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# Collaboration within the Surgical Suite: BoardProbe Design For and With the Surgical Team

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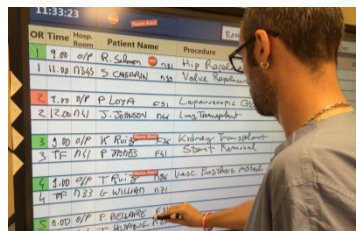
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**Figure 1.** Hardware and software of BoardProbe.

## Abstract

The expectations of computerizing hospitals are high, in the belief that it will improve health care quality, reduce costs, and increase administrative efficiency. However, effective computerization of hospitals is a real challenge. The explanations of this failure are typical of HCI misdesign. In

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this paper, we focus on the computer support of the activity within the surgical suite. Our research objectives are to understand the local activity at the DUNN Operating Rooms surgical suite of the Houston Methodist Hospital, propose a technological solution to instrument the staff activity, and deliver a design method and a toolkit to adapt our solutions to other hospitals.

## Author Keywords

Computerization; surgical team; collaboration; ATC; decision-aids.

## ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## Introduction

The expectations of computerizing hospitals are high, in the belief that it will improve health care quality, reduce costs, and increase administrative efficiency [10]. Computerization is the act of using a computer to do something that was done by people or other machines before (*Cambridge Dictionary*). Electronic Patient Records are an example that has been implemented in order to improve cost-effectiveness, distribution, reliability, and exchange [13].

However, effective computerization of hospitals is a real challenge: Himmelstein et al. [10] estimate that so far computerization did not bring any evidence of improvement in administrative costs neither overall costs, or brought modest improvements in quality of patient outcomes. Black et al. [3] highlight the gap between the postulated and empirically demonstrated benefits of eHealth technologies, as well as the lack of best practice guidelines in effective development and deployment strategies.

The explanations of this failure are typical of HCI misdesign. Multiple works highlight the fact that computerization brings benefits to a specific context if the system has been especially customized for this given context. For example, Himmelstein et al. [10] states that computerization cannot decrease costs because what is saved is compensated by the purchase and the maintenance of the computer system (presumably evolution maintenance of the system to adapt to context particularities). The failure also remains in the lack of pertinent evaluation of the computer system and should include socio-technical factors to adapt and fit a local activity as best as possible [3]. Evidence of the beneficial impact of such systems is limited to a few academic clinical centers of excellence where the systems were developed in house, undergoing extensive evaluation with continual improvement, supported by a strong sense of local ownership by their clinical users [3]. The contrast between the success of these systems and the relative failure of much of the wider body of evidence is "striking" [3]. Himmelstein et al. [10] mentions that the few custom-built systems that have been deployed have improved quality of patient outcomes. However, the extent to which the results of these primary studies on custom-built systems can be generalized beyond their local environment is questionable [3].

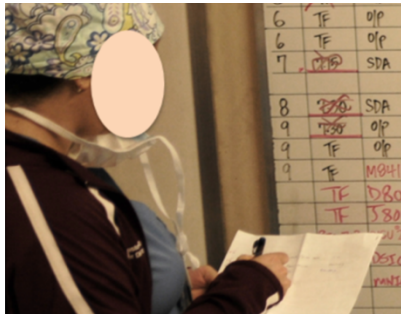
In this paper, we focus on the computer support of the activity within the "surgical suite". The surgical suite is a

group of one or more operating rooms and adjunct facilities, such as a sterile storage area, scrub room, and recovery (*The free dictionary, medical dictionary*). There is an important demand of course for improving patient outcomes in surgery but also reducing its high costs. Therefore, we target the management of the surgical suite, in particular the management of patients, operations, operating rooms and hospital personnel around a shared whiteboard.

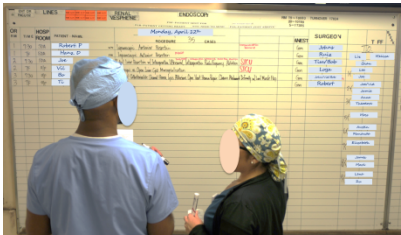
Our research objectives are:

1. Understand the local activity at the DUNN Operating Rooms surgical suite of the Houston Methodist Hospital: how does the staff exchange, shift, evolve and adapt to the patient flow and staff and equipment allocation? What are their habits and how do they deal with unforeseen events? What are their current organizational and collaborative tools and how do they deal with them? What is the team synergy?
2. Propose a technological solution to instrument the staff activity the best possible. What do they need to improve their efficiency, effectiveness and satisfaction? What do they need to improve patient outcomes? What do they need to be more cost-effective? How can we measure the efficiency of these solutions?
3. Deliver a design method and a toolkit to adapt our solutions to other hospitals and other surgical suites, to help generalize effective computerization of hospitals beyond a particular one.

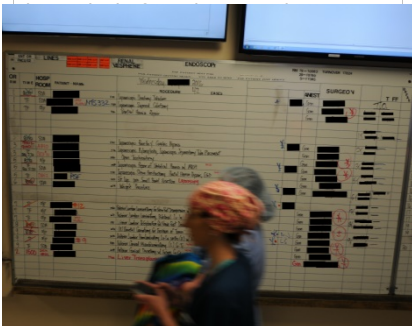
In the next section we describe the related work. We then present the three methods that we follow: the Technology Probes, the Air Traffic Control analogy and the ethnographic study of the activity. We finally expose our first prototypes and our perspectives for future work.



**Figure 2.** A Nurse, taking notes from the whiteboard on personal support.



**Figure 3.** Two Nurses working together on preparing the whiteboard



**Figure 4.** Staff walking in front of the whiteboard, sending a text to coworkers.

**Related work**

*Surgical suite studies*

Several ethnographic studies collaboration in the surgical suite [1],[2],[14],[15]. Bardram [1] mentions that the problem of computerization at hospitals is mainly because “the systems are “typically single-user oriented”, whereas teamwork is omnipresent. These studies describe activities within the surgical suite of other hospitals, sometimes around the same kind of whiteboards as in DUNN Operating Rooms (OR). They also provide recommendations for designing collaborative tools for the surgical suite. However, these studies did not develop collaborative tools themselves or test their design, which is missing in CSCW for hospitals [9]. Fitzpatrick et al. [9] also mention that, for the past 20 years, commercial offerings of electronic whiteboards have been a failure. They claim that the mistake comes mainly from the lack of usability, the weakness of the quality of the display and hardware.

As recommended by Bossen et al. [5], we should consider “moving from design-for-use to design-for-future-use”, in order to deploy pliant systems. The design choice of Bossen et al. [5] to improve collaboration in the care hotel was an electronic whiteboard, a large device with good visibility. The whiteboard of the surgical suite is what Bossen et al. [5] call the “common ground”. This tool is essential to coordination and understanding between teammates. The situation awareness of the staff in the surgical suite relies partly on what is written on the whiteboard. According to Branham et al. [6] whiteboards are poor tools for archival and reuse, but they are familiar, pliant and allow for quick creation and modification.

*Air Traffic Control studies*

Air Traffic Control and the surgical suite activity are both critical environments. They share specific requirements related to collaboration. Air Traffic Control research projects involved the development of new concepts that imitated and improved the current way of working of the staff by minimizing the difference with work habits [7],[8],[11]. We will inspire from these studies to design our collaborative tools for the surgical suite.

**Methods**

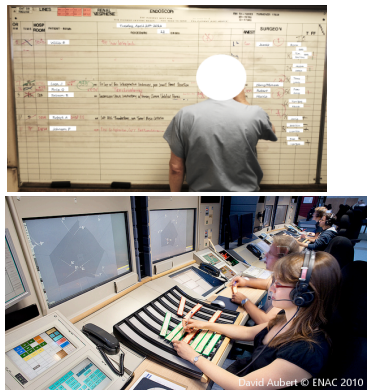
*Inquiries and Observations*

To capture the local activity at DUNN OR,

1. We realized contextual inquiries and shadowing within the surgical suite, with the main actors.
2. And we set up a camera that can capture a whole whiteboard.

We have already started conducting contextual inquiries and direct observations within the surgical suite. We interviewed two Board Runners, two surgeons, two nurses, two Anesthesiologists and a Member of the DUNN OR surgical suite council. Because the staff is very busy, the Board Runners, the Surgeons and the Member of the council were interviewed out of the context of work. In a second part, Board Runners, Anesthesiologists and Nurses were interviewed and observed in their work environment.

With the camera, we can capture 1000 photos per day, taken with 1min delay between each photo or 30s. On the photos, we can see the symbols that are written/put on the whiteboard, the modifications/evolutions (updates, adds, writings, erasings, see Figure 4) brought to the whiteboard



**Figure 5.** Comparison Surgical Suite activity and Air Traffic Controllers' activity.

along the day, as well as the user-whiteboard (Figures 2 and Figure 5) and the user-user interactions (Figures 3 and 4).

From these studies, we extracted 20 identified scenarios (an example Figure 6), we started to identify 25 first user requirements and we identified more than 30 different "symbols" used on the whiteboard (which is a local language).

*Technology Probe*

Our approach is to equip the surgical suite information hall with BoardProbe, a whiteboard-like multi-touch screen application, by following the Technology Probe design approach. Such a probe has 3 dimensions [4],[12]:

1. The social science goal of collecting information about the use and the users of the technology in operational, track how users deal with the probe over time: we must understand the local activity of the staff at the surgical suite DUNN OR, Houston Methodist Hospital.
2. The engineering goal of testing the technology in operational: the technology has to be functional and allow them to perform their daily tasks such as managing the schedule, adding and communicating information through the day. How can we measure their efficiency through this probe?
3. The design goal of inspiring the staff and the design team to create adapted features answering the needs of the surgical team.

ID	SC4	
Description	The Surgeon wants to squeeze an additional case in the schedule of the day (called "add-on", or "emergency" even if it most of the time is not an emergency).	
Aim	Add a case in the day	
Actors	Surgeon + charge nurse + anesthesiologist	
Place	Information hall	
System context	Wb edited and updated	
User context	/	
Photo/Diagram	Description	Drawbacks(-) Benefits(+)
	Intention: Determine when and where can be squeezed the additional case Actions: Discussions in front of the wb and in the control room in front of an EPIC computer to see the schedule and modify it.	(-) sometimes there is no room on the wb (+) The wb is a good support to the discussion and the interaction.
	Intention: inform the others that there will be an additional case. Actions: Nurse writes the additional case in red on the wb when the decision has been made. Case also entered in EPIC system.	(-) (+) updated only when decision is made. Red shows the fact it is a new case.

**Figure 6.** Example of a scenario of Add-on arrival.

In order to capture the users' interaction with BoradProbe, we will use the webcam on the screen, automatic screenshots and logs of the input.

*Air Traffic Control Analogy*

An analogy can be drawn between the surgical suite computerization and Air Traffic Control computerization issues linked to critical environments (Figures 5, Figure 6 and Figure 7). In terms of social science, we will compare the collaborative activity of the surgical staff and their whiteboard with the collaborative activity of the controllers and their strips board. In terms of technology/engineering issues, we encounter the same problems due to the difficulty to set experiments and new tools for activities in operational context. This difficulty is one of the reasons why we chose to use a Technology Probe methodology: to allow the staff to actually use a very simple but functional device to gather information, test the technology and evolve the design.

ATC	Workstation representation	Surgical Suite	Whiteboard representation
<b>Flight</b> – flight information A flight has a beginning and an end, purpose is to have a safe flight.	Strip	Case A case has a beginning and an end, purpose is to have a safely managed case.	Line on the whiteboard
Altitude	Altitude	Case status	Symbols
Position The air traffic controllers follow the flight in terms of timing and position in space.	Coordinates at a moment m	The OR board runner follow the cases in terms of time and human/equipment resources needs.	

**Figure 7.** Extract of the analogy tabs between Air Traffic Control and the Surgical Suite activity.

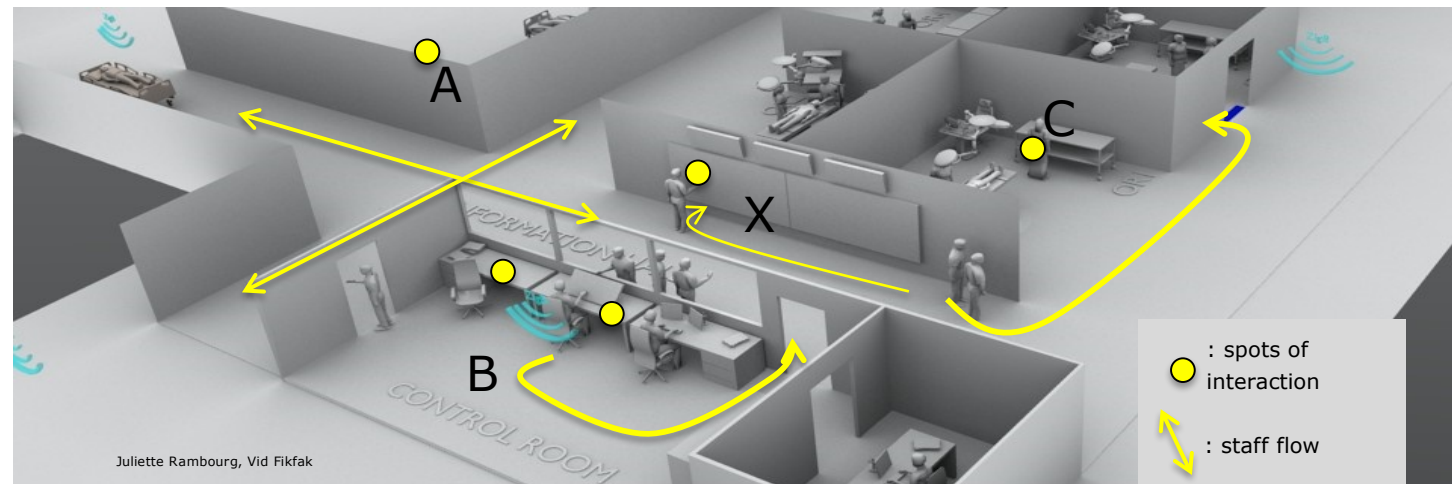
**[Board Runner]** The "name alert" magnet is used when two patients have the same name. Blue is usually for the anesthesia information and black is for the first edition of the schedule in the evening.

**[Anesthesiologist]** I do not really input information myself on the board, I read it to know what I have to do, this is more the other anesthesiologist Dr. A. that manages whiteboard inputs.

**[Surgeon]** When I arrive the morning in the surgical suite, I like to see this big whiteboard with all the information I need for the day from where I am. I check that my patients and their surgery procedures are well written by the nurses on the whiteboard.

**[Nurse]** As soon as we have time: when a patient arrives in PreOp, we cross out the time of his case line so that everybody can know he is in here. We cross it then a second and third time, as a star, when the surgery has begun.

**[Council member]** We need objective data to understand the staff and know how efficient we are to improve patient outcomes and reduce costs of surgery.



**Figure 8.** Reconstruction of a part of the surgical suite of DUNN OR, Houston Methodist Hospital.

## Results of first observations

### The surgical suite

The central organizational and collaborative tool consists of two large whiteboards placed in the surgical suite. On Figure 8, "X" represents where the large whiteboards are. "A" represents the Post Operating Rooms (*PostOp*). There are also other rooms where the patient scheduled for surgery can be before or after the surgery: Holding Room - *Holding*, Pre Operating room - *PreOp* and *PostOp*. "B" represents the Coordinative Area. It is physically separated in 2 parts: the *Information Hall* with the whiteboards and the *Control Room* where necessary information about cases is dispatched. Information within the *Control Room* is available for individual consultation. Information that is displayed in the *Information Hall* has for purpose to be shown publicly - to the whole staff of the surgical suite. "C" represents the operating rooms, where the surgeries take place. DUNN OR

contains about 23 operating rooms, which requires a very strict organization in terms of management of the resources - human and equipment.

### The surgical team

The cases are updated throughout the day: new scheduling, shifts, patient location, etc. All necessary information about the organization of the case is contained in the whiteboard, which makes it a large source of information, allowing synchronous as well as asynchronous collaboration among the team, made of Board Runners, Nurses, Surgeons, Anesthesiologists and the Members of the DUNN OR surgical suite council (some examples Figure 9). The case schedule for the next day is edited late in the evening on the whiteboard, and starts to be used by the staff early in the morning (Figure 4).

**Figure 9.** Samples of interviews with DUNN OR surgical staff.

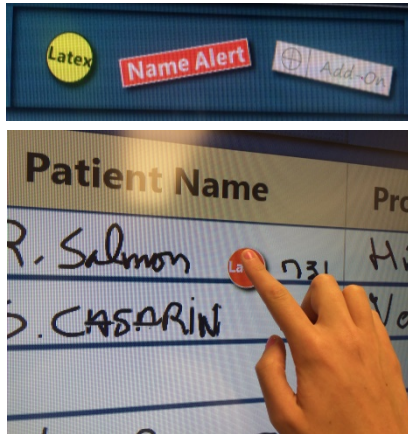


Figure 10. Magnets feature.

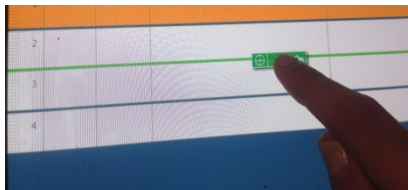


Figure 11. Adds-on feature.

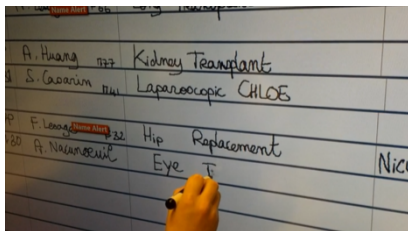


Figure 12. Writing feature.

## Early Prototypes

### Our guidelines

So far, we determined the necessary “minimum” features to set up the BoardProbe within the surgical suite and observe the use (see *Current features*). The purpose is that the staff could be able to use the prototype as a replacement of the whiteboard. This set was progressively tested by the DUNN OR staff and people from the Computational Surgery laboratory, Houston Methodist Hospital.

### Current features

We develop an application (Figures 1 and Figure 14), running on a 70 inches MultiTouch screen. Our purpose is to reach a maximum of flexibility and similarity compare to the original whiteboard. The global organization is exactly the same as the original whiteboard (Figures 5 and Figure 14).

### WRITE-ERASE

We first developed the basic feature “write-erase” that is mandatory for flexibility purpose and technology transition (Figures 12 and Figure 13).

### MAGNETS

Magnets are items that can be dragged and dropped freely on a case - Name conflict alert, or allergy to latex, (Figure 10).

### ADDS-ON AND REORGANIZATION

Add-ons (Figure 11) are additional cases that will be added during the day, as an emergency or not. Their insertion in the schedule is always a difficult decision and a “physically” complicated task to perform, due to the lack of space on the board.

## Future work

The project started in January 2016; we began with ethnologic studies and design of prototypes, with users’ feedback, observations and tests constantly in the loop. We

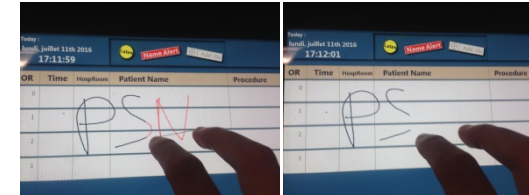


Figure 13. Erasing function with two fingers.

OR Time	Hosp. Room	Patient Name	Procedure	Anest.	Surgeon	STAFF	Break
1 9:00	01P	R. Salmon n71	HIP Replacement	Sev	Gen HUANG	Archer	+
1 10:00	014	A. Longe E66	Long Transplant	# R Gen		May	+
2 9:00	01P	A. Huang n77	Kidney Transplant		Gen TEHNS	Archer	+
2 10:00	013	S. CASARIN n41	LAPAROSCOPIC CHOLE		Gen	Archer	+
3 9:00	01P	A. SAHWIN F61	HIP Replacement	NEU	Gen STEVEN	Archer	+
3 11:00	014	C. SAUNIER 071	Long Transplant		Gen	Archer	+
4 8:30	01P	G. JERGER n89	Kidney Transplant		Gen RUIZ	Archer	+
4 10:00	014	V. FRIJOL N60	LAPAROSCOPIC CHOLE		Gen	Archer	+
5 9:00	01P	S. RUIZ n51	Long Transplant		Gen ROBERT	Archer	+
5 11:00	014	S. SALMAN n81	Kidney Transplant		Gen	Archer	+

Figure 14. Prototype overview: same columns and visual architecture as the whiteboard.

are planning to set up the experiment in operational at DUNN OR within a couple months. Before that we need to make sure the application is robust enough. The application will be improved according to the user satisfaction, efficiency and effectiveness during the user experiments.

## Acknowledgments

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