A MULTIMETHODOLOGY FOR HOSPITAL PROCESS REDESIGN

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Abstract

Hospitals are complex organizations, faced with major challenges. They are required to reach higher cost efficiency, while improving treatment quality and achieving patient-focused care. Yet, hospitals are still fragmented organizations, which prevents them from reaching these targets. In this article, we propose a multimethodology to achieve coordination and integration between different hospital departments involved in the same care process. Our proposition combines Soft Systems Methodology, Discrete Event Simulation, benchmarking and Service Blueprinting. It offers both qualitative and quantitative aspects, and takes into account both the logical/technical and the social/political dimensions of interventions and change management in organizations. The multimethodology is evaluated on a project in outpatient chemotherapy delivery within a partner hospital. Solutions are generated and refined for the problem of patient waiting times. The study makes a methodological contribution, by proposing this multimethodology. It also offers a practical solution concept for outpatient chemotherapy planning.

Keywords: Service design, Design methodology, Simulation, Healthcare systems engineering, Organizational processes

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1 INTRODUCTION

Hospitals have long been described as complex systems (Georgopoulos and Matejko, 1967). To address the rising costs on healthcare, they need to integrate their activities through improved coordination (Lillrank, 2012). Yet multidepartment studies are rather rare in healthcare systems modelling and analysis (Vanberkel et al., 2009).

Many hospitals are still quite close to Mintzberg's description of professional bureaucracies (Mintzberg, 1979), where experienced professionals who carry frontline work—in this case, physicians—have more influence on the organization than in more common industrial organizations. This political dimension is fundamental to the analysis, because when multiple departments are involved, more often than not diverging interests will emerge. Hospitals are also complex social organizations, with a strong ethical dimension, probably exacerbated in public hospitals due to the wide array of stakeholders (Klein and Young, 2015). Finally, hospitals have to address the challenge of efficiency and physicians must more and more be skilled at operations management and adopt (or at least understand) the accountant's perspective.

In such complex human activity systems, hard, mechanistic systems engineering is not suitable (Checkland, 1981). Such issues need a more open approach, combining the quantitative aspects of systems engineering with more interpretive insights. In this article, we propose a method for redesigning hospital processes with a focus on patient flows. This method was developed during an action-research project in a French hospital. It combines four existing methods under the principles of creative holism (Jackson, 2006) and multimethodology (Mingers and Gill, 1997). We apply this method in the outpatient chemotherapy delivery system of a French public university hospital. From this project, we derive two contributions:

- A multi-methodological approach for hospital service redesign with a focus on patient flows, validated on this case study
- A concept for outpatient chemotherapy planning into a design proposition, stemming from the case study

In the next section, we introduce the setting for our study. In Section 3, we present our method. In Section 4, we describe the project during which it was developed and validated. Section 5 discusses the contributions drawn from this project.

2 SETTING

Henri Mondor hospital is a public university hospital in Créteil, near Paris, France. It has 1,300 beds and 120 day-hospital spots. Henri Mondor hospital employs 4,000 people, and it has three expert centres in oncology, for urology, haematology and digestive cancers. The oncology department is divided between outpatient and inpatient units. Around 4,000 outpatient chemotherapy sessions take place every year in the outpatient unit. All cytotoxic drug preparations take place in a centralized unit, which prepares around 20,000 chemotherapy doses per year. The global trend is an increase of the number of patients and drug preparations: +10% drug preparations and +19% outpatient oncology sessions between the first semesters of 2014 and 2015. In this context, the head of the oncology department worries that his patients are waiting a lot when they come for a chemotherapy. It is perceived as a double problem:

- A service quality problem, as patients have an appointment time but still have to wait
- A capacity planning problem, as a patient who waits occupies a treatment seat, a critical resource in outpatient chemotherapy. Waiting patients also need nursing attention.

The initial perimeter is restricted to the outpatient oncology unit. The objective of the project is to identify the most efficient actions to reduce waiting times. The initial team consisted of the head of the oncology department, the nurse manager of the department and the external analyst. It was quickly extended to include pharmacists for the chemotherapy preparation unit, because chemotherapy preparation and delivery are closely intertwined processes (Lamé, Jouini and Stal-Le Cardinal, 2016), thus creating a multidepartment issue.

3 PROPOSED METHODOLOGY

To tackle the issue presented above, the required method should:

- Be pragmatic, oriented towards improvement of operations

- Accommodate multiple viewpoints: patients, physicians, nurses, pharmacists
- Be patient-focused, i.e. put the patient's expectations and needs before the organization's
- Offer sufficiently "soft" insights to tackle the political and social dimensions
- Provide quantitative analysis to allow a preliminary assessment of the impact of proposed changes and a discussion with administrators if resources are required
- Given our practical constraints, the method should also be flexible enough to be implemented by one analyst/facilitator working with a team of professionals

To the best of our knowledge, no off-the-shelf method promises to address all these issues. However, there are methods that tackle portions of our problem. During our project, we have identified four: Soft Systems Methodology (SSM), benchmarking, Discrete Event Simulation (DES) and Service Blueprinting (SB). What appears to be the most efficient way forward is the combination of these methods, rather than a new development. Methodological combinations are not without challenges (Kotiadis and Mingers, 2006), yet the potential is huge, and successful projects have been reported (Howick and Ackermann, 2011). We now present the four methods individually, and the way they are connected.

3.1 Soft Systems Methodology

SSM is an action-research framework developed since the 1970's, with a long history of applications (Checkland and Scholes, 1990). It starts from a "problem situation", perceived as such by a set of dissatisfied people. From this problem situation, SSM has two streams of enquiry. First, a stream of logic-based enquiry, where the situation is modelled as a set of relevant systems of connected tasks and issues, which can be compared to the real-world situation. Second, a stream of cultural analysis, where the intervention is analyzed from the social (norms, values, roles) and political (power) perspectives. These two streams rejoin to identify systemically desirable and culturally feasible changes aimed at improving the problem situation. Figure 1 provides the classic seven-stage schematic model of SSM.
SSM can be used in Mode 1, as a step-by-step, explicit method to do the study, or in Mode 2, as a systemic framework to reflect on a project as it progresses (Checkland and Scholes, 1990). In Mode 2, the facilitators think of the situation in terms of SSM but do not necessarily make SSM explicit to other members of the project.

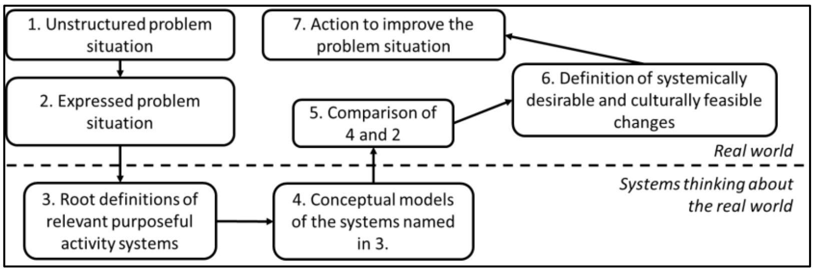

Figure 1. Seven-stage model of SSM, adapted from (Checkland and Scholes, 1990)

3.2 Benchmarking

> "The essence of benchmarking is the process of identifying the highest standards of excellence for products, services, or processes, and then making the improvements necessary to reach those standards – commonly called "best practices"." (Bhutta and Huq, 1999, p. 254)

There are different types of benchmarking, which is basically a comparison of one's organization's performance to the best-in-class. In our case, the best type of benchmarking is process benchmarking, where "methods and processes are compared in an effort to improve the processes in our own company." (Bhutta and Huq, 1999).

3.3 Discrete Event Simulation

> "[Discrete Event] simulation . . . is used for modelling queuing systems. These consist of entities being processed through a series of stages, with queues forming between each stage if there is insufficient processing capacity." (Robinson, 2004, p. 11)

In DES, the operation of complex systems is modelled as a sequence of discrete events. At each event, an entity in the system changes its status. In particular, entities move from one location to another, e.g. by being processed by a machine or transported by an operator. A screenshot from the DES software ARENA is provided in Figure 2. A set of interconnected boxes, representing process steps, is visible. Entities have accumulated before the box labelled “Match 1”, where they wait to be processed.

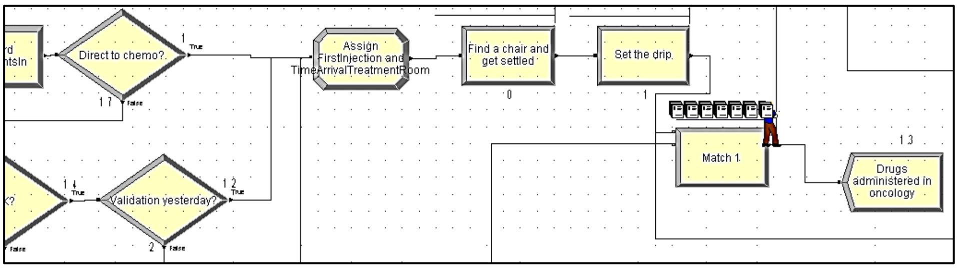

Figure 2. screenshot of ARENA, the DES software used in this study

DES is a well-established approach for analyzing the performance of manufacturing and service systems, including healthcare (Gunal and Pidd, 2010). DES allows the modeller to define different scenarios and picture the behaviour of the system in each one of them. It allows for the definition of various quantitative performance indicators.

3.4 Service Blueprinting

SB is a method for creating activity-based models of services, first presented by Shostack (1984). It has some features which makes it especially fit for modelling services:

> “In comparison to other process-oriented design techniques and tools, service blueprints are first and foremost customer-focused, allowing firms to visualize the service processes, points of customer contact, and the physical evidence associated with their services from their customers’ perspective. Blueprints also illuminate and connect the underlying support processes throughout the organization that drive and support customer-focused service execution.” (Bitner et al., 2008, p. 67)

Figure 3 shows how service blueprints are structured.

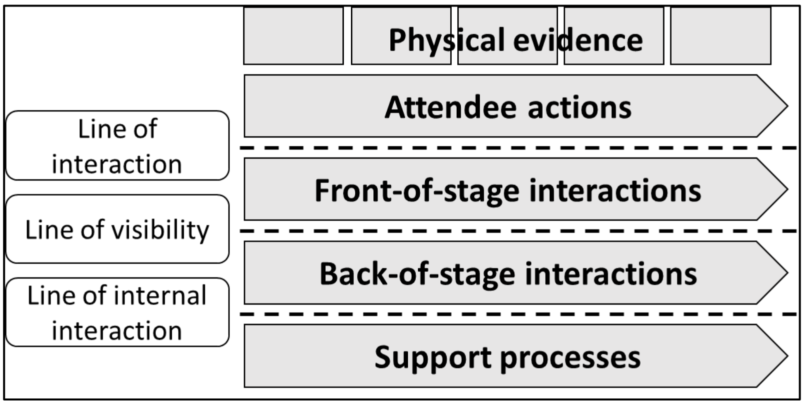

Figure 3. the model for service blueprints

3.5 Coupling the Methods

Table 1 presents the individual advantages of each method, their limits, and to what end they are used in our multimethod. All methods have their weaknesses and their strengths, and we combine them hoping that each will complete the others’ deficiencies.

We organize the methods as a design process. It goes from diagnosing setting the project’s perimeter to identifying promising concepts, to developing them into a detailed solution. Figure 4 provides a sequential view of the different tools and methods in our global method. It can be seen as a variant or an extension of Holm et al.'s multimethodology (2013) which combines SSM and DES: we go further in the process as we tackle detail design with a dedicated tool.

Table 1. the four methods combined in our approach

Method	Individual advantages (in our context)	Individual limits (in our context)	Use in our method
SSM	Complete action-research framework Systemic: multiple dimensions (social, political) Interpretive: multiple viewpoints	No quantitative dimension	As an integrative framework (in mode 2 in our example)
Benchmarking	Brings external knowledge Helps to appreciate one's performance	No guarantee on the transferability of practices Difficulty to obtain data	Identify good practices, gather solution concepts
DES	Quantitative Allows scenario testing Allows animation	Conceptual modelling is much of a craft Data intensive "Black box" modelling	To validate a concept for a solution
SB	Customer/Patient-focused Cross-department: links all activities regardless of organizational boundaries	No quantitative dimension	To design the details of a solution

The status of SSM in this approach is different from that of other methods, as we use some SSM tools in the beginning of the project (during diagnosis), but SSM is also used as a framework for the whole project. SSM provides a "mental model" for thinking the intervention and maintaining the different perspectives in the facilitator's mind.

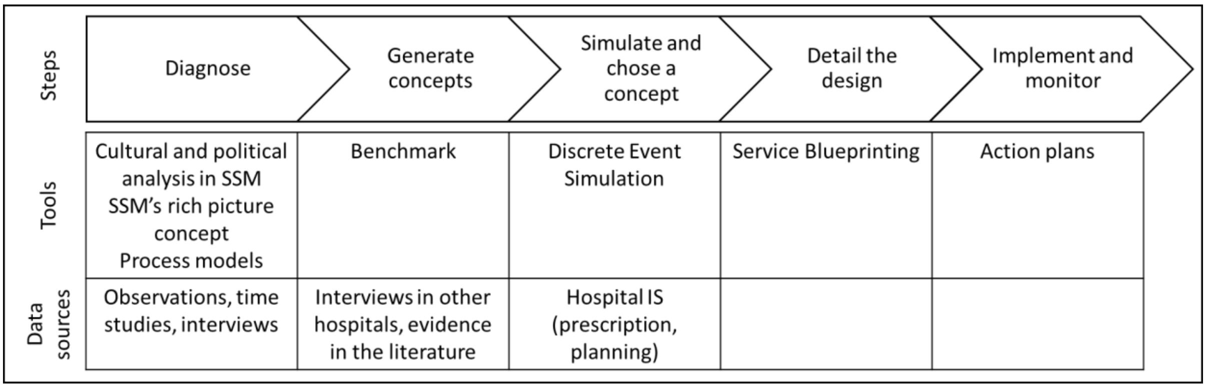

Figure 4. sequential view of the method

4 NARRATIVE OF THE CASE STUDY

The method was developed and tested in an action research (AR) project (Coghlan and Brannick, 2014). Checkland and Holwell (1998) proposed a model to describe AR projects, the *F*-*M*-*A* model, standing for the (theoretical) Framework, the Methodology and the Area of interest of the project. This framework was later extended by McKay and Marshall (2001) to distinguish between the Research Methodology M_R and the Problem-Solving Methodology M_{PS}, and between the theoretical Area of interest A and the practical Problem situation P. In our case, we have:

- F: a design approach with combined quantitative (DES) and qualitative (SSM, SB) methods (benchmarking is mixed) is promising to solve patient flow issues that involve multiple hospital departments
- M_R: action research
- M_{PS}: the multi-method presented above

- *A*: coordination of patient flows that cross multiple hospital departments
- *P*: outpatient chemotherapy delivery in a French public university hospital

McKay and Marshall (McKay and Marshall, 2001) limit the scientific knowledge generated to *F*, *A*, and M_R. We also hope to generate knowledge on *P* and M_{PS} through experiential learning. Figure 5 provides the chronology of three AR cycles performed in this project.

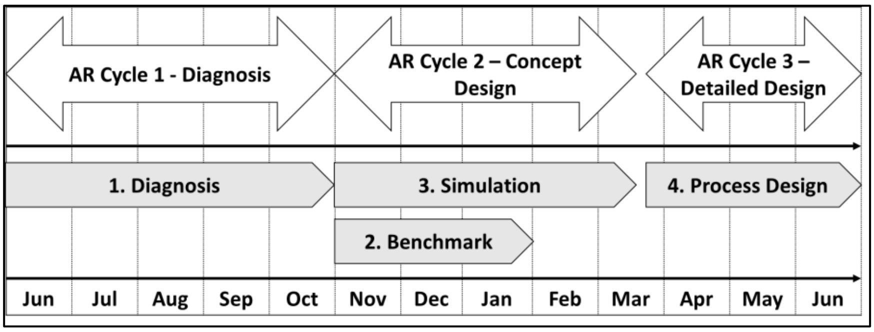

Figure 5. chronology of the project

4.1 AR Cycle 1—Diagnosis

The first phase in the project was a diagnosis of the system studied. It started with a definition of the chemotherapy delivery process, based on interviews and numerous observations. Details on the observation protocol and the intermediate results it yielded can be found in (Lamé, Stal-Le Cardinal, et al., 2016). Time-studies helped to understand the performance of the system and to associate quantitative measurements to the logic-based enquiry in SSM. In parallel, systems of interest were identified and modelled as purposeful activity models along several perspectives: the patient, the oncologist, the nurse, the pharmacist. Figure 6 shows a chronology of the process from the patient's perspective.

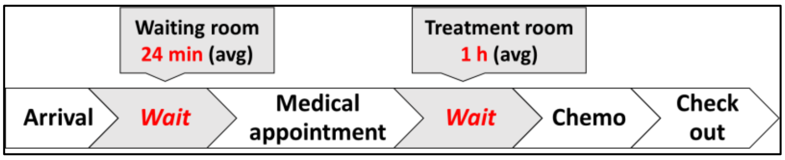

Figure 6. chronology of the process from the patient's perspective

It appeared from this first observation that the main cause of patient's waiting times was that nurses had to wait for chemotherapy drugs to be prepared and transported to the unit before starting infusions. A systematic literature review was conducted on outpatient chemotherapy planning (Lamé, Jouini and Stal-Le Cardinal, 2016), from which it appeared that few papers addressed what appeared to be the main issue in our hospital: the coordination and synchronization between the prescription and administration of chemotherapies in the outpatient unit, and the preparation of the drugs in the pharmacy. Consequently, the protocol of observation and interviews was extended to the pharmacy. This allowed for the understanding of the

In this stage, SSM provided a method for defining and analysing different systems, which model the same real situation from different perspectives. At the end, the diagnosis was presented, and a team was set up with the head of the oncology department and the pharmacist responsible for the chemotherapy preparation unit. It was decided that the analyst would build a simulation model, and visit other outpatient chemotherapy units to look for good practices.

4.2 AR Cycle 2—Concept Design

In the second cycle, two tasks were carried in parallel: modelling and simulating the system, and gathering solution concepts from other organizations. The model was built iteratively and validated using multiple methods: comparison of the results with time studies, internal (conceptual) validation and animated running of the model with physicians and pharmacists. More details on the simulation model can be found in (Lamé, Jouini, Stal-Le Cardinal, et al., 2016).

Concerning the benchmark study, the analyst met with six people from four different hospitals. Three concepts emerged from this study:

- Getting information on the patient's status before she comes for her chemotherapy, so that drugs can be prepared in advance
- Preparing standard, rounded doses of chemotherapy, using a Make-to-Stock (MTS) rather than Make-to-Order (MTO) policy
- Acquiring a robot for chemotherapy preparation

These solutions, and some other suggested by interviewees but not implemented in their hospitals, are summarized in Table 2. The individual impact is that reported by interviewees or the literature. Question marks indicate solutions for which we had no example of the solution implemented in isolation from other solutions. In particular, we did not meet people who used pneumatic tubes for chemotherapy transportation, without getting advanced confirmation on patients' status.

Some solutions were already eliminated. Having the medical consultation on treatment's eve is against regulations in France, as an outpatient chemotherapy session should include a medical consultation. Using pneumatic tubes for transporting outpatient chemotherapy would require to develop a pneumatic network, besides this solution is discouraged in some recommendations (Easty et al., 2014). Three of the solutions (dose banding, advanced confirmation of patient status, consultation on treatment's eve) work on a same solution principle: increasing advanced preparation. This principle was tested in the simulation model against an increase in transportation resources, a modification in work schedules and the addition of resources at various steps in the process.

Table 2. solution concepts identified in the benchmark

Solution	Strengths	Weaknesses	Ref.
Dose banding	Pharmacy can smooth its workload	Needs storage space (currently unavailable) Does not apply to all products Only good for large pharmacies	(Pouliquen et al., 2011)
Advanced confirmation of patient status	Allows advanced preparation of chemotherapy drugs	Cost: a nurse is needed to contact patients and process the information	(Berhoune et al., 2010)
Add resources to existing process	If manpower is the limiting resource, will relieve the bottleneck	Operating cost	
Transport drugs through pneumatic tubes	Reduces transportation cost and delay	No pneumatics today, so investment is necessary Drugs occasionally get damaged	(Easty et al., 2014)
Robotized chemotherapy preparation	Reduces repetitive strain injuries during preparation Robot replaces an assistant: reduced operating costs	Investment cost No impact on delays can be expected without changing the prescription process	(Palma and Bufarini, 2012)
Modify work schedules	No cost	Anticipated resistance	
Patient consultation on treatment's eve	Allows advanced preparation of drugs with almost 100% certainty on the patient's status	Impossible in France: transportation costs would double and an additional consultation fee would apply	(Dobish, 2003)

The simulation study (Lamé, Jouini, Stal-Le Cardinal, et al., 2016) proved that the most promising solution is the advanced preparation of drugs. Two concepts allow for this: dose banding, and advanced acquisition of information on the patients' status. In our case, there is not enough storage capacity to allow for MTS chemotherapy drug production. Therefore, we go for the second solution, getting advanced confirmation of the patient's status.

The simulation study proved that this concept could allow a 20% increase in the number of sessions held each year, which represents 400,000 euros in revenue. The estimated cost is one additional nurse dedicated to the gathering of patient information and its transmission to the pharmacy in a timely manner. This concept was by far the most effective (75% of the patients have less than 35 minutes between their medical appointment and their chemotherapy infusion, as opposed to 1h15' today) and efficient (400,000 euros in additional revenues, with a cost of 50,000 euros). This is the concept that was chosen to be studied forward.

4.3 AR Cycle 3—Detailed Design

To transform a broad concept into a new procedure, we used Service Blueprinting. Three one-hour workshops were organized with nurses, oncologists and pharmacists. During these workshops, many constraints were elicited and discussed: IT systems, working schedules, costs, etc. Peripheral problems where identified and tackled, which permitted quick changes to be made in the process (for instance, to re-communicate to all patients the dates for their blood tests, or to shift premedication from IV to oral). This allowed for the definition of a service blueprint for the new organization of chemotherapy prescription, mixing and delivery.

Even after this stage, the system was not totally defined. A choice remained on the technical means to contact patients. Should it be a synchronous process, by phone, or asynchronous, with patients filling in questionnaires on a web-application? Both possibilities are being investigated, knowing that some patients will not be able to use smartphone or web apps, so phone calls will remain part of the solution.

4.4 Next Steps in the Project

As we have now agreed on a concept and developed it up to an operational solution, we can now move to implementation. However, despite the additional activity and revenue we should generate, French public hospitals are under such financial tension that there is no guarantee that this argument will convince administrators to hire an additional nurse. At this stage, we have backup from the medical and nursing staff and from the pharmacy.

5 DISCUSSION

In action research (the same is true for design science projects), "the methodology, as well as the theoretical output, is almost always emergent because the researcher cannot know in advance what intervention opportunities will arise, or what past interventions may suddenly seem relevant for re-review" (Huxham, 2003, p. 241). We know proceed to the elicitation of the theory generated in this research project. It takes the form of two design propositions, as defined in the case of operations management by van Aken et al. (2016). The first design proposition bears on the content, i.e. the implemented solution in the case study, and the second focuses on the method, i.e. the design process.

5.1 Design Proposition for Outpatient Chemotherapy

Regarding outpatient chemotherapy, we have in this project validated by simulation and theoretical design, the concept of obtaining information on the patient's status in order to prepare her drugs in advance. This concept is not new: it has been validated at Hôpital Européen Georges Pompidou (Berhoune et al., 2010, 2011; Scotté et al., 2013). Our study is therefore what van Aken (2004) refers to as β-testing this concept (although we have not field-tested it yet). Our design proposition is therefore as follows:

> *When trying to reduce patient waiting times in outpatient chemotherapy units, if these waiting times are due to untimely delivery of chemotherapy drugs, then contacting patients prior to their chemotherapy to enquire about their status is a concept of interest since it allows advanced preparation of chemotherapy drugs.*

The potential implications are important: every year, about 650,000 Americans receive outpatient chemotherapy (Halpern and Yabroff, 2008). As for the generating mechanism that makes this solution effective, we can analyse it with Theory of Constraints (Goldratt and Cox, 1989; Gupta and Boyd, 2008): what limited the capacity of the process to reach better performance was the unavailability of timely information in the pharmacy. This prevented advanced preparation of chemotherapy drugs, and generated waiting times due to the inherent inflexibility in chemotherapy mixing procedures.

5.2 Design Proposition for Multi-Department Patient Flow Issues

We also propose a second, methodological, design proposition. It reads as follows:

When trying to improve patient flows that require the involvement of multiple departments, the method described in Section 3.5 is a suitable and effective approach to identify and develop desirable new service designs.

We cannot be definitive at this stage on the generating mechanism that makes this method efficient. We propose three explanations:

- The interpretive approach in the diagnosis stages allows for the integration of the perspectives of all involved departments
- The method progressively reduces the solution space, and does not eliminate solutions until they are clearly outperformed or declared undesirable by participants. This is akin to Set-Based design, as opposed to point-based design, in mechanical engineering (Sobek, II et al., 1999)
- The method combines qualitative, soft dimensions with a quantitative method, which allows it to be participative and convincing from the accounting point-of-view

These three items together provide an explication for the acceptation of the method and its success in reaching an agreement on a solution from all participants.

5.3 Limits and Next Steps

The main limit of the project as a design endeavour is the lack of implementation to date. The dichotomy between the medical and administrative command lines in hospitals make it difficult to have a discussion with both. In this project, we worked with medical and paramedical staffs. The administration was not part of the project, and we assumed that a solution which could generate additional activity would be enough to convince them. In the future, we should investigate further this new factor of complexity. We are not only crossing the limits of medical departments, but also from the medical and paramedical culture to the administrative one. Evidence suggests that values are more shared than one usually thinks (Minvielle et al., 2008), but it remains to be integrated in our method.

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