Contribution of two diagnosis tools to support interface situation during production launch

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Abstract
Firms are urged to constantly introduce new products. Hence, the New Product Development process should be mastered, especially its final phase, the production launch. This paper addresses the critical issue of the information exchange during production launch. Two diagnosis tools considering production launch as a key interface are presented. They permit to examine the information flows, to highlight their weaknesses and hence to find solutions for further improvements. This paper also presents the results of a case study where the diagnosis tools were implemented during a switchgear development project.

Keywords:
New Product Development, Production Start-up, Information exchange, Intermediary objects.

1 INTRODUCTION

The extended globalization and the increasing competition urge firms to constantly innovate and launch new, high technological products on their markets. Therefore, New Product Development (NPD) has become a key process to master for successful companies [1, 2]. As a result, NPD has received a great attention over the past years in the research literature [3-5] . New Product Development has been studied from different points of view, varying from marketing to engineering design and to operations management [6].

The final phase of the NPD process is called " production launch and ramp-up" [4, 5, 7]. Production launch is described as the period when "firm moves development into a pilot manufacturing phase" [4] and ramp-up as the period "after production launch until full capacity utilization" [8]. Production launch and ramp-up are crucial steps for the whole NPD project. Indeed, their success are necessary conditions for the NPD project success [9, 10].

During production launch occurs the handover of the NPD project from R&D (Research & Development) to Production (manufacturing) [7, 11, 12]. This handover requires an intense collaboration and an important information exchange. But the R&D-Production handover is only one of the numerous cross-departmental activities occurring during production launch. Several actors step in the project during this phase (such as the actors from Purchasing, Procurement or Quality control departments), which intensifies the need for information exchange and collaboration. Furthermore, to increase efficiency and reduce the time-to-market, immature or uncertain information is exchanged, implying a higher risk for the NPD project tasks completion and success. This is why the production launch is considered as a very critical phase. Improving the information exchange during production launch could have sizeable positive consequences for the global NPD project.

As a result, this paper is concerned with the information exchange in the context of production launch. Because of the number and variety of actors involved and the intense information exchange that is necessary, production launch will be considered in this paper as an interface situation. Indeed, an interface is defined, in the management science literature, as the links and interactions between several different industrial functions that are used to communicate and collaborate [13, 14]. This paper is concerned with analyzing the different aspects of the interface situation during production launch. It presents the basis of two diagnosis tools, which aim at analyzing the interface situation and highlighting its weaknesses, giving hence possibilities for improvement. These diagnosis tools are implemented in a case study realized in a major original equipment manufacturer of electrical devices.

The next section of this paper will be concerned with the presentation of the concept of an interface, on which the analysis carried out in this paper is based. Section 3 will present in detail the diagnosis tools proposed to analyze the interface moment that happens during production launch. Section 4 addresses the case study and the implementation of the diagnosis tools. Section 5 presents the conclusion of the diagnosis tools and a discussion.

2 FUNDAMENTAL ELEMENTS OF AN INTERFACE

From an organizational point of view, the concept of interface is often related to the connections, links, interactions, and relationships that exist between two or more industrial functions (or teams). There has been a strong focus on the interface concept in the design and engineering management literature [11, 14, 15]. An interface can be considered either on a static point of view – trying to describe the fundamental elements of the interface – or on a dynamic point of view – trying to identify the different information flows that compose the information exchange between the project actors.

Concerning the static aspect, the diagnosis tools presented in this paper are based on the characterization of an interface given by Koike et al. [13]. The authors define the concept of the interface among project actors using five fundamental elements: the stakeholders ("interface members"), the intermediary objects ("artefacts or object"), the tools, the procedures and rules, the interface space and time (see figure 1).

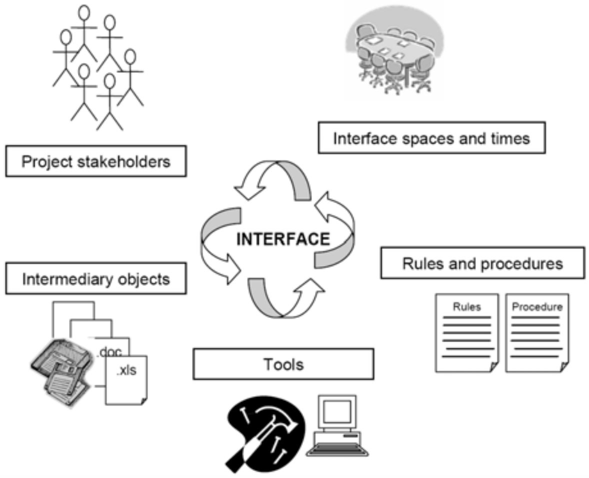

Figure 1 : The five fundamental elements of an interface [13]

Project's stakeholders are persons or groups having an interest in the NPD project. In the case study presented in this paper, the three major stakeholders during production launch were the R&D department, the Production department and the Purchasing department. Other stakeholders also took part in the project such as Procurement, Quality or the factory management.

The concept of **intermediary object** was first presented by Jeantet and Vinck [16]. The authors call "intermediary objects" (IO) items that are used or created during the design process. Jeantet and Vinck explain that these items have two utilizations. They are first a way for actors to exchange information. But the authors also insist on the second utilization of IO: these objects in some way also represent the coordination that exists among their users. Analyzing who can modify, who is using the object, how it is shared among actors brings a lot of insights about how the information is exchanged within the project. Intermediary objects used during production launch are for example product bills of material or component drawings.

The **tools** are essential in a project to help the information exchange as well as the work break down. Several different tools are often at the project stakeholders' disposal such as PLM (Product Lifecycle Management), ERP (Enterprise Resource Planning), and MS Office software.

The **rules and procedures** of an interface define how to design and coordinate the information flows and activity execution. For example, defining the participants of a project structures the information diffusion within the project.

Interface spaces and times are moments and places where stakeholders can interact during the project. They are dedicated moments and places to create or use intermediary objects. The interface times could be either synchronous (such as project status meetings) or asynchronous (such as e-mail exchanges). In this paper, only synchronous interface times will be considered.

These five fundamental elements of an interface illustrated above are useful to describe the core elements of an interface. But examining these five elements isn't sufficient because they only reveal basic and static aspects of an interface. In fact, the most important aspect of an interface is its dynamic one. An interface strongly structures itself around the information flows between its stakeholders. Focusing on the dynamic aspect of information exchange helps identifying the actual information flows during production launch and hence highlighting their weaknesses, giving possibilities for improvement. The diagnosis tools presented in this paper are based on the five fundamental elements of an interface illustrated above. But their principal goal is to capture the dynamic aspect of the interface situation. The diagnosis tools presented in the following section are intended to characterize the information exchange that happens within the different stakeholders interface.

3 DIAGNOSIS TOOLS

The diagnosis tools presented in this section are concerned with the identification and analysis of the information flows that exist within the interface situation during production launch. They are based on the five fundamental elements composing an interface. They are concerned with the analysis of the project interface and its information exchange through the characterization of information and of its spaces of exchange.

To deeper analyze the dynamic aspect of the interface, the diagnosis tools are focusing on the intermediary objects (as support for the information exchange) and the interface spaces (as spaces for the exchange and the diffusion of information). As a result, the diagnosis tools presented here are two grids: a first grid investigating the project intermediary objects and a second grid investigating the synchronous interface times. The former grid will be named as the IO grid and the latter one as the SIT grid.

The IO grid has the objective of investigating the different intermediary objects that are created during the project, because intermediary objects support the information exchange. To further examine the information that is exchanged thanks the different IO, several information characteristics are emphasized in the IO grid. Indeed, to identify and characterize the information flows, the IO grid focuses on the information dynamic, taking into account three characteristics:

- The **information update frequency**, to evaluate how often the information changes, and thus qualifying its maturity. The update frequency evaluates the rate of change occurrence of the IO information.
- The **information evolution**, to evaluate with which tendency the information is reaching its final value. Information evolution [17] characterizes the velocity with which the information will reach its final value. A piece of information with a *fast evolution* will quickly reach its final value and thus only have small-scale changes. On the contrary, a *slow evolution* piece of information will not approach its final value until the very end of its evolution.
- The **possibility of modification** of the information, to evaluate if the information can be changed after its release by the information source. An object which cannot be modified by its users is a *closed* IO whereas an object which is a support for negotiation and interaction is an *open* IO [18]. This characteristic is used to determine the influence of the different users on the IO and whether the object is more a support for negotiation or for prescription.

However, as explained in section 1, a key element of the information exchange is the risk due to the exchange of immature or uncertain information. As a result, the IO grid also focuses on the evaluation of the information maturity. The maturity of information is evaluated with respect to the different impacts an information change can have on the global project process. The IO grid entails three evaluations of information impact:

- The **sensitivity of information**, to evaluate the impact of information changes on downstream tasks. Sensitivity [17] characterizes the information exchanged between an upstream activity (for which the piece of information is an output) and overlapped downstream activities (for which the piece of information is an input). A piece of information is v*ery sensitive* if its modification will have serious impacts on the downstream activities. On the contrary, information with a *low sensitivity* will not have a high impact on its downstream activities.
- The **update duration**, to evaluate the load for the person in charge of the information release to update the information. The longest update duration, the heaviest load for the person in charge of updating the IO.
- The **information structure**, to evaluate elements of context attached to the document to interpret it. There are three degrees of information structure [19] :
  - Structured Information (SI): Structured Information's content and form are strongly regulated and fixed through rules and procedures. For example, a design drawing is an IO with Structured Information: all the information enclosed in the drawing sheet is mandatory and thoroughly predefined by official company rules.
  - Semi-structured information (SSI): The content and the form of Semi-Structured Information can only be partially shaped by the company's official rules. For example, minutes of meeting could always be handed out following the same frame but the content will always be various. SSI could be either very explicit or totally meaningless for external actors, depending on their personal knowledge.
  - Non Structured Information (NSI): the information enclosed in the IO is very little formalized. Context elements are the bare minimum for the information receiver to understand.

All these IO information characteristics allow a precise picture to be made of the information exchanged between stakeholders. The proposed frame for the IO grid, the first diagnosis tool is presented in figure 2.

	Intermediary object	Description	General description					
			Support		Person in charge		Users	
			Information dynamic			Information Impact		
			Update frequency	Evolution	Modification	Sensitivity	Update duration	Information structure
n°	Name	Short description of the object						

Figure 2 : Analysis of the project intermediary objects – the IO grid.

Filling in the IO grid leads to a first deep analysis of the information exchange. The IO grid reveals which objects are critical to the information exchange within the project. Identifying the person in charge and the users of IO helps identifying the real major information flows. The IO grid, as a diagnosis tool, also allows possible weaknesses or failures in the information exchange and hence difficulties in the actors collaboration and/or relationships to be identified.

The second diagnosis tool, the SIT grid, consists in listing the synchronous interface times occurring during the production launch phase of the NDP project. Indeed, these times are precious interface times, where information is exchanged and/or diffused, where IO are created and/or used. In the SIT grid, the team responsible for the interface time is also registered, as well as the participants. The SIT grid also concentrates on the identification of information flows in utilizing the concept developed by Blanco et al. [18], to determine at which level the information is exchanged. Blanco et al. defined four levels of information diffusion in collaborative design activities:

- The **public workspace**: it is in the public workspace that official deliverables are published. It is also the place for external communication with suppliers or customers. In general, the information exchanged in the public workspace is extremely formalized.
- The **project workspace**: this intermediary level concerns the sharing of information within the project team. This level is still influenced by the company formalization of information (and by project's role segmentation)
- The **proximity workspace**: this level corresponds to the information producers' personal network. The invited actors accepted in the information producer's proximity workspace compose a "friendly" assistance for the share of information.
- The **private workspace**: it is in the private workspace that each stakeholder keeps its own information.

The SIT grid, as the second diagnosis tool presented in this paper, reveals in which workspace the information is exchanged during the listed meetings. The private workspace isn't reviewed in the SIT grid, because first of all, it is difficult to access and review the personal data of each stakeholder, and second, the information kept in the private workspace isn't generally shared as is with any of the other stakeholders.

So, as a second part of the diagnosis, the SIT grid illustrated in figure 3 is proposed.

	Meeting(s)	Person in charge	Participants	Nb of meetings	Public workspace	Project workspace	Proximity workspace
n°	Name				To tick		

Figure 3 : Investigation of the synchronous interface times– the SIT grid.

The following section details the industrial case study realized to illustrate how the above presented diagnosis tools can be implemented in the production launch phase of an NPD project and contribute to draw valuable conclusions on the weaknesses of the project.

4 CASE STUDY

The field study was carried out within a plant of the Siemens Group AG in France. Siemens AG is a global powerhouse in electronics and electrical engineering, operating in the industry, energy and healthcare sectors. The company has around 400,000 employees working to develop and manufacture products, design and install complex systems and projects, and tailor a wide range of solutions for individual requirements. In fiscal 2007, Siemens had revenue of €72.4 billion. In its Power Transmission & Distribution business area, Siemens is the world's second largest solutions provider to power utilities and industrial customers, offering solutions for the transport and distribution of electricity from the power plant to the consumer.

The followed up project was a switchgear development project. As mentioned in section 2, the three most important stakeholders of the production launch phase of the development project were the R&D department, the Purchasing department and the Production department. Concerning the R&D department, the switchgear design was carried out by two physically separated R&D teams (R&D 1 and R&D 2), one of them (R&D 1) being located in the plant where the field study was carried out. Dedicated teams were also appointed in the Purchasing department (2 to 6 persons) and in the Production department (4 to 6 persons). The Quality department and the Procurement department of the plant were also involved.

The major information flow needed during the production launch of the switchgear development project is depicted in figure 4. The Siemens factory being an electrical devices' OEM (original equipment manufacturer), the Purchasing department plays a key role in the setting-up of the new supply chain. Hence, during production launch, the Purchasing team needs information from the R&D team so as to be able to purchase the newly created components. Further downstream, the Production team needs information from the Purchasing department about availability of the components (see figure 4). The Purchasing team is at the centre of the major information flow during production launch.

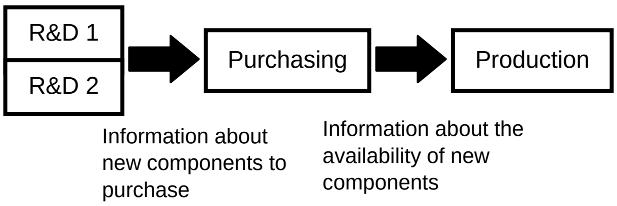

Figure 4 : Main information flow during production launch.

Thanks to the diagnosis tools presented in section 3, a deeper identification of the real information flow is possible. Filling the IO and SIT grid allows depicting in detail how and when information is exchange. As a result, the weaknesses of the information exchange are detected and improvement possibilities are identified.

4.1 Methodology

The field study was carried out by the authors through an operational involvement of the first author in the NPD project of the Siemens factory. Indeed, her involvement allowed her to keep track of what happened during the production launch phase of the switchgear development project. Several focused interviewed were also carried out to enable the authors to look into imprecise or interesting topics. This operational involvement was completed with a literature review and group meetings.

4.2 IO grid

Concerning the IO grid, the operational involvement in the production launch phase of the switchgear development project enabled to list the principal IO used by the project stakeholders. Then, reality-anchored criteria (listed here below) were used to precise the different characteristics defined in the IO grid (presented in section 3).

About the update frequency characteristic, the following categories were chosen:

- High update frequency, if the IO was updated more than 10 times in its life-time. Indeed, the field study lasted five months: an IO which was updated more than 10 times is equivalent to information changes at least every two weeks.
- Average update frequency, if the IO was updated between 4 and 9 times (i.e. information updated at least once a month)
- Low update frequency, if the IO was updated 3 times or less. (i.e. very few information changes)

The update duration column is filled with the average necessary time (in hours) for the person in charge of the IO for updating the IO information (based on experience).

About the possibility of modification, the rule applied was the following one: either the content of the IO is modifiable by the users and the object is an open one, or the content is definitely fixed by the person in charge of the IO and the object is a closed one.

About the information structure, the below detailed rule was followed:

- if the IO is an official object of the company (official document, official content of the ERP…), the IO information is considered as structured information (SI)
- if the IO information is referenced (for example, Excel-sheet columns with explicit titles) and if the document is shared by various actors without needing additional context information, the IO information is considered as semi-structured information (SSI)
- if the IO information is almost raw information (raw data) with no special layout so that the person in charge of the IO is almost the only one to understand the information, then it is considered as non-structured information (*NSI*)

The information sensitivity was evaluated with respect to the project lead time and the project cost. As in almost all NPD projects, the switchgear development project was mainly steered according to lead time and cost criteria (in order of importance). So the following categories were established:

- High sensitivity of the IO information means that a change in IO information has a direct impact in the project lead time (i.e. the final delivery date of the first customer product).
- Average sensitivity of the IO information means that an information change implies rework for some activities and thus an additional cost but no delay in the project lead time.
- Low sensitivity means that the global impact (in the project lead time or project cost) of the information change isn't significant with respect to the project lead time and the project cost.

About the information evolution, the criterion chosen was the time occurrence of the update in the lifecycle of the IO.

- Either the updates were in a majority at the end of the IO life-cycle (slow evolution).
- Or the updates were in a majority close to the first release date of the IO (fast evolution).

All these rules and criteria led to the filled grid shown in figure 5.

	Intermediary object	Description	General description			Information dynamic			Information Impact		
1	R&D Critical Components follow-up list	References of components that are difficult to supply in the R&D point of view. This list enabled the R&D department to have a closer follow up of these references' procurement	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
			Excel-sheet	R&D 1	R&D 1 + Purchasing	Average	Fast	Closed	High	1 hour	NSI
2	R&D Bills of Materials	Bills of materials created and updated by the R&D team. These BOM entailed only technical information (reference, description, revision number, raw material…)	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
			PLM tool	R&D 1 R&D 2	All	Low	Fast	Closed	High	1,5 hour	SI
3	Production bills of materials	Bills of materials with all the necessary production information (price, delivery time, assembly duration…). These BOM were based on information transfered from the PLM tool database	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
			ERP tool	Shared responsibility	All excepted R&D 1 and R&D 2	Low	Fast	Closed	High	1 hour	SI
4	Purchasing follow up list	References of components to be qualified by the Purchasing department. This list was based on information given by the R&D department to the Purchasing department	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
			Paper	Purchasing	Purchasing + Production	Average	Slow	Closed	High	0,5 hour	NSI
5	Long lead-time components list	References of the first production's components with a lead time higher than 4 months. This list was realized in order to focus the components qualification on the long lead time components at first.	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
			Excel-sheet	Production	Prod. + R&D 1+ Purchasing + Procurement	Average	Slow	Open	High	0,5 hour	SSI
6	"Samples tests" component follow-up list	References of components that are concerned by "samples tests". "Samples tests" is a procedure in which the component supplier-to-be sends samples, that are thoroughly checked by the Quality Department before approving the supplier qualification.	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
			Excel-sheet	Quality department	Quality dep. + R&D 1 + Purchasing	High	Slow	Open	High	2 hours	SSI
7	Components-to-buy list	References of the necessary components to assemble the first products to be manufactured by the plant	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
			Excel-sheet	Production	Prod. + R&D 1 + Purchasing + Procurement + Factory management	High	Slow	Open	High	4 hours	SSI

Figure 5 : Intermediary objects grid realized during the field study at Siemens

This grid helps to draw conclusions about the information exchange. Indeed, the objects listed in figure 5 are carrying information created by one project actors (the person in charge of the IO) and necessary to several other project actors (the users of the IO).

Having an overall view of the IO grid presented in figure 5 allows three remarks to be done.

First of all, all the IO listed in this grid are "high sensitivity information" IO. Since the list presented in figure 5 isn't certainly exhaustive, this characteristic shows that the listed objects are at least part of the most important ones for the project.

Second, it emerges that the Purchasing team is always cited as "user" of the IO (IO n°1-7) and only once as a "person in charge of the IO" (n°4). Contradictorily the Purchasing team should be at the centre of the major information flow needed during production launch (as depicted in figure 4) which goes from the R&D to the Purchasing and from Purchasing to Production. The Purchasing team being only "user" of IO seems to reveal that it had a "passive attitude" toward the information exchange.

Third, R&D 2 is only cited once as user and person in charge of IO (IO n°2). It denotes a light implication of the R&D 2 team in the information exchange during production launch.

Going a deep further in the IO grid, it is remarkable that IO n°1, 2 and 3 share a common profile: the information they enclose is not very often updated and evolves quickly. Even though the impact of the information they embody is high, these objects can be considered as not the most critical ones of the list. Since their information evolves quickly, the information exchange isn't the riskier one and hence collaboration around the object isn't the most intense.

On the contrary, the next four objects (4, 5, 6, 7) depicted in the grid are "slow evolution" information IO.

IO n°4, the NP Purchaser follow-up list, is an object only shared by two actors (Purchasing and Production). Since it is a closed object, it doesn't let to Production much freedom about it. This IO isn't considered as the most interesting in order to analyze the information exchange.

IO n° 5, 6 and 7 are open objects shared by numerous users. As a result, these IO are believed to be the most critical ones for the global project collaboration. These IO are major supports for activities coordination within the project.

To conclude the diagnosis with the help of the IO grid, the IO n°7, the Components-to-buy list, can be identified as being the most critical intermediary object of the production launch phase in the switchgear development project. There are several reasons. First this IO is part of the three most critical IO. Then it also has the biggest number of users (almost all the NPD project actors). Lastly, it was very often updated, even if the update duration is very long (which makes the update particularly difficult).

4.3 SIT grid

The second diagnosis tool, the SIT grid, was implemented during the case study in the switchgear development project to allow the analysis of who exchange information and when. As mentioned in section 2, the analysis presented in this paper with the SIT grid is limited to the synchronous interface spaces (i.e. meetings).

In order to fill in the SIT grid, our second diagnosis tool, all the gatherings and meetings observed during the production launch phase of the switchgear development project were listed. Then precise criteria were set up to determine the characteristic of these meetings:

- If the meeting was with participants who didn't belong to the project team, then its information diffusion level is the *public workspace*.
- If the meeting concerned only actors of the project team and that it was a formal meeting

(officially set in the actors' schedule) then its information diffusion level is the *project workspace.*

- If the meeting concerned actors of the project team and that it was an informal gathering (not scheduled in the participants' calendar), then its information diffusion level is considered as the *proximity workspace.*

Figure 6 illustrates the SIT grid realized during the field study at Siemens.

	Meeting(s)	Person in charge	Participants	Nb of meetings	Public workspace	Project workspace	Proximity workspace
1	Project Status Meetings	Project Manager	R&D 1 + R&D 2 + Purchasing + Production + Procurement + Quality	3	X		
2	Supplier visits	Purchasing	Procurement + R&D 1 + Quality department	10	X		
3	Project Milestones Meetings	Production	R&D 1 + Purchasing + Procurement + Quality + Factory management	2	X		
4	Project follow-up meetings	Production	R&D 1 + Purchasing + Procurement + Quality	11		X	
5	R&D 1- Purchasing Meetings	R&D 1	Purchasing	8		X	
6	Production - Purchasing - Procurement Meetings	Production	Purchasing + Procurement	20		X	
7	Purchasing - Procurement Meetings	Purchasing	Procurement	12		X	
8	Purchasing informal visits	Purchasing	Quality	7			X
9	Production technical information gathering	Production	R&D 1	22			X
10	Production supplying information gathering	Production	R&D 1 + Purchasing + Procurement	19			X
11	R&D 1 informal visits	R&D 1	Purchasing	17			X
12	Procurement information gathering	Procurement	Purchasing	15			X

Figure 6 : SIT grid, second diagnosis tool implemented during the field study.

Two major conclusions can be drawn from this grid.

First of all this grid helps to identify the intense collaboration around the Purchasing team. Indeed, the Purchasing department is involved in almost all the meetings and gatherings that are listed in the SIT grid (all except n°9).

Second, the SIT grid presented in figure 6 points out that a vast part of the project coordination was organized within small groups of actors. Only few meetings to support project-wide coordination were officially scheduled (n°1, with the participation of R&D 2, n°3 and 4, for a total of 16 meetings) while numerous of formal and informal meetings took place locally between two to three actors' teams (n°5-12, for a total of 120 meetings).

In the following section, the conclusions drawn from the realization of the IO and the SIT grid will be confronted to the reality of the switchgear project, as experienced and kept recorded during the case study.

5 CONFRONTATION OF THE DIAGNOSIS TOOLS' CONCLUSIONS AND DISCUSSION

There are several conclusions drawn from the two diagnosis tools implemented during the case study, as presented in section 4.

First of all, one of the conclusions drawn thanks to the IO grid is that the Purchasing team seemed to have a "passive attitude" toward information exchange, even though it was supposed to be at the centre of the information exchange (see figure 4). The analysis of the SIT grid, the second diagnosis tool, also revealed that the project actors developed a lot of means to manage and secure the information exchange and the coordination within their interface with the Purchasing team. More generally it became clear thanks to general observations during the field study that there existed a real communication problem between Purchasing and other actors of the NPD team. For example, the "components-to-buy" list (IO n°7, figure 5) emerged from a need of the Production team to have a clearer view of the progress in purchasing activities. Moreover, a particularly heavy work load during production launch for the Purchasing department was identified, implying that the Purchasing department was less proactive in the project. In future project, being aware of the need for project actors to secure the information exchange with the Purchasing team could be very useful in order to succeed more easily in the production launch phase.

Second, in the IO grid, identifying the "Components-to-buy list" (IO n°7, see figure 5) as being the most critical IO of the production launch phase urges to improve and perfect this object for future similar project. Several improvement possibilities are entailed in the diagnosis of the IO grid. Indeed, the IO grid shows that the information of IO n°7 isn't totally formalized. It is only semi-structured. Moreover, IO n°7 is an open object (modifiable by users) used by numerous actors within the project. In future projects, an interesting improvement could be to define in the company's rule and procedure what should exactly be the content and the frame of such an object. A generic template could be for example defined. It could avoid some interpretation mistakes noticed during the lifetime of the IO and thus improve the efficiency of this IO. Besides, the "update duration" characteristic signals that it was extremely absorbing for the person in charge of it to update this list, even though it needed to be updated frequently (every week). Another interesting issue could be to facilitate the creation and the update of this list, here again to improve the information exchange and thus the collaboration around this IO.

Lastly, the SIT grid draws attention to the fact that most of the collaboration between actors seemed to be localized and between small groups of actors. This conclusion also shed a very interesting light on the communication problems observed between the R&D 2 team and the other teams during the field study within the switchgear development project. As the R&D 2 team was located in another plant of Siemens than all the other teams, the information exchange was more difficult and hence poorer. This led to a very light collaboration between the R&D 2 teams and the other ones and hence difficulties in the achievement of common activities. A major improvement for future production launch phases could be to pay attention to teams located in other plants and consequently secure the information exchange between all the teams. For example, scheduling several dedicated meetings could be a solution easy to implement.

To conclude, the diagnosis tools presented in this paper are very helpful in a production launch context to investigate the information exchange within the project stakeholders. They are valuable to analyze who, where, when and how information is exchanged and thus how collaboration is performed. These diagnosis tools enable the detection of weaknesses in the information exchange between project actors. Besides, the in-depth analysis provided by the two diagnosis tools, the IO grid and the SIT grid, allows possible improvement solutions to be found.

A first limit to this work can be found. The analysis of the interface times is limited in the SIT grid to the synchronous interface times. Even if it would be difficult to track each interface time, trying to take into account asynchronous interface times could bring valuable insights about parallel information flows. Increasing the number of IO and interface times studied could be also very interesting to get a more acute picture of the real information flows.

As a final point, an interesting further research issue could be to add a quantitative dimension to this work.

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