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5. Experimental Reality: Principles for the Design of Augmented Environments.

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Abstract: The Laboratory of Design for Cognition at EDF R&D (LDC) is a living laboratory which we created in order to develop AE for collaborative work, more specifically "cognitive work" (white collars, engineers, office workers). It is a corporate laboratory in a large industry, where natural activity of real users is observed in a continuous manner in various spaces (project space, meeting room, lounge, etc.) The RAO room, an augmented meeting room, is used daily for "normal" meetings; it is also the "mother room" of all augmented meeting rooms in the company; where new systems, services and devices are tested. The LDC has gathered a unique set of data on the use of AE, and developed various observation and design techniques, described in this chapter. LDC uses novel techniques of digital ethnography, some of which were invented there (SubCam, offsat) some of which were developed elsewhere and adapted (360° video, WebDiver, etc.) At LDC have also been developed some new theories to explain behavior and guide innovation: cognitive attractors, experimental reality, and the triple-determination framework.

1. Context: the digitization of work and its impacts

As work is being digitized, redesigning office environments becomes an efficiency challenge for those organizations who rely heavily on "white collar" performance: administration, media and research; more generally office work is a significant contribution to the production process of every organization. In fact, in most organizations there is a general trend of automation of "white collar" work (Lansdale, 1990; Malone, 1983, 1996).

For example, at Electricité de France (EDF), one of the world's largest energy production and distribution companies: more than half of EDF employees are "cognitive workers" (or "knowledge workers": Kidd, 1994), who spend their workday in offices interacting with computers, information systems and other people.

While organizations are interested in more efficient and productive environments, and focus on systems and their costs, users are under strong pressure. Even more than the 1940s administrators studied by Herb Simon, (Simon, 1997), they tend to adopt bounded rationality because they are short of time and attention, and will therefore discard new systems if they fail to "satisfice" at first use[1]. They simply couldn't afford otherwise considering the current work rhythms and pressure.

[1] Satisficing is one of the "crucial alterations" that depart Simon's bounded rationality model from the classic rational actor model: "Whereas economic man supposedly maximizes – selects the best alternative from among all those available to him – his cousin, the administrator, satisfices – looks for a course of action that is satisfactory or "good enough". (…) Administrators (and everyone else, for that matter) take into account just a few of the factors of the situation regarded as

This is visible in the demands of the executive studied by Back et al. (Chapter 4). Users will tend to focus on their own activity, and pay little effort in operations which are useful at collective level but bring themselves little added value. New systems should then integrate graciously into existing environments, institutions, procedures; avoid creating more problems than they solve and in general not add overhead to users. Dissemination, Operations, Maintenance and Evolution ("DOME") of these systems are part of the design problem and of the costs (Lahlou, 2005, 2007a) – we cannot afford considering that we create isolated artefacts.

In this context, how can we design environments which will produce good and sustainable practice at collective level? This chapter describes our efforts in tackling these issues in the real industrial context of a non-IT industry in the last decade, which led us to set up a novel design process: "experimental reality".
Section 2 will provide corporate reasons why industry needs specific design efforts for Augmented Environments. Section 3 will explicit our design strategy: experimental reality. Section 4 describes two instruments we use in the design process: a tool, the SubCam, and a model, cognitive attractors. Section 5, "the triple determination framework" explains why AE design must go beyond mere ICT implementation and include also training and institutional change. Section 6 details our experimental reality process and the AE testbed we constructed, the K1 building, its content and layout, digital ethnography observation techniques. Section 7 zooms on the RAO augmented meeting room, its installation and some of the AE systems we installed in it.

2. Why design specific environments for cognitive workers?

At LDC we study activity in the workplace, with emphasis on Information and Communication Technology (ICT) and collaborative work. Based on workplace studies, LDC helps EDF R&D Division design more comfortable and efficient environments for cognitive workers. LDC research staff includes psychologists, cognitive scientists, ergonomists, computer scientists, engineers. LDC uses an experimental building dedicated to naturalistic work observation, the K1, as a living laboratory where new environments are developed in a continuous design process with the help of the users themselves, in realistic conditions.

Figure 5.1: The K1 project space seen from an OffSat in the ceiling grid. Notice the glass box enclave on the right.

most relevant and crucial. In particular, they deal with one or few problems at a time, because the limits of attention simply don't permit everything to be attended to at once" (Simon, 1997, p. 119).

Setting up an ICT design laboratory is not a natural move for an electricity company. The decision was the result of a series of surveys on the use of information in the workplace (Fischler and Lahlou, 1995; Lahlou and Fischler, 1996; Autissier, Melkior and Lahlou 1997; Lahlou, 1998; Lahlou, Kirsh, Rebotier, Reeves and Remy, 1999; Autissier and Lahlou, 1999) and a natural effect of the conclusion that the digitization of all work processes needed to be addressed with specific tools. Indeed, digitization of work brings some new issues. Most users agree ICT led to enormous progress and change, to such an extent that they sometimes can hardly describe what they did “before”, when there were no PCs and email. They also express some dissatisfaction, mainly about the increased volume of information and “lack of time”.

In this section we trace back how the decision to study and deploy AE in this large company emerged. This section may seem a bit off topic; it is not. Augmented work environments are expensive; they imply some painful decisions (hiring wizards or specialized maintenance personnel, adapting firewall procedures, buying unfamiliar equipment etc); therefore the issue of their necessity and return on investment (ROI) is at the heart of decision-making and determines the budget envelopes. So “selling” the AE to the organization is a primary aspect of their design.

Starting in the 1980s surveys showed that new digital communication channels add to the previous paper and oral media without much substitution (Moatty, 1994), but it is difficult to measure the volume and the content of the circulating information. Information is not reducible to its size in bytes or the number of printed pages (which, by the way, explode). Acknowledgment of individual problems due to excess of information came along with digitization. Lea (1987) described the “information shock syndrome” of some information system users; “information overload” (Hiltz and Turoff, 1985) is a widespread term, and various forms of the phenomenon are repeatedly described in various places: “communication overflow” (Ljundberg, 1996), “information fatigue syndrome” (Lewis, 1996); “infoglut”, etc.

In the mid-1990s the French Association for Cognitive Research mandated a subgroup to study the problem, and came out with a comprehensive description adding organizational aspects to the classical individual symptoms, under the name of “COS” (Cognitive Overflow Syndrome”). The syndrome combines:

- a growing production of information: as measured by media volume (paper, disks, etc.), message flow, and cost of information systems;
- individual stress: subjects complain to be overloaded by "useless" information; complaints focus on the "lack of time" and delay in the processing of "real work";
- organizational incapacity to point at a specific cause: overflow seems to come from many sources. From the field, the problem appears systemic, without cure, and no specific entity is in charge of it;
- loss of meaning: individuals cannot make sense of information, and tend to fall back in short term, local, information processing concerning their own duty, with little care about the overall effect. (Lahlou, Lenay, Gueniffey and Zacklad, 1997).

COS is an organizational problem with individual symptoms. As industrial production is the result of labor division and coordination, group efficiency is impaired by its members’ hampering. Individuals complain they don’t have time to carry their “real work”; there are also effects at aggregate level: reactive rather than proactive units, loss of control over large projects, a growing distance between reports and reality.

In 1999, a survey of a representative sample of 501 white collars, following several years of qualitative research, enabled us to quantify the COS. These results are especially interesting since at the time of survey (1999), only 63% on respondents declared receiving more than 6 emails per day.

Table 5.2 shows some of the results of this survey, which are coherent with field observations (Fischler & Lahlou, 1995; Lahlou and Fischler, 1999). Other results from the same survey show that cognitive workers indeed are far from having full control over their activity:

- 67% declared having a « to-do » list, including in most cases one to five items.
- 17% had more than 20 items on their list.
- The oldest task on the list is in most cases (74%) from one to six months overdue, although this task is considered important (64%).

Do you agree with the following statements?	Totally agree	Slightly agree	Slightly disagree	Disagree	Don't know
We have too much administrative work	23	41	25	11	1
I am overloaded	11	39	37	11	1
I dream of a tidy office	16	25	33	26	
My colleagues are overloaded	20	49	22	4	5
I spend a lot of time in tasks of sorting and filing which could be done by someone less qualified	10	21	40	30	1
I lose an incredible time fixing details	23	40	28	10	
I am continuously interrupted in my work	21	41	30	9	
My successor will easily find his (her) way in my archive	22	47	23	6	1
I would need more time	22	43	26	8	1
I often stay late at the office, or work at home in the evening	28	34	17	19	1
I often cannot find a document although I know it is somewhere in my files	11	27	37	5	
Sometimes I delay a decision because I can't find time to read the case.	11	37	38	14	1
I cannot manage to do what I had planned to do during the day.	18	44	31	7	1
Sometimes I come home exhausted but wondering what I have been doing today	19	31	32	18	
I have the feeling I process what's urgent before what's important	25	44.5	23.6	6	1
Sometimes I wonder whether I did receive a document I am told about	9,2	30.3	36.7	23.6	0.2
Sometimes I forget tasks or commitments.	4.8	20.8	44.9	29.5	

Table 5.1: Some results of the "Use of Information" survey (Fischler and Lahlou, 2000): percent of white collars agreeing with a series of COS symptoms (telephone survey on 501 white collars, drawn at random in the telephone list, representative of the R&D Division).

Obviously the work context seems to get in the way of "getting the job done" rather than helping. This points at the need for redesigning more supportive AE.

To go beyond user's subjective declarations we tested the actual destiny of information through the same telephone survey, with three messages "which had been sent recently [to the respondent] by the top management". The first was a massive corporate emailing operation targeting *all* employees: 31% did not even recall receiving it, less than two weeks after it was sent.

The second was about "the safety survey of the Division" 21% declared recalling reception of this message (5% "perhaps"). 18 individual respondents even reported having responded or filled and/or sent a form to the department in charge. Which is embarrassing because no such mail about a safety survey had in fact been sent: this question was asked as a bias control item.

Answers about this inexistent message may sound funny, but the results of questions about the third (real) message were not. Let us remind readers that the survey was done during the second half of December 1999, where the W2K bug was a major preoccupation worldwide; the Corporate IT Division had sent *everyone*, a few days before the survey, a special warning asking each user to backup and close their workstations on a specific day for preventive maintenance operations against this potential W2K bug: 49.7% did not recall having received the message (6% "perhaps"). The survey then included precise investigation on those respondents recalling this specific email. We started by clarifying which mail was considered, giving the exact header and date. "Did you receive this message and keep it?" 88 respondents said yes, 164 no. Out of the 88 who said yes, 29

people were indeed able to find, on request of the interviewer, the dates given for preventive maintenance operations (6% of the total sample!); 20 subjects said they had in fact erased the document, 25 searched but did not find, 14 said they found it but that it contained no date. Fortunately, the company had no problem with the W2K bug, and the results of the survey would have been quite different in the Production division where the rules are almost military, rather than in this R&D back office setting. Still, these results were worrying. In parallel to this survey we conducted a benchmark study on 17 large companies in many sectors (bank, agro-food, transports, telecom…): their situation regarding COS was similar (Autissier and Lahlou, 1999). We can see here that COS can produce delay in decision or reaction, loss in information, inadequate representations, and finally that some critical information may not be processed by its destinators. In other industry, some organizational catastrophes have been attributed precisely to this kind of problem; one of the most prominent is the explosion of a NASA space shuttle.
The conclusion is that the Cognitive Overflow Syndrome is not simply a matter of user comfort, but a menace for the organization. Therefore, investing in a specific design effort to create appropriate environments for digitized work is not a waste. Although this conclusion was quickly adopted at the executive level in the mid 1990s (and triggered a multi-million investment in the creation of LDC) for a while many people still regarded LDC suspiciously as a place where mad engineers played with expensive and futuristic gadgets because ICT was not in the core business of the company ("why don't we just buy solutions outside?"). It took almost six years, until the lesson was fully understood, before the ICT solutions designed by LDC started to scale out in the company.

A lesson to learn here is that many users fear that the new ICT systems will bring them more stress, overheads, and work pressure. Sponsors are aware of potential costs. Their fears, alas, are grounded in actual experience of poorly designed ICT systems. Therefore the first implementations of AE should indeed address painful issues for the users, and bring clear added value. Once this added value is perceived in daily operations, the users' attitude changes and they become more open and receptive.
To anticipate results presented later in this chapter, our experience shows that not only is redesigning work environment for digital work a way to prevent the risks of organizational catastrophe, but it is also a way to make cognitive workers more comfortable, and a way to save money and pollution. The use of the sole augmented RAO meeting room for videoconferencing saves over $50.000 per month in transportation[2] and the reduction of over nine tons of CO2 emission. Not to mention the fact that our survey showed that using videoconferencing enables the reduction of the delay to find a date for a meeting (between two people) of about 50% – and more for a multi-party meetings: it is much easier to find a one hour slot in a packed schedule than to find the three hours needed for a one-hour meeting plus two hours of transport.

3. Design strategy

The issues in cognitive work are many, and as I outlined in chapter 1 of this book, designing for it is a never-ending problem which continuously develops as technology changes, as users become more demanding, as new uses appear, etc. We have limited resources. We try to find the best cost/use ratio functional targets for new implementation, and also avoid introducing excessive overheads or problems with the new system. Our final goal is to set up sustainable administrative ecosystems, where the systems we launch should grow and survive with support from their users, with a minimum need for "top-down" organizational pressure.
Our strategy for the first aspect (find where it hurts and what has an easy cure) is simple: we follow the subjects in their actual daily practice, spot every occasion where there is a problem or discomfort. Then we try to solve it, by addressing the three dimensions of the environment (physical, cognitive, institutional) either by designing appropriate physical or digital systems, changing the organization rules, or providing new representations to help the subjects in framing the situation properly. Among these possible directions we choose the best efficiency/cost ratio

[2] This includes direct transport costs plus valuation of "improductive" time lost in transportation.

with pragmatic opportunism. Often, we have to act upon at least two of those three levels simultaneously. How do we do this in practice? Section 4 will describe our capture instruments and techniques (SubCam, etc.). Nosulenko and Samoylenko, in chapter 8, describe some of the evaluation techniques we use.
For the second aspect (easy and harmless implementation) we have gradually set up a series of requirements for our systems, which we familiarly call the "zeroes" list:

- **Zero training**
- **Zero configuration, Zero impact on user workstation**
- **Zero user maintenance**
- **Zero complication**
- **Zero payment**
- **Immediate benefit for individual end-user**
- **High security and privacy**

3.1 Zero training

Zero training means that the user should be able to get a first successful use of the system immediately, without having to read a manual. When the user first comes to the system, she is usually pushed by the immediate need of using it, not by the desire of learning how the system works. Most of the time, users have « no time to learn » anyway.
The way we address this apparently strong zero condition is by building on pre-existing cognitive skills and representations in the user; and by providing strong contextual guidance from the context (interface, fellow users or institutional procedures). For example, one can assume that the average user in the company will know how to use an internet browser, the company's choice of desktop suite (e.g. Open Office), etc. We design the system so that the interface logics follow these pre-existing skills, representations and mental models. Now this is true only for the minimal use; for more sophisticated functions, the user may have to learn (through online contextual help, colleagues, hotline, etc.) but at least this first successful experience will give the user a good image of the system and motivate her to learn the more sophisticated functions.

3.2 Zero configuration, Zero impact on user workstation

Configuration, as Jansson notes in his chapter 7, is a major obstacle to fluid use.
Users have « no time to instal» new software on their devices, and often they simply do not even have the administrative rights or the necessary skills. We try to provide services in such a way that users do not have to modify their own devices. In the current state of the art, this can be obtained either by providing the proper interface on-site (e.g. with a touch screen in the room like the one described by Back et al. in their chapter 4, or with augmented tokens like the ServiceTags described infra in section 6.5) or through web services, for example. In some cases, when forced (e.g. Gridboard, cf. section 6.5), we use some Active-X or java applets, which are more or less transparent to users.

3.3 Zero user maintenance

Expecting that users can some do some maintenance is simply « not manageable » and this is true for hardware as well as for software. There should be a specific dedicated workforce and online help. Systems which need frequent maintenance, e.g. which have batteries, are usually a problem: failure always happens during use, of course. All occasions for maintenance must be listed when they occur during the test phase, and specific solutions found. Often, some changes in form factor do help minimize maintenance or failure. For example, the less moving pieces, the less apparent cables, the best. Any apparent possibility for customizing the system by users may lead some users to change the parameters and then make the whole system behave in an unexpected way to the next user.

3.4 Zero complication

Of course this is a general guideline. Two clicks maximum to get the action done, and a trivial graphic user interface (GUI) are preferable, refer to your favorite HCI gurus. The way we get there is to carefully observe activity and do *activity-based design*. Complicated interface usually occurs when the system has to propose many choices to the user. It may be better to identify the possibilities of action a user is likely to take in a given situation, then propose one command artifact for each, rather than have one single interface that leads to all possible actions. For example, our DumbleTag system proposes a credit-card style tag for each possible action (which the user puts on the desk antenna to perform an action) instead of a screen interface which would mean lists and choices. One possibility of AE is precisely to use physical objects as commands (cf. the iStuff principle where ordinary objects can each be used as a one-action button). This makes it easier and unambiguous to operate the system.

3.5 Zero payment

« Not on my budget ». Many services have a cost which must to be charged somewhere. We suggest that all costs be on the server side, and that payment should not constitute some operation for the user, especially prior to use. If one had to log into the telephone system for charging purposes before dialing a number, using telephones would be cumbersome. We proceed by charging automatically the entity “in charge”, e.g. the department whop owns the room, or who employs the users; or some central corporate support.

3.6 Immediate benefit for individual end-user

« And God bless you if it’s good for the group.» The user’s real motives are usually individualistic. Of course, in an organization, many services have some collective utility aspect, but it is very difficult to get the users make the efforts to fulfill these. Therefore, when these collective functions need to be performed, they should be transparent to the user, or the user should see some immediate personal positive feedback. This is true of many workflows which are aimed at creating some collective database or collect user data. In such cases, the possibility of getting personal feedback on the information input asked to the user will help data collection. For example, statistics on her own use of the system, or some immediately useful calculation. When we collect a user’s identity or pictures to enter into the meeting room database (which will be used to display his photo the meeting interface and signal who is present, and also give access to the conference room), we want to do this in such a way that, when the user logs in at the entrance of the meeting room, he gets a customized physical token in return which he will be able to use in the meting e.g. for indexing moments of interest in the recording, or to signal the system he wants to take a speech turn.

3.7 High security and privacy

AE systems must be compliant with corporate rules. This constraint is strong: no IT manager will accept a system which compromises security policy. Alas, security (and privacy) usually go in opposite way to usability. This is precisely why they must be taken into account early enough at architectural level[3]. Otherwise, as they will have to be added anyway, chances are they will add cumbersome procedures in the interface.

This zero list may appear impossible to comply with. Experience shows that it is actually feasible, and often easier in AE than in pure ICT environments, because the material aspects provide new, multimodal, affordances for interface. Also, physical tokens can solve a large number of security issues, since physical presence in the space usually means that the user has already satisfied to a series of access controls.

[3] Cf. chapter 1 and (Lahlou, 2008b) for the way we recommend tackling privacy issues.

Our design strategy is to follow the user's actual practice; then try pragmatically to erase obstacles or cognitive costs on her activity track. This is activity-based design (cf. Chapter 1). We proceed progressively and with the collaboration of users, as the next sections will show.

4. The SubCam and Cognitive Attractors

This section shows how we proceed in practice to spot the main issues in solving and understanding the nature of the user's activity.

4.1 The SubCam

Following the subject's activity from her own perspective is a good way to understand the actual problems, which often occur in "details". We need a recording technique that introduces minimal bias while providing fine-grained details and especially pointing at where the subject focuses her attention. After trying most classic techniques (participant observation, interview, videotaping, shadowing, etc.) we found that they either do not give enough detail or produce too much bias. So we specified and constructed a new tool, the "SubCam" (Figure 5.2): a miniature video camera with a wide-angle and directional microphone worn on a pair of glasses (Lahlou, 1999), or other form factors depending on the activity (e.g. attached to a helmet for industrial activity, on a bandana for kids, etc.). We hand this wearable tool to the subject and simply ask her to perform the activity. In some cases we ask the subject to talk out loud, especially when problems are encountered. The researcher does not need to be present. The subject is left alone and simply gives the subfilms to the researchers at the end of the day. The protocols are described in detail in (Lahlou, 2006).

Figure 5.2: two versions of the SubCam: office work (left); plant version (right).

This protocol provides the design team with a continuous record of the "phenomenological tunnel" lived by the subject. It provides situated recording of what the subject sees, hears and does. It also provides more. First, this enables to understand where the subject focuses his attention. Then, variations in the breathing or voice tone (hearable on the sound track) give indications about emotions.

But, most importantly, a lot of the subject's intentions and subjective interpretations are accessible through self-confrontation of the subjects with their subfilms. Watching the subtapes and discussing them with the subjects, designers, engineers and other stakeholders is a crucial part of the process; because what we are interested in is the *goals* of the subjects, and how they *subjectively* judge the quality of the environment in supporting them to reach these goals.

Confronted with their subfilms, subjects, because they are put back in the same activity track they actually lived, exhibit an amazing capacity to remember and describe their intentions, emotions, reasoning, and hereby provide us with the elements necessary to make a good activity analysis (goals, motives, intentions, evaluation, etc.).
The current version of the SubCam has high resolution ("HD") and enables reading the documents subjects hold in their hands or read on their PC screen. The SubCam is a merciless observation tool, it enables monitoring the activity in its multimodal dimensions, in detail. For example, when a subject works, she may use *simultaneously*, her PC, her fixed and mobile phone, paper, colleagues, etc. The SubCam alone enables recording all these dimensions – which is easier than having to record each device separately.
Discussion with the subjects is crucial to understanding the issues in depth. Actions which may appear strange at first sight are often explained by the far reaching consequences they may have in the global organization, or past experience of the subject. Situations may be more complex than the visible because every detail is connected to many issues in the full life-cycle of the system. For example, often we refused to implement some nice features because they could cause nasty maintenance problems, or would be too integrated with others and therefore make it impossible to have a "plan B" in case of failure. Users know these issues, can illustrate them with actual examples to designers and system engineers; therefore the SubCam debrief sessions are extremely useful for specification. Also, watching the subject's SubCam films helps designers get a first person experience of the activity they are designing; and also some empathy with the problems subjects encounter as they progress in their activity through their own phenomenological tunnel. This "entheasy" (neologism expressing this state of "sharing the vision of action" we had to forge in order to describe this very special and unprecedented feeling of being a passenger in someone else's head: Lahlou, 2006) is a strong experience for designers, and certainly helps them to have a more realistic approach.

Figure 5.3: A frame extracted from a SubCam film.

With SubCam data, not only do we get a realistic account of what subjects do, and the capacity to quantify e.g. time lost in inadequate operations, but also we can spot in an almost trivial manner all the points where improvement and redesign is necessary (or wished). The design choices then become arbitrating which issues can be solved with existing technology at reasonable DOME cost. When the current state of Commercial-Off-The-Shelf technology is not mature enough for robust implementation we usually delay or abandon – and address an easier issue.

We then proceed to some quick prototyping, change the environment with the prototypes (or some "Wizard of Oz" mock-ups), and ask subjects to use the environment again; watch their subtapes with them for evaluation, and reiterate until we reach some satisfying state. The number of such iterations is unpredictable. This is by the way a problem for design planning. Sometimes we need 20 or more iterations to reach a fluid interaction. On the other hand, since the evaluation procedure is informal and much lighter than classic ergonomic studies, one iteration can be very fast and cheap, so the problem of being unable to plan the exact number of iterations is not so dramatic.

At LDC we collected hundreds of hours of the natural activity of (volunteer) office workers, using the SubCam. These records shows that users, unlike what is predicted by classic psychological theories, often *do not do what they intended*, even when they could have. They continuously get sidetracked in unplanned activities. This is consistent with table 5.1, where 62% declared fully or rather agree that they cannot manage to do what they had planned for the day. Some sidetracks are forced by usability issues, when the subject cannot manage to operate the system as he planned. For example, in a simple action of sending an email with a PDA, we measured how interface issues produced a final sequence quite different from what the subject said he was going to operate before starting the task; and as a result, unplanned operations took 58% of the some 8 minutes total (Lahlou, Nosulenko and Samoylenko, 2002). The analysis of this single sequence, by comparing what the subject said what he intended to do and what he actually did enabled us to spot nine unplanned operations which pinpoint interface issues.

But interface issues are not the only sidetracking points. Subjects are captured by interrupting colleagues (on the phone…), by the context (fixing the copier…), by activities planned by others (meetings…), or even by themselves through sidetracking routines (answering email, clearing their desk from "small" or "urgent" tasks…). Any disruption in a planned task (e.g. not reaching immediately the person one tries to get in contact with) may result in pausing current task and opening a new, potentially disruptive, activity path – and this is one more reason to design AE for fluid and seamless interaction. In the course of this new path, the original activity track may be lost. As a result, subjects often do not manage to do what they had planned for themselves in their day (cf. the survey results supra in Table 5.1).

The underlying reason is that people are not simply deciding what they do individually; they are entangled in a whole environment which guides and constrains their activity. The guidance is on three levels: affordances of the physical world, social rules, internal representations and learned routines which automatically provide interpretation of the context and trigger behaviour, in an almost unconscious manner. Our design effort against COS aims at controlling these effects, and giving back the user more decision on her own activity. AE should be empowering for the users and not force them into following some rigid workflow.

The next section will describe in more detail the model of "cognitive attractors" (Lahlou, 2000) which helps us in understanding human behavior, but also in designing environments which support humans as they perform their activity.

4.2. Cognitive attractors

The cognitive attractor theory (Lahlou, 2000; Lahlou, Nosulenko and Samoylenko, 2009) describes how subjects are led into a specific activity path by a combination of patterns in the context ("data") and matching representations in their mind ("lata"). In conjunction, data and lata produce an automatic *interpretation* of the context. Interpretation should be understood here both in the sense of understanding (meaning), and of playing (like a musician would interpret a piece). Cognitive attractor theory predicts that if a critical mass of data and matching lata are present, the drive for the corresponding *activity* spontaneously emerges. What is amazing is that the process of interpretation emerges automatically, beyond the subject's will: "it just happens", just like a Gestalt imposes a pattern to perception when a sufficient portion of the pattern is present (Figure 5.4).

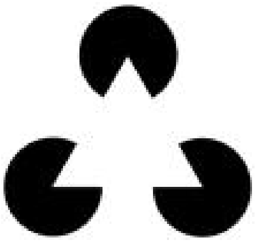

Figure 5.4: This set of elements is “naturally” interpreted as a single triangular pattern.

A trivial example is the coffee discussion. A couple of colleagues chatting next to the coffee-machine are an attractor for “coffee discussion”. Such an attractor is so strong that some other colleague who comes by during a pause in his (say, report writing) activity, with the sole intention of taking a coffee and going back to his office, has few chances to escape it and will probably stay and chat for a few minutes, although a debrief will show that this was *not* his intention in the first place. This subject escaped from the initial attractor “report writing” and got caught in the “coffee discussion” attractor.

Another, less trivial, example is email. The fact that email is a cognitive attractor has major impacts on office life. When a subject is in front of his email box, the mental and physical framework becomes “doing email” activity, which means looking at the emails and answering them. So, when a subject who finds himself with hands on the keyboard and the email messaging system open, chances are that he will automatically interpret the situation as “doing email” activity: checking new ones, and processing all emails which are easily processable. It is like a bicycle rider who gets her wheel locked in the tramway’s track, and starts following that track. The problem with the “doing email” attractor is that there are many cases when the subject gets exposed to this situation, especially if the mailbox windows is always open on the desktop screen, or if the subject is prompted by some popup when a new mail comes in. Two nasty effects appear. The first is email capture: every time the subject gets into the email attraction situation (hands on keyboard, mailbox open) he will tend to process emails until something stops him (e.g. external interruption, or one email too difficult to process). The second is less obvious but maybe worse. Often, an email contains some demand, e.g. information processing, or action. This action can usually be performed in many ways: e.g. calling the email sender on the phone for discussion, consulting colleagues or acting on some real-world object. More often than not, the best way to solve a problem in collaboration is to have face-to-face or at least vocal interaction. But as the subject is caught into this attractor of “email processing”, there is a tunneling effect. The modalities of output for the action he will use will be within this email processing activity: the subject will tend to consider output in the form of text processing only, and input as well. Instead of calling or meeting face-to-face the sender or others for discussion, which would allow wide communication bandwidth, the subject will tend to spend hours writing a complex message and copy others for action; hereby contributing to a snowballing effect where email finally unduly absorbs an enormous part of the workflow. This forces complex issues into the low bandwidth and poor textual representation format, and contributes to information overload, among other things.

These behaviors are not systematic or compulsory, but obviously some situations *attract* us into performing a specific type of activity, which indeed produces some kind of benefit. Salutations, putting things into order, checking incoming information are of this kind. Social prompts are almost impossible to avoid answering; e.g. interruptions or jokes call for a response. A close-up look at users’ video tapes suggests that a substantial part of our everyday activity is composed by following the paths of these stereotyped attractors. This does not mean that subjects do not display original and creative behaviors, they do indeed. Most of the time though, creation is in a new assembly of existing segments, just like a new text can be composed by assembling pre-existing words, expressions, or sentences.

Attractors are a different notion from stimuli. For example, they may need to be disambiguated, they do not exist independently of the observer’s frame of mind, they may be ignored and have no automatic implication on the subject’s behavior. Any given setting may contain many different attractors for the subject. The issue is *which* attractor will be seized by the subject. It is a matter of competition between attractors.

Data in the environment and lata in the mind

Attractors are a combination of *data* (located in the environment) and *lata* (located in the observer). The combination of both may form patterns which trigger activities. Therefore, presence of the relevant data in the environment will change the probability of occurrence of a given activity. By affording a specific activity track, data will favor this track over another possible activity. By evoking the associated lata, data may induce motivation for an activity in subjects among participants who were initially without this motivation. Space is too scarce here for a full description of the cognitive attractor theory and its psychological basis, which are described in more detail in Lahlou (2000, 2004). Let us simply note that subjects are continuously confronted with a large numbers of attractors in their context. An attractor acts like a script which feeds-forward the action.

As long as the activity is fluid, with continuous coupling with the environment and adequate system response, chances are that the subject will continue on the same track. But if some obstacle or failure occurs, there may be a re-computation of "what to do" and some locally stronger attractor may take over. For example, in the course of some activity, Robert needs to send an e-mail to someone. He opens his mailbox to do so and sees a just-arrived message from his big boss. Chances are he will open the message, and get sidetracked.

Cognitive attractors are not simply distractors capturing subjects: they are at the very basis of the efficiency of human behavior. An attractor is a routine procedure, and following it is a way of doing something in an efficient and proved way; while liberating attentional resources, like any routine. It also makes the world predictable for others and hence makes cooperation possible since each participant will act as expected (if they all follow the same attractor), each one performing his local role in the play.

Tuning attractors

The strength of attractors is a combination of three factors: pregnance (attraction of attention), value (attraction of desire) and cost to be completed (attraction of effort). As designers, we can address the system at the level of data, by modifying affordances or pregnance; at the level of lata in creating or disseminating new interpretations of the situation or raising motivation; at the level of coupling by changing the costs of coupling with the system. We must also remember that the relation between the user and the system is immersed in a social space of institutional rules; and that other people can – and do indeed – intervene in one's activity. Therefore many control mechanisms are in fact at the social level, either because they prompt the subject into doing something, guide or help him, or inhibit or prevent the subject from choosing some specific behavioral tracks which would be physically possible, and psychologically imaginable, but are not socially acceptable. "Other people" can be a resource for our design of AE as well as physical objects or mental representations.

Attractors are complex patterns, and difficult to investigate because each pattern is distributed over the external context and within the mind of the subjects. In practice we explore attractors through a trial and error process which is *de facto* already a design process. What we need is not a complete model of each attractor, but rather to find a way to frame the attractor for better user comfort in an activity. Just as in economics for the notion of Utility, there is no absolute scale, but rather the possibility of evaluating marginal differences between two situations (one being preferred by users). This is enough for practical purposes. Incidentally, in this exploration procedure we learn more about the deep nature of the attractor itself; but this is not always the case and sometimes we find a better design solution before understanding why this design was better.

Our design therefore aims at guiding users into efficient behavior, by offering specific affordances along their activity path. The idea is not to design artifacts and devices, but rather to understand activity and functions, and *then* design into the environment a set of affordances which will keep the subjects on the best practice tracks.

Ideally, the best practice track should have, at every step, a lower cognitive cost than other possibilities, thereby inclining the subjects to naturally follow the easiest slope. This includes the first adoption phase when subjects are lured into choosing our new system instead of their previous one. Of course we hardly ever succeed completely. But if a good practice activity track is kept at low cognitive cost, e.g. by erasing the spots of high cost on the way, spreading good practice is easier, and social control may become a strong enough safeguard to keep good practice dominant. Specific to our approach is doing this at social level, and considering environments as a whole.

In an experiment conducted in individual offices in 1998 and 1999, we changed the arrangement of the furniture and displays and created new affordances for collaboration (by making it easy and inviting for a pair of people to sit together in front of a better quality computer screen). Before, the main occupant of the workstation was mostly working on a stand-alone basis. We left a time-lapse camera on the ceiling above the workplace ("offsat": Lahlou, 1999, cf. infra section 6.4) for nine months and observed change. The speeded up films showed a dramatic increase of collaborative sessions with two or three individuals, facing the screen; in contrast with the previous period where work was more solitary. During a presentation of these results, the managers of this group expressed surprise: they had tried for years to obtain this result (collaboration) but never succeeded. Interestingly, this behavior had occurred spontaneously after our office refurbishment, simply because the new setting offered good affordances for collaboration. This affordance was not planned by us, but it produced effects anyway. The new behavior, documented two months after installation of the new setting, remained stable (Lahlou 2008).

The fact that changing instruments will change practices, and vice-versa has been known and documented for a long time (Bödker, 1996; Engeström, 1990, 1993; Engeström and Middleton, 1996). Our experience shows that providing new affordances can spontaneously produce new behaviors, in a smoother and more effective manner than managerial pressure. This grounds our strategy of social change: "don't try to change the people, simply change the context". This strategy has some advantages: context is persistent, and can "talk" to the users any time they will use it, which a teacher cannot. Also, there are fewer power and social issues in interacting with the context; therefore it provokes less resistance among users.

5. The triple determination framework ("installation" theory)

The subject is part, as a worker and as a social being, of a larger ecosystem than the local technical system being designed. As we saw with cognitive attractors, this coupling between the subject and the setting tends to determine the subject's behavior far beyond what classic psychological theories describe. This systemic view has much in common with the one developed by Hutchins and Hollan in distributed cognition (see chapter 9), and also with the Russian approach of the engineering psychology school (see Nosulenko & Samoylenko, chapter 8). It implies that to design new work environments we must actually design a whole new system, encompassing the three levels of guidance: the physical artifacts and ICT; the subjects' cognitive models; and the institutional rules of practice.

The World can be considered as a cultural "installation" (Lahlou, 2008a) which guides subjects into their activity track, at three levels: physical, mental, institutional. The physical level refers to material artifacts; it provides *affordances* (Gibson, 1967): which activities can be supported by the objects. For example, chairs afford sitting; screens afford collaborative viewing; etc. This is the first level determines what is physically possible to do.

Humans have mental representations of what is feasible in a given situation. These representations provide possible interpretations, and enable the elaboration of plans or decision-making. With this second level of determination, people can interpret affordances into support for their activities. Objects may be interpreted as "connotation for activity" (Uexküll, 1956).

Representations and the objects they represent follow a co-evolution process: representations are constructed by the practice people have of objects. Conversely, objects are made after the pattern of their representation: chairs are made to look like chairs; firemen are trained to behave as firemen; email software are built after the representation of email. And this is the reason why representations match with objects. So if we want new ICT systems to be usable and sustainable, we also have to work on their representations among users and designers.

At a social level, the co-evolution of objects and representations is monitored by domain-local communities of interest (users, providers, administrators, etc.) who set the patterns of objects, the rules of practice etc. Because these stakeholders know the field, objects, representations and rules are adapted to behaviors. These stakeholders create “institutions”, which are both sets of rules to be applied to keep order and cooperation, and communities of interest aware that they play in the same game.

Knowing how to use the affordances is not always sufficient to execute adequate behavior. Not all that is feasible is socially acceptable. Some people might do wrong and provoke (by ignorance, personal interest) negative externalities for themselves or others. Institutions are a social answer: they create and enforce rules to control these potential misuses or abuses; they set common conventions which enable cooperation (e.g. people should all drive on the same side of the road; they should use “netiquette” in their digital communication, etc.). Many of these rules are already contained in the mental representations, which are by nature normative. But institutions bring a physical control layer to these norms. They enforce them with special personnel. Also, every loyal member of the community tends to serve as a rule-enforcer and bring back mavericks or ignorants on track. Often these rules are made formal and explicit (regulations, laws, etc.) but they may stay informal rules of good practice, tricks of the trade or traditions. As these rules are the result of compromise between local interests, they vary from place to place. The co-evolution between artifacts and representations is done under continuous monitoring and control of stakeholder communities, which use institutions as social and economics tools to safeguard their interests.

The resources and constraints provided at these three levels guide our social life and make it possible and fluid. Subjects rely on them simultaneously and alternatively. They are compatible and somewhat redundant which makes this triple-determination system pretty robust and stable. This triple determination framework explains how we behave at a given moment in time.

Evolving towards a stable and sustainable state of the system therefore means making changes at three levels: physical (technical system ICT framework, from digital networks to software and business models); representational (the ideas people have of what “using AE” means); institutional (rules of good practice accepted and enforced).

So the limits of what is to be designed are not bounded to the technical system of devices and software. When Winograd talks about setting a “semantic Rubicon” as a design principle for AE, one could interpret this in a strict sense and conclude that the designer should draw limits to what the system is supposed to do. But tracing such a limit is also a choice of what the subjects and institutions must learn to do on the other side of the Rubicon. These changes to be implemented on the other side of the Rubicon are also a matter of (organizational) design and training, and part of the system design itself. So, if the computer systems should not take initiatives beyond the Rubicon, this doesn’t mean that the designer shouldn’t. That is what interaction design is about; the Russian psychology of engineering has long recognized this issue, and they talk about “activity design” (Lomov, 1977), referring to a process where redesign of the global system includes all the aspects of the system, from building new machines to setting up new training programs for the operators.

Take a simple example: meeting room access. Access, especially if the doors are usually locked, is a matter of technology (biometrics etc.) but primarily is an organizational matter of access rights management. Depending upon who (users, management, secretaries, facility managers) is entitled to make reservations or grant access, and on what basis (permanent, or based on participation in meetings), the specifications of the technical system which is supposed to unlock the door for authorized users will be quite different. For example, if the local “owner” of the meeting room (e.g. the Department owning the corridor) wants to have control over the use of the room (and therefore not allow online reservation), this will make any multisite reservation procedure difficult because nobody can get an instant and reliable global vision of which rooms are available for multi-site videoconferencing. The same type of issue comes with digital meeting support specifications: how far should the convener, or the animator, have priority access on resources over other participants? What is traceable in the meeting? Who is allowed to access the records of the meeting? These issues are not technical, they are political. Different groups may take different options; OK: but should the system support all options?

These simple issues of “who will be allowed to use the system”, “who will grant access (and suppress it)” and “with what procedures”; “who will help novice users”, “who will maintain and repair”, “who will pay for operations, consumables, telecom” etc. must be made clear, because they will have a major impact on design. Experience shows that settling these issues is a matter of time and negotiation and that rarely “obvious” answers are “obvious” for all stakeholders.
In the present state of the art, designing a wizardless self-service room where systems are robust and integrated enough to leave the room unlocked is very difficult. We know many augmented meeting rooms which did not survive because they were designed on the base of providing nice features but did not address these simple daily operation issues. It may be, often, simpler to act upon external non-ICT constraints (e.g. making sure one secretary has the responsibility for giving the key of the room or the access codes, or for enrolling users in the biometric system) than to implement complex ICT functions. These supposedly make the system autonomous, but in fact often end up in awfully complicated procedures because of the multiplicity of cases to handle. Keep in mind that these systems must be designed for evolution anyway: functionalities for which we do not yet have robust solutions should *not* be implemented but rather provided by a separate, old fashioned human resource until robust ICT solutions are available. A single, minor failure in an AE will jeopardize the whole system because users will get a bad experience which may cast a halo effect on the whole service. This three-layered approach (solve the issues with the layer that makes it easier) is a great resource for AE, and designers should cross the technical Rubicon more often.
As an example of our three-layered strategy: access rights management to the K1 testbed has two levels: access from the outside of the building to the lounge (the lounge acts as an airlock to the project space) is granted by the general R&D facility management upon request made by the testbed manager (Olivier Nadiras), because of the safety regulations of the facility; while internal access from the lounge to the project space is granted by Olivier and/or the head of LDC (Saadi) who control the K1 testbed local information system. This is why there is a specific biometric enrollment totem in the lounge, where those members of the lab who are entitled to recruit new users can empower access tags with habilitation tokens. The totem also enables automatic activation of the badges of people participating in meetings in RAO to cross the automatic door from RAO to the lounge during their presence in K1. It took a long time to set this procedure up which ensures compatibility with facility security, protection of the project space, and still easy circulation between the RAO room and the lounge (strategic because toilets and public coffee machine are in the lounge: the devil is in the detail).
Another case is the new role for “conveners” in augmented meetings. It is socially implicit that the local organizer finds himself in charge of all the issues regarding access to the meeting room; during videoconferences it extends to digital spaces, and this often causes many problems when the convener is also the meeting animator (Lahlou, 2007a). We therefore try to find a social solution for this by constructing the role of “convener” in the room reservation system. Then, in the case of technical issues, while the convener solves the problems with the distant sites and local wizards, the meeting animator can still concentrate on the content rather than on technical trivialities.
Finally an example on the issue of mental models. The mental model underlying the use of Gridboard is: “we are all in front of the same screen, each with our own mouse and keyboard”. We need all participants, especially the new ones, to be aware of this. In version 2008 of Gridboard, when accessing the Gridboard URL, a small animation is launched showing the Gridboard machine coming from cyberspace and sticking its window onto the users’ desktop. Also desktop contour is specific to visualize that *this* is a window into another distant machine (Figure 5.5).

Figure 5.5: The Gridboard login animation (“reaching a distant shared desktop”) frames the user mental model.

As we see here, AE designers must be prepared to go beyond ICT issues, and cross the technological Rubicon. The environment often serves as an “external” memory or as a local plan, or “mediating structures“[4] (Hutchins, 1987), through its affordances. Architecture, organization and management rules, individual training are part of the picture and must be considered as parameters in design.

6. Experimental reality and design

We apply a pragmatic design process which we call “experimental reality”. The underlying vision is as follows: designing AE is a progressive task, because new functionalities emerge as the users get acquainted with the new system, and the number of elements involved (devices, users, institutions) is so high that one can hardly model what is actually going to fit beforehand. So we need to test the new AE in real environments (real users, real tasks) which will provide a good reality test. On the other hand, proper observation, evaluation and design needs to be done in a lab. So we made a lab big enough to encapsulate real situations, and constructed an institutional framework which filled this lab with real users in a cooperative mood.
We built a specific building, the K1, where we implement and test AE with real users. Users are volunteers who work in the AE, and use them on an everyday basis. The AE are monitored by a multidisciplinary team of designers, engineers, and cognitive scientists aided by powerful observation tools. A specific highly skilled task force (at least two system engineers, designers) maintains systems in operation, and installs modifications. The team as a group, with the help of the users, decides what modifications should be made, based on the problems encountered by users and their wishes. We observe the users in detail in their daily activities, with the SubCam and other instruments, and analyze activity and the perceived quality of the AE. When the systems or functions installed in the K1 testbed have reached a satisfying state, we scale them out in the company.

[4] “Mediation refers to a particular mode of organizing behavior with respect to some task by achieving coordination with a mediating structure that is not itself inherent in the domain of the task. That is, in a mediated performance, the actor does not simply coordinate with the task environment, instead, the actor coordinates with something else as well, something that provides structure that can be used to shape the actor's behavior (...) Language, cultural knowledge, mental models, arithmetic procedures, and rules of logic are all mediating structures too. So are traffic lights, supermarket layouts, and the contexts we arrange for each other's behaviors. Mediating structures can be embodied in artifacts, in ideas, in systems of social interaction, or in all of these at once.” (Hutchins, 1987).

Figure 5.6: The Laboratory of Design for Cognition K1 building: CAD view and outside view

The K1 is a 400 square meter (4000 square feet) user laboratory (described further in this section); but it also has a virtual part which is used by volunteers who do not inhabit the physical building and are distributed in the company and sister labs outside of the company. The K1 AE are a continuous work-in-progress; sometimes, when a sub-system reaches maturity, this stable version is disseminated in the company – but we keep working on the future versions in the K1. This is especially true for the RAO room, which is the “mother room” of all other augmented meeting rooms in the company. This organization enables dealing with the never-endingness of the design process. The RAO room is where new systems and artifacts are tested, in a realistic manner, since it is actually connected with the rest of the company’s information system, and used for real meetings. For example, in 2007, 210 videoconferences took place in the K1, often with distant sites outside the company. Participants in such meetings are a natural flow of potential testers for our new systems.
Why do users come into the lab? Because it offers better comfort and functionalities that they cannot get elsewhere. Why do they trust us? Because we are part of the company, share their culture, and are bound by strict professional and privacy rules. Why are they in cooperative mode? Because they know that our work does indeed bring *them* individual benefits in their daily activity. In fact, it took a long time to create this situation and trust came gradually, as useful and user-friendly systems designed in the K1 started to disseminate in the company. Also, the work process we apply is not a “project mode” where we use the users as testers to design new systems, but rather accompanying them in their activity and try to solve the issues with them in a cooperative mode; a process in which they can freely benefit from our own resources to solve their individual problems.

6.1. The K1: a flexible infrastructure

The K1 is a 1950s building which was completely cleaned out: we only kept some of the architectural envelope; The K1 was retrofitted according to plans made by the Carnegie-Mellon architecture department: we applied the design principles of the CBPD for flexibility (cf. the Loftness et al. Chapter 2). Everything in the building is flexible, from the wiring to walls and furniture. We installed the raised floors systems described by Loftness et al. in chapter 2 and Borchers in chapter 10, the ceiling grid described by Borchers in pattern n°5 in chapter 10, etc. We have moveable furniture (cf. furniture section, further down) and even moveable “flying walls” (Figures 5.7 and 5.8) designed by François Jégou.

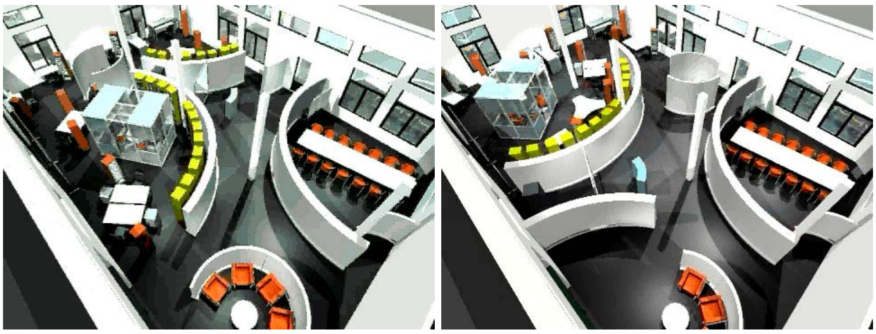

Figure 5.7: Reconfiguration of the K1 project space by its occupants between December 2000 (left) and March 2001 (right).

The walls are self standing because they are thick and curved, and mounted on a layer which enables the users to slide them and assemble them in a few seconds, without any equipment (unlike the so-called “moveable partitions” installed in many office buildings, which actually never move). The walls also are sound-proof and covered on one side with studio-quality absorbing fabric, of a light grey color which also provides low-contrast background for videoconferencing.

Figure 5.8: Users moving a « flying wall ».

Figure 5.9. The infrastructure of K1 Building: raised floors. Left: a user moves a tile with a suction grip. Right: the "highway" of network cables as they originate from a control room and run to underfloor distribution boxes in various areas of the building, where local cables with a loose end can be plugged.

6.2. The architectural charrette

All this flexibility is extremely handy on a daily basis, and almost everyday users open the floor, change the installation, and rearrange the furniture. By the way, this shows that provided good affordances, users indeed do often change the setting. But this is possible only if the infrastructure is planned beforehand. Devil is in the detail. For example, when one wants to move walls, it is necessary that lighting controls, for example, are also moveable, and that there is an easy way to change the ventilation outlets (a meeting room needs more ventilation). In our case, all controls are wireless (presence sensors in the ceiling grid, plus handheld remote controls). The HVAC system is unusual: fresh air comes pressurized in the plenum underneath the raised floor (which is about 40 cm high). Some of the floor tiles are ventilation grids (they are full of small holes); there are return air ducts in the ceiling: the clean air flows naturally from floor to ceiling slowly and silently, clearing away the dust and producing a cleaner atmosphere. When we want to have more ventilation somewhere, moving the tile grids takes a matter of minutes and the users do it themselves.

Therefore, constructing an AE starts at architectural stage. A good envelope (with operable windows, easy access etc.) and infrastructure must be planned beforehand; and this involves more stakeholders than computer system administrators only. In that respect, most interesting to note is that the CMU team organized an "architectural charrette" crash workshop for the K1 including all stakeholders at the very onset of the design process. There were two intense days which were completely recorded with 35 participants: architects, future users, facility managers, lawyers, administrators, specialists of the future construction team (electricity, HVAC, etc.), IT and security, designers, and members of supplying industries or potential subcontractors (lighting, automation and controls, security etc.)

Design hypotheses were sketched on the fly, introduced in a CAD representation of the building in real time for discussion. Decisions were traced and stakeholders were therefore committed. Having all stakeholders assembled enabled them to discover many potential issues, and to solve them on the spot, which enabled the construction to be done very fast. The workshop took place on March 27 and 28, 2000, and produced a detailed specifications document (Hartkopf, Loftness and Aziz, 2000). At that time the building was installed with classic office partition inside, on two levels. Following this charrette everything except the outside walls was destroyed, and the new infrastructure installed. The K1 in its new form was finished, fully operational including ICT systems and inhabited when inaugurated nine months later, on December 20, 2000. While the construction team retrofitted the building and installed the infrastructure, the ICT team was preparing the internal systems in parallel, which were tested separately and finally assembled on the spot in two weeks.

Without this previous discussion of all stakeholders, such short a quick turnaround for the overall installation would have been impossible; because with the usual procedure one discovers problems as the construction goes, and they are more difficult and longer to solve as they weren't planned.

The ICT infrastructure is also designed to be modular, and assembles off-the shelf components with web-services, in a spirit similar to that described by other authors of this book.

6.3. Multiple spaces

The K1 building includes several functional spaces which all serve as testbed. The main space is K a 25m x 12m platform we call the project space (Figure 5.10, and Figure 5.1). This project space is a mixture of open space and enclaves. We now know that open space is only good for some types of activities (when participants need awareness of what others do); individual work requires closed and sound isolated spaces; whereas meetings need dedicated meeting rooms with large displays and a variable number of tables and seats.

Figure 5.10: The K1 project space (floorplan as in December 2000).

The project space currently includes two small fully closed enclaves (at one point we had three of these, and only one in the beginning, as depicted on the floorplan on Figure 5.10). These enclaves made by Burkhardt-Leitner Constructiv are glass boxes (3m x 3m and 3m x 2m); they are soundproof and mounted on wheels; each can serve as a videoconference room for small groups (Figure 15).

Figure 5.11: A view from the K1 project space. Notice one of the movable glass-box enclaves, next to one of the users.

The project space is partitioned with moveable “flying walls” (Figure 5.8). It also contains an augmented meeting room of variable surface (usually about 60 square meters), the RAO room (see section 6.5).
Next to the project space and on the same level, a 5m x 20m lounge with a nice view (Figure 5.12) including a small work area for visiting nomadic workers (with meeting and videoconferencing capability) and toilets.

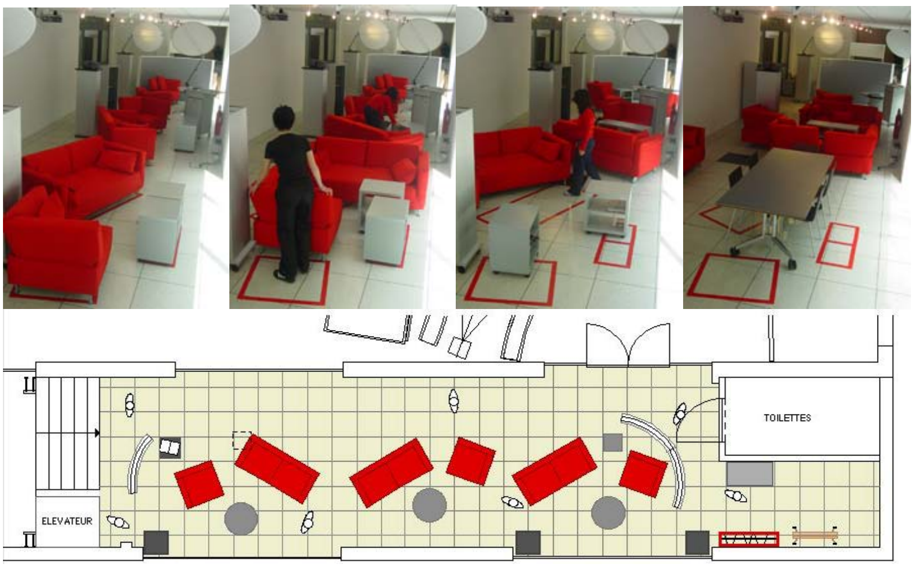

Figure 5.12: An example of reconfiguration of the GATEP from the “default configuration” to “table group work + pause area”. The operation takes less than 5 minutes, and is effortless since all furniture is on wheels. Notice the markings on the floor for the default configuration which helps users reset the environment at the end of the meeting.

Adjacent to the project space, and on the same ground floor, two more technical rooms: one for electricity, one for servicing the conference room and next to it, which contains the backstage equipment of RAO including the beamers. There is also a kitchen.

On the first floor, a relaxation room with a special bed, a space dedicated to data and video analysis and editing, a computer room.
The building is designed to be a comfortable workplace with amenities to test AE. Any kind of environment, from the classic one-person closed office to Augmented open spaces can be installed in a matter of hours or days. This is true as well for the ICT infrastructure: all types of networks are available from fiber to wireless, including powerline, infrared, RFID, different types of radio etc. We also have several types of biometric and geolocation systems, and access to the large EDF R&D computer infrastructure with virtually unlimited computing power and storage (massive clusters, BlueGene supercomputer, etc.).

6.4 Digital Ethnography

K1 is a *vivarium* designed for human observation. We use classic ethnographic and ergonomic techniques (observation, interviews, videos, etc.) and some we invented for continuous detailed record with minimal burden on the subjects and researcher.

6.4.1 Observation systems

Anything happening in the meeting room is recordable. Inhabitants are volunteers, who are sometimes asked to wear SubCams (cf. section 4.1 supra) and other systems for lifelogging (Gemmell, Bell, Lueder, Drucker and Wong, 2002) ranging from the Microsoft Research SenseCam (Hodges, Williams, Berry, Izadi, Srinivasan, Butler, Smyth, Kapur and Wood, 2006) to the Portapres (ambulatory blood pressure recorder) or having their workstations screens recorded, e.g. with Camtasia.
The lab was designed as an observation box: over 25 video cameras ("OffSats") run 24/7 in the lab. A ceiling grid enables fixing cameras anywhere at any angle; the ceiling is high enough to get good coverage. The Offsat (short for Office Satellite: Lahlou, 1998) is a time lapse camera situated above a workspace. It has no moving part and can stay for long periods of time (in the K1, the older of these OffSats have been operating continuously for over eight years, and yield a spectacular accelerated movie of the building history, starting during construction in 2000). Automatic movement analysis enables tracing activity zones (Lahlou, 1998); automatic movement detection enables recording only when something is happening. We use Axis NetEye® server cameras, which send the images on a remote securized hard disk.
Spaces within the K1 (not the toilet and relaxation room, nor the inside of glass enclaves though) are under continuous observation by these OffSats, connected to an automatic archival and automated movement analysis system.

Figure 5.13: a series of OffSat image, showing the activity in an office.

The meeting room is recorded by a series of OffSats but also by several video cameras (we also use the videoconference cameras as recording sources); the large displays of the RAO room are directly recorded; this includes the videoconference displays. Films from RAO are recorded on a single digital recorder, so by one single gesture (putting the "record" ServiceTag on the room's reader) everything is recorded (Figure 5.14).

Figure 5.14: Example of automatic recording of a meeting in RAO. Here, a videoconference of the rufae group. Tico Ballagas, then in Borcher's Aachen group (top left) presents a PowerPoint presentation which all participants follow in the rufae labs on both sides of the Atlantic. The PowerPoint is viewed on the right screen of the RAO room, and is record on lower right of this image. The two other views top right, bottom left) are views of the RAO room, one from the back, one from the front. This kind of recording enables us to analyze in detail every part of the meeting, and more specifically issues with the ICT and AE systems (cf. Lahlou, 2007b).

We also have a 360° panoramic video camera which enables capturing complex scenes in one single take and take any perspective for analysis. This camera is handy because it is light and portable, although very high resolution, and can be transported to capture meetings in any room.

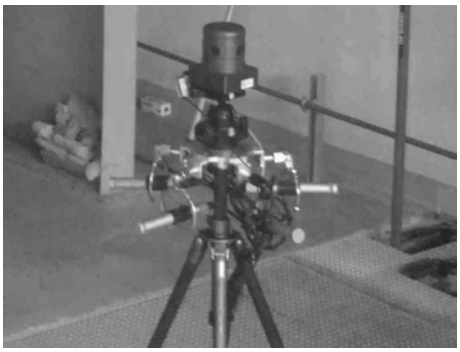

Figure 5.15: The Point Grey high resolution "Ladybug" 360° panoramic video camera (on top) to which our colleague Antoine Cordelois added a panoramic sound capture system (array of 5 microphones below).

Figure 5.16: a frame from our portable 360° panoramic video camera: here a seminar with LDC members in the UCSD DCog-HCI laboratory of Jim Hollan and Ed Hutchins.

We use several systems for video analysis, but the most useful is WebDiver, developed by the Stanford CISL (Pea, Lindgren and Rosen, 2008) which enables collaborative analysis of videos by searching, visualizing, annotating and editing in a shared manner all of the videos.

In order not to get drowned in the data we apply the “retro-sampling” strategy. This consists in recording everything, with automatic gross indexation by timestamp and automatic logs (e.g. meeting agendas from the room reservation system, incoming participants etc.). Then, when we know what we look for, e.g. the detailed history of a specific process or incident), we locate in time the relevant moments by a fast cueing of offsat images based on the gross indexing; and proceed to close analysis of the activity by confronting users with the films at normal speed (Lahlou, Nosulenko and Samoylenko, 2002, 2009).

Our observation techniques are potentially invasive. Respecting users’ privacy is a basic requirement. Of course users are aware of the observation; they sign an informed consent as they enter the building. We apply very strict privacy enhancing rules. Users have control over their data, including the right to erase them without giving any reason. For example, users go away with their SubCam data and watch them before giving them to us for analysis, if they wish (if they don’t, we destroy the data in their presence, no questions asked). See Lahlou (2006) for a detailed account of our SubCam protocols. The subjects’ interest and face are a crucial asset of the lab, more important to us than any data set. Any incident would destroy the whole project, since all is based on trust; we are therefore extremely careful – and the subjects as well as the research group are quite aware of the risks and the necessary precautions.

Of course data capture should bring no overhead to users, and this is why most of our data capture is automatic.

6.4.2 Enrolling Users

The final quality of what is designed is deeply dependant upon how much clever input users actually put in.

The key of success is *active* user collaboration. Putting users in the loop is not enough; they must be involved in a constructive way – beyond simply reacting to propositions of designers. The expertise in the goals, the knowledge of how the company *really* works and the actual limits of its flexibility lay in the users. So a critical feature of our process is to *spark users into creative mode*.

Not all users are creative, not all users can envision what technology could bring them. More often than not, when they are asked about their needs and wants their answer is a not-very-imaginative modification of the present process (e.g. faster, cheaper, etc.). This is because it takes time and trust for them to dare give their opinion and wishes, or simply tell the truth about their practices, which are often in contravention with the company rules. To get there, one positive aspect of experimental reality is that we actually deliver operational service. This makes relations with users that are direct, pragmatic and focused on actual issues. We often find ourselves trying to solve issues in cooperation with users: e.g. helping organizing nomadic videoconferencing, inserting exotic new subsystems etc. Discussing specifications and possible improvements is easier with someone whom you have helped a few days before organize a hazardous satellite connection for a live collaborative session with engineers on the field in some jungle on the other side of the globe!

Another risky choice we made was to enroll the board of executives of the Division as a test user group (an option similar to the Fuji-Xerox approach described in Chapter 4). This is challenging because executives often have tough requirements which push the system to its limits; it is useful because we get better support when we need the collaboration of other entities inside the group to realize some environments; it helps disseminating the technology because it has some prestigious managerial aura; it is of course dangerous because system failures have big consequences.

So the nature of users involved in the process is far from neutral. There is nothing such as “normal” users. We suggest to choose “friendly users” (see chapter 1 and Jégou’s chapter 6) in the first phases of design, and gradually extend the scope to less cooperative users.

6.5 The RAO augmented meeting room: a “mother of rooms”

The RAO (Réunion Assistée par Ordinateur) room is a flexible space where users can arrange the physical and digital setting in a matter of minutes, according to their needs. Technically, its main features are flexible furniture, multimedia connectivity to other spaces, and physical interface (“Augmented Reality”: Ishii and Ullmer, 1997). Functionally, RAO is both an observation lab and the “mother room” of augmented rooms at EDF[5]. It is continuously in a beta version, and when upgrading is considered stable, the solutions are transferred into other rooms. This enables us to address the never-endingness of AE design.

6.5.1 Flexible and mobile furniture

What users enjoy first in the RAO room is simply its quality as a room in terms of lighting, acoustic, and thermal ambiance. RAO has large operable windows, at two levels in order to avoid glare. Walls and ceiling have advanced acoustic treatment. Whatever the quality of the ICT layer, if the physical infrastructure is poor the result will be mediocre. Conference rooms without daylight meetings are usually less productive: humans are animals who need clean air, good light, and enjoy a nice view – and leg-space.

Figure 5.17: Well lit screens enable use of the RAO room in daylight.

The electric lighting has “sunlight” quality with appropriate wavelength. The ventilation is intense but silent thanks to the laminar flux. The ceiling is high (4.5 meters). RAO is comfortable, and has comfortable amenities (access lounge with excellent espresso machine, nice toilets, etc.). It also always seems to be the appropriate size, since we adapt the furniture to the number of participants and the type of meetings.

[5] Films presenting the RAO room are available at www.tecog.org.

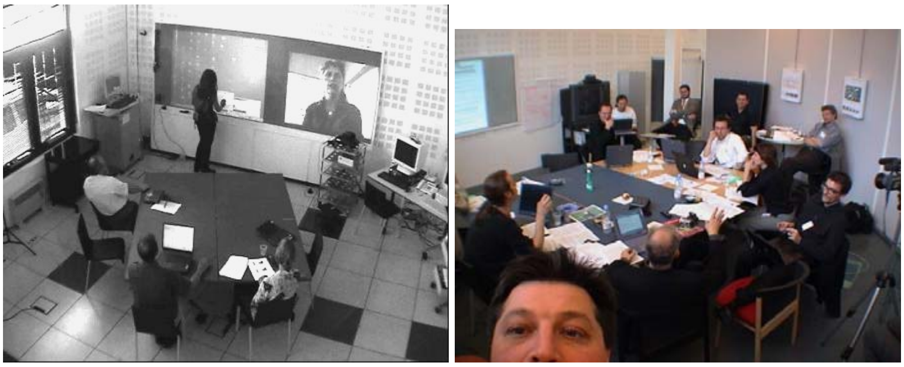

Figure 5.18: Left: a small videoconference between two sites in the RAO room in 2003. Notice the control screen and keyboard in the left corner. The window at the time still had classic Venetian blinds which we later replaced with “white screen” blinds. Right: a more classic creativity meeting of the “Ambient Agoras” project group.

The rounded walls give a nice cozy feeling, the furniture, although stackable and on wheels, is heavy and of excellent quality.

Figure 5.19: Stackable chairs and foldable tables and tablets stored on the edge of RAO.

We use a dozen stackable chairs of various models, seven folding tables on wheels designed by Wilkhahn, foldable tables and various prototypes of smaller wheeled furniture, two dozen chairs “.03” designed by Vitra (some visible on Figure 5.19), stools by Stokke and Wilkhahn; these chairs have no wheels, unlike the ergonomic chairs used in the project space, in order to take less floor footprint around the tables.

Lighting is automatic with ceiling based presence sensors; intensity is variable and can be overridden by manual remote controls, like the windows’ blinds. The blinds (as in the lounge) are designed to serve also as projection screens when needed, and have their inner face white. In the lounge where the windows are not operable, a second internal layer of sliding glass transforms the windows (each bay is 4m x 2.5m) into huge whiteboards. In general, every glass window can be turned into a whiteboard, since whiteboard markers erase well on glass, but it is more convenient to have a plan white background, which we get by sliding opaque white blinders between the two layers of double glazing.

A vast choice of sensing devices can then be used to transform these into electronic whiteboards (we use e-Beam or Mimio, and also the Wiimote system designed by Johnny Lee at CMU). We also have a choice of classic white boards and repositionable paper boards (3M Post-it Self-Stick Easel Wall Pads).

Old fashioned technology is a good plan B in case things fail or some users simply don’t dare using the AE. In our experience, having these classical systems available makes users at ease, and they will be more willing to try the new devices in real situations because they know they have a plan B, so they do not fear messing up the meeting or make a fool of themselves. Anyway, having a plan B, a plan C, and sometimes D, is necessary because one cannot afford failure e.g. in a

multiplex videoconferencing where important negotiations with top executives take place. It is because our AE systems enable such important meetings to take place in good conditions that they finally gain trust in the organization. Nevertheless, bugs and failures are always possible, especially when distant sites who may have a low mastery of technology are involved. Plan B is necessary to avoid users having a bad experience which would be a counter-reference.
The 4m base giant display “TabEc” (Tableau-Ecran) is served by two strong beamers in back projection, which enables operating the display with full daylight. This system is cheap and easily scalable (this glass panel cost about 4000 € at a time when this kind of glass was still produced in very low quantities), and we benefit of continuous upgrade of the quality of beamers. The COTS elements are compatible with the standard procurement procedures of the company, and therefore scaling out was easy. A system of plain backlighting (four ordinary strong projectors with translucent screening directed at the screen from the back) transform at the flick of switch the TabEc into a large electronic whiteboard. It must be noted here, though, that we now almost never use the electronic panel capability of these screens, since users are not much used to it. Also, the electronic pens tended to have battery failure in the worst moments, which stressed the users. Finally, automatic handwriting recognition and pen entry into usual software is not always trivial in the current state of the art. We are waiting until COTS elements will reach 100% reliability to reintroduce this feature for lay users. We currently rather give the users easy capability of annotating the screen with remote mouse, keyboard, or pens and tablets, which they can use from their seat. These devices have longer battery autonomy, periodic maintenance is enough to ensure they are always operational, and every lay user knows how to operate them without hesitation.
Figure 5.18 shows views of RAO in operation with small groups, but the room can comfortably house up to 20 people, and less comfortably up to 40 when walls are pushed back. Over this number, the distance the screen is too small for all to see comfortably the small print.

Figure 5.20: the RAO room in collocated discussion (left) and collocated presentation (right). Notice the folded tablets (stacked near window on left image), and the folding tables (stored folded on right corner in right image).

Flexible furniture enables configuration RAO for very different uses, e.g. creative meeting, presentation, etc. Figure 5.20 shows how with folding tables and tablets, the meeting room can be changed in a few minutes by the users themselves. Figure 5.21 illustrates setting the room from default to decision meeting configuration.

Figure 5.21: The RAO meeting room. The two pictures where taken at 1 minute interval. Left, room in default state, right room after the users rolled in and unfolded the tables, and set up the screens and digital work environment by putting the appropriate RFID tags on the reader. Notice the power outlet that was pulled out of one of the floor traps.

Not for one second did we regret the initial investment cost in high end furniture, which has now been stacked thousands of times and still looks good. If you go for moveable furniture, cheap stuff is not a good choice. Users tend to sit on tables, stack up chairs the wrong way, drop remote controls and, in general, exhibit an amazing creativity using the items in the room in ways which were not forecasted by their makers. The same goes with electronic equipment. This is one reason why we custom-made sturdy big one-button or two-button oversized remote controls.

Mobility is also neede for electronic equipment, thanks to wireless and battery autonomy. Large electric equipment (e.g. large screens) often need to be moved (e.g. from meeting room to lounge, etc.) small distances. We made them moveable by adding a UPS (Uninterrupted Power Supply) to their rolling stand and plugging the equipment to the UPS on a continuous basis (the UPS is plugged to a fixed power outlet and is unplugged when we move the equipment on its rolling stand). Stands are usually large and sturdy enough since they should support heavy equipment anyway. Because equipment usually only needs to be rolled from one place with a power plug to another place with a plug, taking less than 20 minutes, this trick is enough. For example: our “video trolley” is a (Polycom Polyspan) videoconference camera and microphone, with a screen, connected to a wireless hub – all this equipments being plugged to a UPS with 30mn autonomy: we can roll the video trolley around the lab to make a “videoconference guided tour” of the lab, or conveniently roll along the distant participants as we go to the coffee area during pauses. In the worst case, such a trolley, securely connected to the internet in controlled bypass of company firewalls under wizard supervision, could be used as a Plan D “roll into the meeting” a distant participant who can communicate only by Skype videoconferencing.

We currently do these transports by human hand and foot, but in the future autonomous mobile equipment will probably move by itself, and dock in for power when needed, like the lab’s robot vacuum cleaner (“Roomba”) does when it comes back from its nightly operations.

6.5.2 Physical interface: ServiceTags

Some of the physical interface are incorporated in the walls or in column: e.g. RFID antennas, biometric access controls, motion sensors, toilet seat cleaner etc. (there are no light switches in the toilets or in the kitchen, for example, which is both easier and cleaner).

We make a massive use of large screen displays, for display but also for “system response” (the system tells the user what it is doing, acknowledges orders, etc.). One of the issues we had in the beginning was timing: for example, powerline technology, voice recognition or pattern identification may be slow in responding. As the user doesn’t know what happens, he repeats the order; and this repetition actually messes up the system. We are very careful now to give the user some feedback on what the system is doing. Graphic or text display (sometimes as simple as a flashing diode) is a better choice than vocal because it is less intrusive.

In some cases though, we need vocal: when the RAO room reminds the last occupants to clean up the room before leaving, when the building welcomes visitors and directs their attention to the displays. Voice tends to have a much stronger emotional impact on the user, both ways: when it

works well the user gets a warm feeling, but when it talks in an irrelevant way the users get annoyed. Using voice is like giving a personality to the AE, and the user then reacts in a human to human rather than in a cold human to machine way. This effect tends to fade when the users know the system well; they will then tend to override the system and give a quick series of orders, rather than having a conversation-like rhythm as first users do. In a way, a double command system seems an interesting option: vocal for beginners, then gesture, remote control or keyboard shortcuts for expert users.
The AE interface which met most success so far is the ServiceTags. Each tag is a physical item which represents an operation (e.g.: “switch on the beamer”) or a sequence of actions (“switch on the video projector, turn on the videoconferencing software and connect us to the iLounge at KTH”). We were not the first to apply this interface principle: Joan Mattsson (2007), when he was troubadouring[6] in the K1, demonstrated us his iBowl system which does exactly what is described in the second example; the iStuff approach (Ballagas, Ringel, Stone and Borchers, 2003). We created a series of credit card format (or smaller) RFID tags: each tag is an operation (e.g. “set up a videoconference with the Chatou island EDF R&D site/ room XX” ; record everything in the meeting room”; display the current traffic density roadmap in the Paris area” – good to know before you take your car at the end of a meeting – ; “display the bus schedule from the facility to Paris center”; “display on the main screen the screen of the PC which is connected to black VGA cable”, “open a Gridboard Mediaspace”, “open my DumbleTag virtual machine”, etc.).

Figure 5.22: RFID ServiceTags on a reader (on the left notice the 1€ coin for scale).

Each ServiceTag has an icon on it, and the command is explained in natural language. To execute the command, the users simply put the tag on a table antenna (in some executive rooms with beautiful tables, the antenna is hidden under the table and the active area materialized by a circle). When the ServiceTag is taken off the antenna, the command is reversed or terminated. The reader can execute as many commands as tags can be piled on the antenna (Figure 5.22); there are cards in meeting rooms, and users can have their own for personalized commands or authentication. e.g. some users have been granted a virtual clone (VMWare) of their workstation – called “DumbleTags”, which they can access as a webservice from any machine connected to the company’s network – which is handy because they can go around with their hands in their pockets and still have access to their workstation anywhere). The DumbleTag tag enables them to access their machine in a second on the meeting room display, by putting their tag on the antenna. They can then, for example, do their PowerPoint presentation from their own virtual machine.
ServiceTags are nice to hold and fun to use, the users experience the famous “delightful surprise” effect when they use them and fear not failure. On the DOME side, the tags proved robust, batteryless, easy to trace, replace, securized – and cheap. There is no moving part, and the users

[6] Rufae lab members can “troubadour” from one lab to another: visitors pay their transport but are lodged and fed by the hosting lab for as long as they stay; in return, the troubadour must leave “something” to the host lab, usually by installing his own system locally. This helps dissemination between member labs.

have no possibility of messing up the system; in fact they have much less than before since we can now let the users control the rooms without granting them access to any hardware (buttons, cables etc. which are always a cause of problem). The whole system can be maintained at a distance (the central wizards can log the users operations, see the problems, command or reboot remotely). The system is cheaply scalable and open to modifications.
Of course this does not solve the classic problems of local hardware failure or infrastructure, but a specific "maintenance" tag enables the local users or secretaries to check whether the system is OK. e.g. the day before an important meeting, one can just run the "test" ServiceTag and verify all controls are green. As RFID tokens are rewriteable, the system enables participants in a meeting to add some resources, credits, or links by putting their personal tags on the antenna.

6.5.3 Multimedia connectivity: Videoconferencing, Gridboard

Videoconferencing
One of the main function of RAO is videoconferencing capability. In RAO started IP videoconferencing at EDF. There are many issues in videoconferencing, which we discuss in detail elsewhere (Lahlou, 2007a).
To make a long story short, good videoconferencing needs at least two large screens, one for displaying the participants, one for displaying the contents presented and discussed (e.g. text processor, PowerPoint, etc.). The videoconference must have good sound, and the shared screen must have high resolution. The lighting and sound quality crucially depend upon the physical settings. For example, image depends upon the contrast rather than lighting. A room with white walls will never produce a good image, whatever the lighting; a grey or mid-colored background is better. Rooms with strong ventilation noise will always be more problematic. Also, room layout must be different in videoconferencing: long conference tables with the video camera at one end are the worst possible setting: the main protagonists (high status) usually sit at the wrong end and visibility is bad for everyone.
There are many sophisticated solutions available for videoconferencing. We focused on cheap and scalable ones which can be installed to augment any meeting room into a videoconference room; and also be usable in many different situations (one-to-many conference; distributed discussion with many small groups etc.). Once again, we tried to keep it simple. The ServiceTags enable connecting to any known room in a matter of two or three seconds. For multiple open meetings we direct all rooms towards one of the multiplex star nodes, each one going independently there. Say: "let's all go to the Kubrick room" – which means both a videoconference node and shared Gridboard workspace (cf. infra) – : each end user puts the Kubrick ServiceTag on their antennas and they all meet in the multiplex videoconference node.

Shared workspace: Gridboard
For meetings, one cannot expect to train all participants beforehand. We must check that there is no initial cost barrier in the learning curve for novice users, and adapt the system accordingly. The system must respect the "zero" list on the client side: zero training, zero configuration, etc. Unless these requirements are met, when a new participant tries to connect in a meeting, something will usually get into the way.

Figure 5.23: A videoconference in the RAO room: the left screen is the videoconference screen, the right the shared Gridboard.

A good cognitive design will rely on what users already know, provide obvious affordances, and systems which respond accordingly to implicit expectations. This is easier to do when subjects already share a common socket of competences. All the designer has to do is program the interaction using these implicits.

Let us illustrate this with the case of our digital collaborative space, “Gridboard”. From the user’s side, it follows the attractor of “being together in front of the same machine and sharing the mouse and the keyboard with the usual interface”. Instead of being physically in front of the machine, participants all see it live on their own screen, while being in audio contact by audioconference or videoconference. Figure 5.4 showed how we prompt this mental model into the user.

Technically, we provide a URL. The user, with his browser, goes to this URL, and opens a window which *is* the shared screen: inside the window *is* a standard, complete, Microsoft Windows desktop. This shared desktop behaves *exactly* as users expect, because *it is actually* a (virtual) Microsoft Windows desktop, containing the standard Microsoft Office suite, and other classic software (Lotus Notes, SAP, etc.) used in the company. All users simultaneously access the same machine, they share the mouse and keyboard (using their own, and resolving conflicts by voice: “Don’t use the mouse, I’m writing!”).

This interface is “simple” because every user already knows how to use such a desktop (Macintosh users can also share it, but it is still a Windows interface for them). Experience shows that incoming first-time users use the system fluently within seconds, simply because this is not a “new” environment to them.

Of course we also have ServiceTags pointing to these URLs; but not every PC in the company has a tag reader antenna, so usually people use their browser to type in the URL, click the link in their favorites.

As usual, simplicity on the user’s side is paid by some complexity at the proramming level. It took us about two years to strip down the initial interfaces we had made until we reached something really simple. The files exchange issues and the access rights managements were not so trivial, and the user feedback was precious. There are still screen real-estate issues if the system is used with only one screen. The environments we now deploy inside the company always use twin screen systems, one for presentation and minutes, and the other for videoconferencing.

It is worthy to note that we trained two dozen users only, and have now over 3000 regular users who were recruited and trained by viral diffusion only. Let us see how we framed the viral diffusion. There is one single URL to access all Gridboards (the ones dedicated to a specific group, the ones shared by departments on the basis of reservation, etc.). On this page are some “sandbox”

Gridboards which are free access with a constant, easy to remember, password. So anyone who knows the password can open a shared Gridboard space, e.g. to hold a meeting.
Here is how viral diffusion takes place. When one participant in a group knows a good solution to a group problem, and can demonstrate its validity on the spot, often the group will adopt the solution (which would not be the case if the same solution was proposed by an outsider or not in a "need" context). Provided that the solution works, the proposer will gain social value in doing this viral contamination because she brought a good solution. And all participants in the group, if they can learn during this first exposure how to use the system, will probably be diffusers later when they find themselves in a situation of being "the one who can bring the solution".
We liberally give out the passwords for sandboxes, therefore empowering all our users to contaminate other users by giving them, in turn, access to the resource.
Of course, at some point, users who use these sandboxes on a regular basis encounter the problem of finding the sandbox occupied by somebody else when they want to use it for a meeting. In such cases they may decide to click the buy-in button to get their own personal space.

6. Conclusion: Design process vs. design project

We described the nature of the problem which makes AE design necessary and specific: digitization of work; we showed how in one specific company this idea led to the creation of a dedicated user Laboratory of Design for Cognition.
We made explicit our design strategy, experimental reality, which encapsulates a continuous hands-on design process, with a multidisciplinary team enrolling users to test AE in real work conditions. This approach is based on the use of digital ethnography (especially the SubCam) to spot the problems users encounter in their daily activity.
In practice, we constructed a whole Augmented Building where users work, the K1, fully armed for continuous observation. This building contains various types of workspaces, the most prominent being the RAO augmented meeting room.
RAO is a "mother room" for other augmented rooms in the company: when solutions in RAO reach a satisfying level of usability, they are disseminated, preferably by viral diffusion. This solves the never-endingness issue of AE design, and enables inclusion, in a realistic way, of the DOME aspects of innovation. Our approach enabled us to spark users into creative mode and quickly develop a large number of innovations and robust AE.
We described some of the features of RAO, and more specifically the use of physical artifacts as command interface (ServiceTags), and the Gridboard collaborative desktop which meet the "zero" list of requirements we think is necessary for fluid and sustainable AE systems. Our design approach has specific characteristics which come from the specific context of its birth; it is quite different from current classic "project" management of design issues; still we believe it can be transferred into other settings.
We found experimental reality has many advantages in our specific context. It enables us to deal with never-endingness, to adapt COTS systems to the specifics of the corporation. The initial investment is substantial (a few million euros) but the ROI is good. Also, having a mother room concentrates demand and helps capitalizing know-how.
Hoewever, there are a series of limits and unsolved issues. This approach needs a visionary sponsor, at least in the first years, because it does not fit with the dominant project approach. It is very difficult to know beforehand how long it will take to solve a problem; the detailed timing is unclear: this makes it very difficult to "sell" a given project with deliverables. Also, the lab is profitable because it enables us to deal simultaneously with many issues and aspects of AE (meetings, workflows, nomadic use, security, etc.). Setting up the whole installation for one single project would be overkill.
Another issue is the multidisciplinary work, and continuous work-in-progress. This makes it difficult for each local specialist to describe his own added value in the process. Especially for ergonomists: their input is directly used in new versioning, but there is hardly a trace of a "clean" user study, since we try to solve the issues rather than document them, which saves time and resources but fails to provide the academic papers needed for our career.

Finally, it took a long time to build a good reputation and users' trust. This was possible because the laboratory was built and directed by an insider; but it is quite infrequent that non-ICT companies dare making such a research lab on issues which they consider are not part of their core business. We must thank EDF R&D for its courage and vision – which partly comes from the fact that this company always had a deep investment in basic research (the R&D staff is over 2000 people) and long term vision due to its very long investment cycle (about half a century for power plants, even more for the distribution networks).
We do not know how far subcontracting this kind of experimental reality is possible, since academic or business considerations tend to focus the lab members on showing their sponsors or peers that they do "clean" work, rather than focus them on producing results in a process which is sometimes quick and dirty. Also, the trust of participants was partly based on the fact that they knew we were insiders bound to company rules, which may not be the case with external teams.
Still, we believe the concept of the mother room and experimental reality can be transplanted, with some adaptation. In fact over the last year LDC has been involved in adapting the technique for a similar large scale initiative, developing AE in production power plants.

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