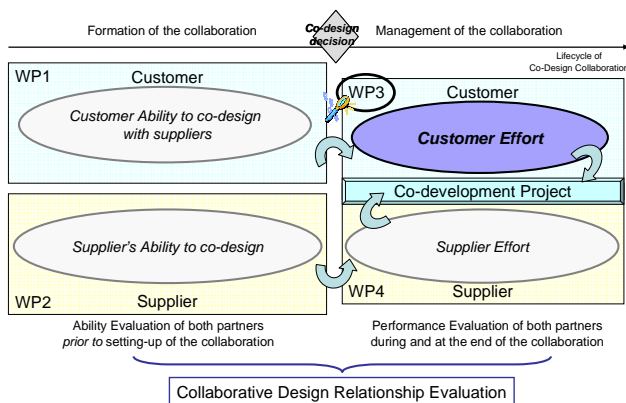


Figure 2: The PRAXIS Research Project

Thus, this paper is part of the PRAXIS research project and focuses on the foundation of Work Package 3. The issue addressed here is how to evaluate the results expected of the customer in *Collaborative Design situations*. The main findings presented are outcomes of an action research conducted within the Schneider Electric group, which is one of the partners of the PRAXIS project.

3- Research Methodology

In January 2006, Schneider Electric Companyii launched the Tango project for the worldwide unification of methods and tools to facilitate and improve *key* and *challengeri*iii supplier involvement in product development. Last year, a senior researcher joined the Tango project team on a full-time basis to handle, in particular, development of methods and associated tools concerning the four WP presented in Figure 2. In addition, a *mirror group* including representatives of all the skills involved in an NPDP was allocated to Tango. This included Purchasing, Electro Mechanic Design, Electronic Design, Software Design, Industrialization, Project Quality, and Project Management.

In our research project, the goal is to build up *generic actionable knowledge*, i.e. knowledge taking the form of generic propositional statements and/or principles, which are mutually consistent for both researchers and practitioners [A3]. For practitioners, this knowledge must be actionable in a

concrete setting and for researchers it should be recognized as legitimate academic knowledge [A1]. To meet these objectives, we adopted an action research approach based on longstanding interactions between researchers and practitioners for the co-construction of local knowledge, which can finally serve to build *generic actionable knowledge*.

The Customer Performance Evaluation tool presented in this paper was primarily built with the collaboration of Schneider Electric and then discussed in workshops with the other PRAXIS industrial partners. The research was designed in four phases which are described below.

- Phase 1: Prototype Tool Creation

The Customer Performance Evaluation tool was created using the same framework utilized for our Supplier Performance Evaluation (SPE) tool (WP4 see [LC4]). We carried out 50 interviews with Project Leaders for purchasing, design, quality and industrialization as well as Project Managers from Schneider Electric in order to analyze Schneider Electric practices, to understand their needs and to explore collaborative design difficulties experienced with their suppliers. Drawing from a literature review and findings gained from these interviews, we devised a preliminary proposition adopting a *grounded theory* approach [SC2, p56] where “*the researcher begins with an area of study and allows the theory to emerge from data*”.

- Phase 2: Pilot Tool Development

The prototype tool was discussed during workshop sessions with the *mirror group* at Schneider Electric. At the same time, workshop meetings with our other PRAXIS industrial partners were conducted. Modifications were made in response to their feedback. Finally, we proposed to our PRAXIS industrial partners that they use the revised tool as a self-assessment tool. This application was performed with Representative Purchasing and Technical Leaders of each partner. The purpose of this application was twofold: First, to establish the usability of the tool and the user guide, and to verify its *completeness* and its *usefulness*. These three criteria are usually used in similar managerial action research in order to validate an assessment tool [PP2; NM1; FF1; MC2]. The second purpose was to obtain “a picture” of the performance as perceived by customers in order to compare it to “the picture” as perceived by their suppliers (Phase 3). Their remarks were taken into account for the elaboration of the pilot tool which is presented in this paper.

- Phase 3: Pilot Tool Field Tests with the PRAXIS Suppliers Club

Within a specific collaborative design relationship it is important to obtain feedback about the CPE tool from suppliers, since the customers' performance will be evaluated by the NPD project supplier. To obtain this feedback, a Suppliers' Club was set up including ten French manufacturing companies in a broad range of activities (assembly, turning, machining, plastic injection and foundry industries). Our PRAXIS partners selected these suppliers because of their know-how either in *Collaborative Design* or in *Collaborative Development*. Thus, we carried out a survey with the PRAXIS Suppliers' Club. A two-step questionnaire was sent to each supplier to capture feedback regarding: (a) their opinion about relevance of the criteria proposed in the CPE model for evaluating the customer's performance as expected by suppliers and (b) their picture of a representative

performance evaluation of their customers in collaborative design. Finally, we organised a workshop session with these suppliers and our six PRAXIS partners to present the findings of the survey and to discuss the comparison of both perceived performance pictures.

- Phase 4: Generic Tool Validation

The remaining step in the research is validation of the tool, which must be applied in a real-life setting within numerous project teams from each PRAXIS industrial partner in order to continuously improve its usability and to verify its completeness and its usefulness. A researcher will be present at each workshop to incorporate the feedback in order to incrementally improve the tool. The final version of the tool can thus be considered as *generic actionable knowledge* i.e. a meta-model which is (1) co-constructed with practitioners and (2) based on an easy-to-customize framework for each firm.

In this paper, we focus on the engineering work (phases 1 and 2) needed for the creation of the Customer Performance Evaluation tool and on the supplier's validation run (phase 3).

4- Building a customer contribution performance evaluation model in a collaborative design context with suppliers

4.1 - Structure of the Model

Customer practices have changed over time, and in industrial sectors where suppliers now contribute a great deal to product value, customers evaluate the tangible results of the supplier as compared to their expected requirements. This has resulted in the development of Supplier Performance Evaluations in NPDP models in the past few years [DN1; MC1; LC3]. However, there is a lack, both in practice and in theory, in the field of Customer Performance Evaluation (CPE) in NPDP.

The evaluation of the customer's performance within the framework of an NPDP may be used in two different ways: (1) on a short-term basis, to identify critical issues and deliver co-designed solutions for joint implementation, (2) on a middle-term basis to continuously improve the performance of the customer in order to guarantee the success of any future cooperation.

The model suggested here is intentionally generic in order to take into account the different situations of *collaborative design* with suppliers. As previously said, this model is based on the same two axis as our Supplier Performance Evaluation Model [LC4].

- **Required Areas of Performance during the Collaboration.** We have identified three main areas of performance expected of the client by the supplier in collaborative design:

- Requirements definition know-how
- Project management skills,
- Relational skills.

In terms of specification definition, it has been acknowledged that specifications are a crucial issue in guiding customer-supplier relationships. In an exploratory study, Karlsson et al. found that "*the problems with specifications are directly related to product development performance measurements in term of quality, cost and lead time*" [KN1]. Product specifications are critical for developing high quality,

low cost and well-interfaced products [NS1].

The last two pivotal areas, project management and relational skills, were chosen to mirror our SPE model. The ability to be organised into a project team, the existence of a cross-functional team, and reactivity are organisational competences which practitioners consider as key criteria when selecting a supplier [SC1; LP1]. According to practitioners, the organisational competence of the supplier strongly affects the performance of the co-design activity. Similarly, and not surprisingly, it seems relevant that the organisational competence of the customer strongly affects the performance of the co-design activity too.

- **Supplier Involvement stage in an NPDP.** Customer development efforts must be evaluated throughout the project with criteria adapted to each stage. As an illustration, let us consider a relationship between a customer and its supplier in charge of concept design, product and process design and the industrialisation of a sub-system. The customer will involve the supplier at stage 1 (Figure 1). The suppliers' expectations concerning customer performance in the area of requirements definition evolves according to the different stages of the project. Therefore, this performance should be evaluated (a) at stage 1 in terms of the clients' willingness to clearly specify the environment in which the supplier's sub-system would be used, (b) at stage 2 in terms of the quality of the definition of functional requirements and (c) at stage 3 by the quality of the definition of technical specifications.

To build our SPE model, we considered only the first three stages of the product development process because expected supplier performance at the industrial launch phase is more related to classical industrial performance than to engineering design performance. So, our CPE is based on the three first stages of the product development process.

For each combination of these two axes, we propose a set of *effectiveness*, *efficiency* and *pro-activity* criteria to evaluate customer performance in collaborative design (Figure 3) following the advice of Mentzer and Konrad [MK1]. They claim that a common definition of performance measurement is the evaluation of effectiveness and efficiency in the completion of a given task. In addition to these first two dimensions, Le Dain proposes a third criterion - pro-activity [L1].

- **Customer Effectiveness:** A customer is considered *effective* if his obtained results meet the project performance objectives. For example, the quality of the definitions of functional, industrial, supply chain, quality, costs, planning, and requirements correspond to the effectiveness dimension of the performance of a customer.
- **Customer Efficiency:** A customer is considered *efficient* if he perfectly masters the resources available for the project. These project resources are either organisational competencies (project organisation, cross-functional team, etc) or technical competencies (trainings, concurrent engineering methods, FMEA, etc).

- Customer *Pro-activity*: We define customer *pro-activity* as the customers' ability to anticipate, in order to successfully complete the co-development project. For example, a customer who has involved the supplier in the concept definition stage must be able to anticipate the risks likely to impact the co-development project by conducting a preliminary analysis and sharing this analysis with the supplier.

What is the right mix of *effectiveness*, *efficiency* and *pro-activity* which will allow us to evaluate customer/supplier performance in NPDP? To throw light on these issues we can mobilise Ouchi's theory of governance mechanisms [O1]. According to Ouchi, evaluation of the relationship by the sole criteria of effectiveness is reserved for situations characterized by a small ambiguity in the performance measurement. Thus, in the case of *traditional subcontracting*, the criteria of effectiveness should be sufficient. However, in the case of a customer/supplier relationship in the design phase, it is not sufficient to use only *effectiveness* as a gauge.

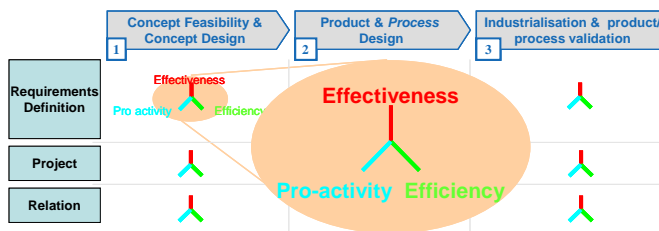


Figure 3. Structure of the Customer Performance Evaluation Model

4.2 - Main Criteria proposed in the CPE Model

In this section, we present the main criteria of effectiveness, efficiency and pro-activity according to the three performance areas of Specification Definition, Project Management, and Relational Performance that were proposed in our Customer Performance Evaluation Model. They were chosen based on the findings of the literature review as well as on findings from workshop sessions with our PRAXIS partners.

4.2.1 – Criteria of Effectiveness

- Requirement Definition Performance

In the context of co-design, which involves significant design input from a supplier, the supplier can “contribute to the design process by helping (the) customer meet functional requirements, without including excessive specification requirements that lead to unproductive additional costs” [HH1, p44]. Thus, three key points are examined concerning this performance area expected of the customer by the supplier: (1) the customer's ability to specify a “need” rather than “a solution” in order to fully benefit from the supplier's expertise in design, (2) the customer's ability to jointly define with suppliers the stakes of the project in order to affect the supplier and to obtain his commitment and (3) the customer's ability to ensure that the supplier clearly understands the customers' specifications in order that the solution proposed by the supplier enables a “lean” definition of the need.

The main criteria proposed to describe each of these three key points are presented below.

- (1) Evaluating the Customer's ability to specify a “need”

reflects a synthesis of issues from case study evidence just as well from literature evidence. The first criterion, *definition of requirements taking into account the customer's product environment*, is one of the most important criteria, according to our PRAXIS partners. A clear specification of the environment in which the supplier's product will be used (T°, pressure, interfaces, tolerance, component life, etc...), if defined at the start of the project, enables the supplier to fully understand utilization constraints and to get an overall picture of expected requirements. Concerning those requirements, we also retained *exhaustiveness* and *stability of the requirement*. According to the suppliers, there are too many changes in specifications [KN1]. According to the PRAXIS partners, it's important that some specifications remain unchanged throughout the project (definition of roles and responsibilities, payment terms...) but most of the specifications have to evolve, the customer adapting them throughout the project according to supplier's suggestion and an improved knowledge of the product. This idea is supported by Karlsson et al. who argues, “The primary role [of specification] is that of being an arena for co-operation among the actors in the design process” [KN1, p537]. However, changes in specifications have to be mastered, as mentioned by our PRAXIS partners. For example, firms have to avoid specification changes after tooling investments. Changes have to be explained to the supplier otherwise “it make(s) it harder for them to adapt and optimize component characteristics, and (to) understand the implications that the changes might lead to in relation to the evolution of a system” [KN1, p540].

- (2) Customer effectiveness must be also evaluated in terms of willingness to co-define (with the supplier) joint objectives in the management of the co-development project. Van Echtelt highlights “the importance of a joint setting of development targets and spending time on defining and agreeing on the work package with deliverables (including their planning) in the early stage of the collaboration” [V1, p175]. This joint definition allows the two parties create a win-win agreement in order to obtain supplier commitment to the project. We translated this idea in the following three criteria: *joint definition of the co-development project schedule*, *joint definition of roles/responsibilities in the development of the verification plan* and *joint definition of the financial commitments of each party*.

- (3) Concerning the customer's ability to obtain a “lean” definition of need, we propose a set of criteria regarding the *quality of the definition of the different specifications* given to the supplier (*Functional, Industrial and Supply Chain specifications, Quality and Costs objectives...*). According to our PRAXIS' partners, the quality of specifications definition enables the supplier to clearly understand the customer's needs and then to propose adapted solutions without unproductive costs.

- Project and Relationship Performance

For the project and relationship dimensions, the effectiveness criteria were adapted from the last updated version of our Supplier Performance Evaluation model [LC3]. Thus, for the project, we defined criteria related to compliance with the contractual agreements to guarantee a win-win collaboration throughout the project. From the customers' point of view, these criteria are defined as *compliance with payment terms and conditions* and *compliance with contractual dates*.

For the relationship performance items, we detailed the effectiveness of the customer in terms of managerial capabilities (*managerial capabilities of the relationship coordinator*), of *responsiveness to customer's requests* and of *reliability of information exchanges during the project*.

4.2.2 - Criteria of Efficiency and Pro-activity

- Requirements Definition Performance

One of the main problems identified by suppliers in the specification process is the fact that “OEM do not listen enough to the expertise of suppliers” [KN1, p538]. Petersen et al. showed that “in the case of black box integration, where the supplier assumes a much greater responsibility in the design effort, supplier involvement in setting technical objectives is nothing less than critical to effective project team decision making” [PH1, p384]. We define the efficiency of the customer in requirement definition by the following criteria: *Use of supplier's expertise, integration of supplier's suggestions* and *integration of the risks identified by the supplier*. These criteria allow the customer to identify the most appropriate solution in terms of design (size of parts, choice of materials...), product/process integration, product and process validation, etc.

- Project and Relationship Performance

We identify a second axis of efficiency that concerns the relevance of customer expertise on project performance. This takes into consideration the level of mastery of the product development process (*management of different configurations and modifications, consistency of development schedules, availability of the necessary business skills, provision of training for the specified methods and tools...*)

Finally, efficiency criteria on relational performance refer to the customer's ability to collaborate with the supplier. We define this as the *availability of the customer's relevant staff* and the *diligence with which services are performed*, which also contribute to the successful fulfilment of the project. In an internationally pursued design context, the criterion of *similarity of mindsets (industrial and/or cultural)* becomes important in order to avoid conflicts in management cultures. Moreover, we agree with Lam and Chin when they highlight that “with the mindset that certain conflict could be beneficial, clients and suppliers are apt to express their judgmental differences for improving decision making” [LC1, p764].

The pro-activity criteria we define to evaluate customer performance are mostly linked to relational performance. As in the Supplier Performance Evaluation Model [LC3], we define the following criteria: *Ability to commit to agreements, Transparency, Ability to capitalise on experience*.

4.2 - Presentation of the pilot tool developed for Schneider Electric

The proposed tool is an Excel file used by the supplier to evaluate the customer throughout the project. This tool is presented on four Excel sheets. The first sheet presents the tool and some instructions for tool use. The three other sheets (Concept / Design / Industrialization) consist of grids that should be completed according to the level of responsibility held by the supplier in the development of the supplied product, i.e.: completion of the "Concept" sheet if the supplier is in charge of the concept studies of the supplied product, "Design" sheet if the supplier is in charge of product and

process design studies and/or the "Industrialization" sheet if the supplier is in charge of the industrialisation activity. Figure 4 illustrates how a supplier evaluates the customer on criteria examined within the Relationship Performance area. Each criterion should be graded from 0 to 5 or as NA (not applicable) by the supplier, using the detailed explanations given for the three performance levels (0, 3, 5) as guides.

Criteria	Rating	Score	Comments
Managerial qualities of the relationship coordinator	2	4.0	
Responsiveness to supplier requests	3	4.5	
Reliability of information exchanges	4	4.0	
Availability of relevant Schneider Electric staff	3	4.0	Schneider Electric does not hesitate to ask the supplier company for any information and/or documents that it needs to do its job. It also systematically asks for any additional information that it deems necessary to understand the supplier's comments, and always checks with the supplier that it has correctly understood the technical and industrial issues.
The diligence with which Schneider Electric is performed	3	4.0	Schneider Electric does not always consult the supplier company to clarify concerns. The response time for both the supplier and Schneider Electric.
Command of the working language on the project	3	4.0	Schneider Electric makes no attempt to ensure that it has clearly understood the supplier's concerns, and to show that it is aligned in a week.
Similarity of mindsets (industrial and/or cultural)	NA	NA	Not Applicable
Ability to commit to agreements	3	4.0	
Transparency	3	4.0	
Ability to capitalise on experience	3	4.0	
Total		4.0	
Total		4.0	

Figure 4. Example of criteria to evaluate customer performance for Relationship items (Data illustrating this example is fictitious)

At the end of each grid, a summary presentation of the results using color codes (red/orange/green) is proposed (Figure 5). The objective of this summary is to support the performance review by the supplier, to promote discussion of the points judged as strong and critical by the supplier, and hence to define together the areas in which to implement a plan for improvement.

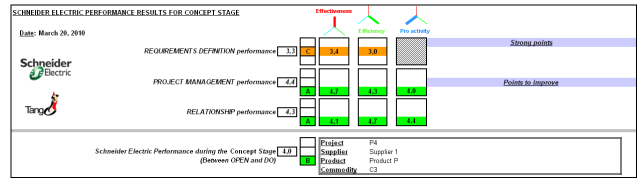


Figure 5. Example of summary of Performance for Concept Stage (Data to illustrate this summary example is fictitious)

This tool is managed by the Purchasing Project Leader and is used by the supplier. It means that the Purchasing Project Leader has to present the objectives for the use of the tool to the supplier and has to ensure that the supplier completes the project on time. He is also in charge of the organisation of the performance review with the supplier and the project team.

5- Implementation and testing of the Customer's Performance Evaluation Tool

5.1 - Presentation of the Survey

As previously outlined in the methodology section, we carried out an application test case with our six PRAXIS partners and a survey with the ten Suppliers of the PRAXIS Club in order to capture first feedback of our pilot tool. Each survey participant received a cover letter and a copy of the questionnaire that was mailed within two days of the initial telephone contact. We placed follow-up calls to respondents who had not returned their surveys within three weeks of the initial mailing.

To introduce the survey, we created three scenarios to various supplier involvement situations in co-design within a New Product Development Project (Figure 6). Each scenario refers to the three possible main stages of supplier

involvement in a NPDP presented in Figure 3 (scenario 1 refers to the stage 1 of concept design, scenario 2 refers to the stage 2 of product and process design and finally scenario 3 refers to the stage 3 of industrialisation). As we said previously, the suppliers' expectations concerning customer performance being different according to these 3 stages, we submitted for each scenario a suitable list of performance criteria (scenario 1 the submitted list of criteria is the list of criteria proposed in the concept sheet of the CPE tool and so on). The purpose of this survey is to validate these three lists of performance criteria by our six customers and ten supplier's partners.

For each scenario, a subsidiary question was asked to determine if the firms had similar previous collaborative design experiences. Based on their own experience in New Product Development Project, the survey participants had to rate the three scenarios according to the number of times they experienced each of them. Then for each scenario, they had to grade the criteria from 1 to 6 according to the relevance of evaluating the customers' performance in co-design (from 1 = worthless to 6 = essential). In addition, each participant completed a questionnaire exploring the usability, the completeness and the usefulness of the tool.

Scenario #1

You've been involved in a New Product Development Project (NPDP) as a specialist supplier for the full realisation of a Sub-Assembly or a complex Component (from concept, product and Supply Chain design to production). This product (Sub-Assembly or Component) is specific and the risk is considered as critical. The necessary skills to realise it are not available within your customers' organization (or less than in your own company). So, you were involved early in order that your customer benefit from your expertise and know-how from the first stage of the NPDP (concept study). Before the beginning of the design stage, you have to evaluate the performance of your customer on these early stages.

Scenario #2

In a New Product Development Project, your customer would like to involve you as supplier for the design, the industrialisation and the production of a simple component. You've been involved in the project at the Product/Process Design stage on the basis of functional specifications. At the end of this stage, (before starting the industrialisation and investment phases), your customer would like you to evaluate his performance on the design stage.

Scenario #3

In an NPDP, your customer would like to involve you as the supplier for the industrialisation and the production of a component. You've been consulted at the Product/Process Design stage to provide your customer with your process and manufacturing know-how. Nevertheless, your major role didn't come into play until the industrialisation stage. At this milestone, which ended the industrialisation phase, your customer would like you (as the supplier) to evaluate his performance during the industrialisation stage.

Figure 6. Survey Scenarios

5.2 - Results of the Survey

The findings presented hereafter are based on the first scenario because this scenario is the most representative of what we called *Collaborative Design*. All six customers and eight of the ten suppliers already experienced a similar scenario during a development project. However, we found differences between

suppliers. Suppliers of complete sub-assembly, or highly specific technologies are mostly involved in NPDP which resemble this first scenario (90% of their projects), while sub-contactors (suppliers of turning, plastic or foundry components) are mostly involved in NPDP which resemble more closely the third scenario (i.e. involvement in the industrialisation phase) and have one-off experience with the first scenario (10% of their projects). We therefore examined the responses of the most experienced supplier(s) more closely.

5.2.1 - Usability, Completeness and Usefulness of the Tool

Customer and supplier feedback was generally positive with favourable comments on usability and usefulness. The respondents appreciated the detailed explanation given for three performance levels (0, 3, 5) to help the supplier in the evaluation as shown in (Figure 4). This provided them with a better understanding of the criteria without ambiguity.

As for the completeness of the tool, it was revealed that the tool was missing a question regarding the appropriate timing for supplier involvement in the project. As explained in a previous paper [LC3], *"unlike the authors who promote Early Supplier Involvement [HMI], we thought that the problematic of 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 Amundson: *"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"* [PA1]. Thus, as suggested by some respondents, it seems relevant to evaluate customer performance on this item.

5.2.2 - Relevance of the Criteria to evaluate Customer Performance

According to the respondents, the proposed criteria are relevant in evaluating customer performance in collaborative design. In the first scenario, the score of each criterion ranges from 4 (= significant) to 6 (= essential). However, we found some limitations in the results. As explained above, the *use of supplier's expertise* has historically been considered as a critical issue [KN1;PH1]. However, the results of our survey show that suppliers consider it to be less important than the *definition of requirements taking into account the customer's product environment* (4.5 as opposed to 6). Asked for further explanation, suppliers claimed that their main customers are quite good at utilising supplier's expertise but have to improve their performance in the definition of requirements. Thus, for the definition of requirements, customer performance was judged as being the least good despite the fact that the criterion is considered important. To avoid this limitation, we decided to ask a second question of our respondents. We requested that they give us an overall score for the customer performance level from 1 to 6 (1 = useless, 6 = first-class).

5.2.3 - Customer Performance perceived by the Suppliers and the Customers

This second step of the survey shows that suppliers and customers have more or less the same perception of customer

performance in collaborative design. This is particularly true for the customer's ability to specify a "need" and to obtain a "lean" definition of the need (see: 4.2.1. Criteria of Effectiveness - Requirements Definition Performance). Both customers and suppliers recognised that customers have to improve in terms of *exhaustiveness* and *stability of the requirements* as well as in terms of *quality of the definition of the different specifications* given to the supplier (*functional, industrial and supply chain requirements, quality and costs objectives...*).

Customers and suppliers also have the same perception concerning what we called absorptiveness, i.e. the customer's willingness to make use of the supplier's innovative capacity. This notion refers more or less to the *absorptive capacity* defined by Petroni and Panciroli as "*the firm's ability to evaluate, assimilate and exploit extramural technological developments*" [PP1, p140]. We evaluated this willingness through efficiency criteria on the Requirement Definition Performance (4.2.2.): *Use of supplier's expertise and integration of supplier's suggestions*. All the respondents judge their customers as "great" on these points. As already explained, this only concerns the first scenario. In the two other scenarios, customer performance was judged as merely "acceptable". This can perhaps be explained by the fact that customers who involved suppliers early in the project (scenario 1) involved them to benefit from their expertise and thus were more willing to use this innovative capacity.

Major response divergence occurs in the evaluation of the "cooperativeness" criteria. McCutcheon et al. defined the supplier's cooperativeness as "*the supplier's responsiveness to the buyer's technical problems ... and (the supplier's) willingness to work with the buyer to find solutions*" [MG1, p278]. Thus, we defined the customer's cooperativeness as the customer's willingness to work together with the supplier to co-define solutions and to solve problems. In our CPE, the two criteria describing this cooperativeness, and for which there is a difference of perceived performance, are the *availability of the necessary skills* and *customer commitment towards a modification with impact on the supplier's tasks*. For the first criterion, according to suppliers, customers do not always respond to requests to provide all the internal and/or external skills needed to ensure that their solutions (product and/or process) are compliant with all the customers' requirements. For the second criterion, the suppliers highlight that when customers request a modification which has a considerable impact on the supplier's tasks, particularly during the industrialisation phase, customers do not really participate in the definition and the implementation of a joint plan of action and do not fulfil all of their commitments.

6- Conclusion and implications

One of the main motivations for our study was the limitation of existing research in providing a broad and comprehensive definition of an efficient co-design customer. The proposed model, based on identification of three performance areas combined with three involvement stages, provides an improved conceptualization for understanding customer performance in an extended product development context. The other important issue implicitly included in our model is that collaborative design should not be limited to the management of the

supplier's involvement within a single development project. To create a real dynamic of capitalization between different NPDPs, firms must improve their understanding of what an effective collaboration is in order, firstly, to drive performance and then to reduce the perceived risks associated with this practice.

As stated in the description of our research methodology, our purpose was to build actionable knowledge, in order to point out the managerial implications of our study. The generic model presented in Figure 3 can be used throughout a product development project as an assessment tool for providing an objective measure of the co-design effort of customers in NPDP. The suggested model allows the customer to identify critical issues and show where improvements can be made in implementing co-defined solutions with the supplier as recommend by Humphreys et al. [HL1]. This tool can serve as a basis for defining the continuous improvement strategy needed to guarantee the success of collaboration. Thus, workshop sessions uniting our six PRAXIS industrial partners and ten of their suppliers (members of the Suppliers' PRAXIS Club) were organised to take into account the supplier's opinion about the relevance of our propositions. Their interest in the model has been high due to the historically ambiguous nature of performance in collaborative design.

This research explores a relatively new area of customer performance in collaborative design and we have identified a number of limitations. Firstly, the industrial partners of PRAXIS joined the project because they lacked extensive experience in collaborative design and had expressed willingness to improve their practices. Our model, co-constructed with these firms, is the reflection of their evolving situation. A recommendation for future research is to carry out investigations in other industrial contexts in order to test the generic nature of our model. A second limitation of our research is applicable in situations where a co-design relationship is marked by a particularly strong collaboration. In this case it is relevant to evaluate the performance of the relationship (as a separate entity), in addition to the performance of the supplier and the customer individually. In a further research project, we plan to aggregate our two models (Customer and Supplier Performance Evaluation) into a Relationship Performance Evaluation tool.

7- Thanks

The authors wish to thank all the partners of the PRAXIS project and most particularly Schneider-Electric for their close cooperation in this work.

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ⁱ This project is supported by the Business & Innovation Centre of Haute-Savoie (Thésame). It gathers researchers in Engineering Design (G-SCOP – Scientific Manager of the project) and in Management Science (CERAG and OEP Prism), a professional syndicate (Udimec) and 6 French industrial partners (BioMérieux, Bosch Rexroth Fluidtech, Salomon, Schneider Electric, SNR Roulements and Somfy). This project began in January 2006 for 4 years.

ⁱⁱ Schneider-Electric is the word leader for electricity and automation management.

ⁱⁱⁱ A *Key supplier* is a globally performing supplier to be actively grown by all Schneider Electric entities. This supplier is a technology leader with favourable performance track record in the group. A *Challenger* is an attractive existing supplier with development potential to become, within 2 years, a future *Key supplier* if proving himself.