

# Changing practice through boundary organizing: A case from medical R&D

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## Abstract

This article contributes to our understanding of practices in innovating organizations. Previous studies have demonstrated how breakthroughs in knowledge may fail to be translated into practices if they are not aligned with existing practices, or if they cut across established boundaries and power structures. By drawing upon an ethnographic study of a medical R&D department that has been highly successful in developing new medical practices, this article investigates how such challenges can be overcome. To date, much of the literature has focused on coordination across single, well-defined boundaries. We here extend this focus and introduce the notion of ‘boundary organizing’ to analyse highly political and contingent processes of innovation and change within and across different practices. We add to existing literature by highlighting how the handling of multiple boundaries, the indirect effects of boundary work, the negotiation of mutual benefits and interests, and mutual adaptation are key aspects of boundary organizing.

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**Introduction**

Many breakthroughs in knowledge fail to be translated into medical practices because they cut across established boundaries and power relations (Newell et al., 2006; Robertson, 2007; Mørk et al., 2010). This article sheds light on how boundary organizing practices may contribute to overcoming such challenges. It does so by drawing upon a longitudinal study of a medical R&D department called the Intervention Centre at Rikshospitalet.<sup>1</sup> The Centre has received recognition, both nationally and internationally, for its capability to develop and transfer new practices. The success of the Centre is often explained with the availability of high-tech equipment and technical support, the personal relationships between individuals working in physical proximity, motivated staff sharing a common vision and their relatively sheltered role as a R&D department rather than a production department<sup>2</sup> (Mørk et al., 2008). However, by analysing the Centre with a practice-based framework we will provide yet other explanations.

The role of boundaries, boundary objects and boundary spanning has been of interest for several decades (March and Simon, 1958; Ancona and Caldwell, 1977; Tushman and Scanlan, 1981; Fennel and Alexander, 1987; Star and Griesemer, 1989; Marrone et al., 2007), and these studies have contributed to our understanding of how coordination and collaboration across boundaries can be enabled. Yet, there are still gaps in the literature on this topic. First, the focus has mainly been on the role of coordination across boundaries, downplaying how the change of practice is political and may lead to both stabilization and destabilization of boundaries. Second, most studies have focused on one predefined boundary (for instance, organizational or disciplinary) rather than having an open and explorative framework to be able to account for simultaneous reconfiguration of multiple boundaries.

This article introduces boundary organizing as an alternative framework. Our framework draws upon Guston's (1999) theory of boundary organization and sociology of translation (Callon, 1986). The combination of these theories may help explain how boundaries are sometimes renegotiated and permanently reconfigured during innovation. We will in particular explore how boundary organizing in a medical context may evolve around the domains of medical practices, scientific practices, industrial practices and policy practices.

The article is organized as follows. First, we relate our analytical framework to the existing literature on boundary spanning, boundary organization and sociology of translation. Second, we present the methodology before giving an account of the case. Finally, we discuss the case against related research and our framework in order to highlight some theoretical implications.

**Boundary organizing: A practice-based framework**

In this section we review existing research and develop our analytical framework. Our aim is to contribute to organization studies, and particularly to practice-based studies of innovation, learning and change. We will begin by defining the terms 'practice', 'innovating

organizations' and 'boundaries', before presenting some studies on boundary spanning. Second, building on Guston's (1999) 'boundary organization', we introduce the notion of 'boundary organizing' as a novel approach to the study of practices in organizations whose main purpose is to change practices through new technologies, products and ways of practicing, hereafter referred to as 'innovating organizations'. We define practice as 'recurrent, materially bounded and situated action engaged in by members of a community' (Orlikowski, 2002: 256). Practices are often linked to boundaries:

Practices do not respect boundaries, because they connect things, people, and events that are distant and only partially congruent, because they allow the coexistence of old and new, because they are able to deal with change and disorder while explaining persistence and order . . . (Nicolini et al., 2003: 28)

Following Kerosuo (2006: 4), we view boundaries as temporary stabilized 'distinctions and differences between and within . . . systems that are created and agreed on by groups and individual actors . . . These distinctions and differences can be categorizations of material objects, people and practices'. Furthermore, boundaries are constructed 'sites of difference', where identity is constituted in the act of drawing boundaries (Abbott, 1995). Such boundaries are dynamic, emergent and enacted. With Hernes (2004) we argue that: 1) organizations operate with multiple boundaries; 2) boundaries are central rather than peripheral to organizations; and 3) boundaries are not static. However, to date, only a few studies have been conducted using this point of departure, some of which will be mentioned below.

### *Beyond boundary spanning and spanners*

Research has demonstrated how boundary spanning enables organizations to manage practices across boundaries (e.g. Aldrich and Herker, 1977; Ancona and Caldwell, 1992; Cross and Parker, 2004; Bechky, 2006). Boundaries have been identified as playing an important role in medicine (Swan et al., 2007). For instance, Barley (1986) and Black et al. (2004) observed how the introduction of CT-scanner technology in two hospitals reconfigured disciplinary boundaries. Ormrod et al. (2007) examined how the spread of new practices within disciplines may be influenced by organizational power, while Ferlie et al. (2005) discuss limits of learning and change across disciplinary boundaries.

Scott (1981) talks about boundary setting and boundary spanning, and emphasizes how organizational boundaries change over time. Fennel and Alexander (1987) examined the role of spanning organizational boundaries in both freestanding organizations and organizations that are members of multi-organizational systems. They identified three types of behaviours: boundary *redefinition*, referring to occurrence of one organization joining a multi-organizational system, *buffering*, which refers to protecting the organization from external disturbances, and *bridging*, referring to the connection between organizations (1987: 458). These concepts are relevant to our study not only because they were applied in the same type of research context (hospitals), but also because they address the boundary spanning practices of organizations. Yet Fennel and Alexander differ from our study in focusing solely on organizational boundaries. Furthermore, rather than using their concepts

of redefinition, buffering and bridging, we prefer the terms 'stabilizing' and 'destabilizing' boundaries to emphasize the political aspects of changing practices. It also implies that rather than merely focusing on the strategic decisions and actions of management, we choose a more explorative focus on other practices for investigating boundary dynamics.

Within the communities of practice literature, brokers and brokering are seen as important (Brown and Duguid, 1998; Kimble, 2010). 'Brokering' is the process during which elements from one practice are introduced to another. Wenger (2000: 236–237) identifies three types of boundary interactions: *boundary encounters*, where knowledge is exchanged between communities; *boundary practices*, in which one boundary requires that specific practices are developed to traverse them; and *peripheries*, which refer to how outsiders can connect in peripheral ways.

Orlikowski (2002) demonstrated how practices cannot simply be transferred across settings, since knowing in practice is an ongoing social accomplishment. The ability to perform global development across seven different types of boundaries (temporal, geographic, social, cultural, historical, technical and political) was grounded in a repertoire of practices: sharing identity, interacting face to face, aligning effort, learning by doing and supporting participation. As highlighted by Levina and Vaast (2005), such practices must be different than the practices that produced the boundaries in the first place otherwise they would end up reproducing the existing boundaries. Meanwhile, there is often a mismatch between the actual practices and expectations others have of these roles (Levina and Vaast, 2005: 339). Levina and Vaast (2005) therefore introduced 'boundary spanners in practice', referring to individuals actually engaging in activities for relating practices from different fields to each other.

In sum, these studies have provided us with important insights into boundary spanning and brokering. However, we will argue that there is a gap in the literature on the simultaneous reconfiguration of multiple boundaries, how new practices may stabilize or destabilize boundaries and the role of power during such processes. Hence, recent work has emphasized the importance of looking into the underpinning relationships between practice, politics, networks and technology (Swan and Scarbrough, 2005; Cicmil et al., 2008).

While acknowledging the relevance of previous studies on boundary spanning, we will now introduce our framework for understanding practices in innovating organizations. To achieve this, we will draw on Guston's theory of boundary organizations and sociology of translation.

### *From boundary organizations to boundary organizing*

Guston (1999) introduced the theory on boundary organizations to explain the characteristics of a particular kind of organization that evolved on the boundary between the domains of science and politics. Such organizations are characterized by the following three criteria:

They provide a space that legitimizes the creation and use of boundary objects and standardized packages. They involve the participation of principals and agents, as well as specialized (or professionalized) mediators, and they exist on the frontier of two relatively distinct social worlds with definite lines of responsibility and accountability to each. (Guston, 1999: 93)

Guston makes a theoretical contribution by combining boundary work and principal-agent theory to explain how 'boundary organizations' (e.g. knowledge and technology transfer organizations) participate in stabilizing the boundary between science and politics, by internalizing boundary negotiations. Boundary work was introduced by Gieryn (1983) to describe how scientists draw a distinction between science and non-science, while boundary objects (Star and Griesemer, 1989)<sup>3</sup> are objects that enable the coordination of practices across communities. The stability of such objects is entirely based on consent. Fujimora (1992) introduced standardized packages that combine boundary objects and common methods, and which thereby makes them robust enough to change practices.

Principal-agent theory argues that organizational relations result from how principal and agents delegate responsibilities both within and between organizations (Guston, 2001: 401). On this basis, Guston (1999) argues that the stability of the boundary between science and politics emerges and is maintained through the negotiation of interests between actors across the boundary. In contrast to boundary spanning organizations (Aldrich, 1979), this stability does not come from isolation from external actors; rather, it comes from being accountable to each other (Guston, 1999). Both the producers and the users of research can thereby construct boundaries favourable to them.<sup>4</sup>

For our purpose we find Guston's (1999) elements of an arena for interaction, and the use of boundary objects and standardized packages, to be highly relevant for studying practices in innovating organizations. Further, this theory adds to the literature on boundary spanning by focusing on how these organizations stabilize the boundaries between the domains of science and politics. Meanwhile, we introduce the boundary organizing concept to contribute to theory in the following ways. First, it focuses on the politics and practices that contribute to both stabilization and destabilization. In addition to Guston, we will therefore draw upon insights from sociology of translation. Second, it enables us to explore the practices used when simultaneously managing the boundaries between multiple practices. We will now outline each of these two elements further:

*Politics, stabilization and destabilization.* The practices of Guston's boundary organizations are by nature different from innovating organizations, because the purpose of the latter is to continuously drive and participate in innovation, thereby – by definition – challenging and destabilizing established boundaries. As boundaries are challenged, and the negotiation of roles and responsibilities are central to the process, principal-agent theory becomes less useful, with its a priori assumption of a hierarchical relationship across a particular boundary. Instead, we draw on sociology of translation to explain how boundaries are negotiated, i.e. destabilized and (re-)stabilized, during innovation. This literature (Callon, 1986; Latour, 1987) has conceptualized how knowledge practices and organizations are produced through careful building and expansion of 'actor-networks'. From this point of view, the process of organizing boundaries is not given from the outset; rather, it is a relational process of destabilizing boundaries to include new actors and resources, and re-stabilizing boundaries to stabilize the social and material relations that internally constitute the practice, while also protecting it from external actors with conflicting interests.

Callon (1986) identified certain aspects of the politics of networked expansion on the boundary between science and other practices in a way that also helps explain innovation

more generally (Hoholm, 2011). Through '*problematization*', scientists were able to define a problem, such that other actors also recognized it as their problem. In this way, established boundaries that were taken for granted could be destabilized, and suggestions about how to reorganize them in ways that better aligned with the proposed solution could be offered. If this new 'programme' was accepted, it became an 'obligatory passage point' for everyone who wanted to deal with the problem. It was also important to establish a common agreement regarding 'what the entities will be getting in return for getting itself involved in the network' (Nicolini and Gherardi, 2005: 289), which Callon (1986) named '*interessement*'. As a new set of interrelated roles are defined and attributed to the actors accepting them ('*enrolment*'), the reconfigured boundaries may stabilize, at least provisionally. Finally, through '*mobilization*', some actors get into a position to represent many actors and the new way of organizing boundaries will begin to be accepted as a given and thereby adding to their stability. However, stability will never be final, as there is always a potential for opposition.

*Multiple boundaries between different domains of practices.* The boundary organizing framework is empirically open for types of boundaries other than solely the predefined science-politics boundary. This resonates with Waterton (2005) and Klerkx and Leeuwis (2008: 186), who have argued that focusing on just one boundary is too narrow.

Based on our study, we find that in a medical setting boundary organizing often takes place at the boundaries between the following four domains of practice: 1) *Medical practices*, which refers to established daily practices in health care organizations. Different medical disciplines, as well as non-medical professionals, will often need to negotiate on an ongoing basis to resolve their tasks. In addition, the division of labour between hospital departments and hospitals are renegotiated as part of medical practice. There will often be an element of applied scientific knowledge in medical practices; 2) *Scientific practices*, which refers to the practices involved in producing new scientific knowledge; 3) *Industrial practices*, which refers to the practices of industrial actors as they develop new technologies and products, often in close collaboration with medical practitioners; and 4) *Policy practices*, which refers to the practices involved in producing policies for the three other practices.

In conclusion, the combination of Guston (1999) with sociology of translation can be used to analyse how resources are mobilized and committed across relatively stable boundaries (e.g. the science-policy boundary). Furthermore, the combination of these theories may help explain how boundaries are sometimes renegotiated and permanently reconfigured (e.g. between professions and organizations, or between the users and suppliers of technology, etc.) during innovation. Thus, the problem of organizing at multiple boundaries, and the different dynamics that are likely to occur, may be handled under one conceptual framework.

Hence, the conceptual premises for our analysis are based on the notions that boundary organizing operates in the following ways. First, it takes place in organizations that provide a space for interaction with the use of boundary objects and standardized packages. Second, it takes place in organizations with spanners being able to negotiate on the frontiers of different domains. Third, when reconfiguring multiple boundaries simultaneously, boundary organizing may lead to both stabilization and destabilization.

We will now turn to methodology before providing an account of some of the main events in the case. Thereafter, we will apply the boundary organizing framework on the case, and highlight some of the contributions and implications.

## Methodology

This article is based on an ethnographic longitudinal case study of ‘practices in the making’ at the Intervention Centre, thereby minimizing the challenges of post-hoc rationalization (Hoholm and Araujo, 2011). Our case was selected for several reasons. First, the Centre is unique in Norway with its cross-disciplinary composition. Second, we could study attempts at developing new practices for diagnosis, and treatments utilising new digital imaging technologies and minimally invasive procedures. These practices challenge traditional boundaries between the domains of medicine, science, industry and policy. Third, we were given broad access to gather research material. Since the objective of this article is to discuss the process of boundary organizing, we have chosen to represent the empirical material in an aggregated way. Our extensive ethnographic studies of the Centre provide a wide range of observations, interviews, and documents. It is precisely this systematic overview of the process that has informed this article. Detailed ‘micro-studies’ reporting from selected projects at the Centre, as well as extensive presentation of interview and document materials, are published elsewhere (Mørk, 2009; Mørk et al., 2006, 2008, 2010).

The research material is based on observations, interviews and document analysis. The first two authors were PhD students involved in various research projects (BEM 2000–7, MA 1998–2001) and participated in the daily activities, seminars and research projects. We conducted 38 semi-structured interviews with surgeons, nurses, radiographers and engineers. The informants were selected based on their roles at the Centre. Most interviews lasted 45–90 minutes, and all of them were fully transcribed. In addition, we have thoroughly examined internal documents, scientific publications, the Centre’s homepage and media coverage. The research material consists of several books with handwritten field notes, and over 550 pages of transcriptions. When analysing the material, we manually coded it following the techniques described by Strauss and Corbin (1990) and Coffey and Atkinson (1996) along different themes, and organized it in matrixes. As we developed our interpretations of the material, quotes and observations were moved elsewhere in the matrices.

Our current aim was not clearly formulated from the beginning. This perspective became clearer during the writing, discussions and rewriting process. In accordance with Hallier and Forbes (2004), the analysis also required us to use experiences from studies in other fields. Thus, the analysis happened through a combination of approaching the material with an open mind, and looking at existing theories to develop process explanations (Hallier and Forbes, 2004: 1381). The initial analysis was empirically driven and focused on recurrent patterns. The second step included comparing the empirical material with the theory in order to develop a theoretical framework.

To ensure robust analysis, we used different methods to check for consistency of the findings (Denzin, 1978; Patton, 1999). We also collected the material at different points in time. This not only gave us the opportunity to collect real-time processual material, but also the advantage of examining the consistency of different sources. Our prolonged involvement at the Centre distinguishes this study from most other studies, which, according to



Ormrod et al. (2007), are often based on a short period in the field combined with some interviews. Furthermore, the article has been analysed and written by researchers with different backgrounds (information systems, sociology, and organization theory). Finally, we shared our findings and interpretations with the informants, and, on the basis of these discussions, we gathered more material, analysed it further and rewrote the article. This resonates with Lincoln and Guba (1985) who underscore that, in qualitative studies, the soundness and validity of the research is dependent on its credibility, transferability, dependability and confirmability.

Our study does have some methodological limitations. First, the emphasis was on the Centre, implying that actors from other organizations were given less 'voice' (Hardy, 2001). Second, we did not participate in all the arenas where disputes took place. Third, parts of the study were constructed on the basis of retrospective accounts. We have tried to address these challenges by contrasting the different perspectives of the informants.

## Empirical setting

The Centre was established as an independent R&D department at Rikshospitalet in 1996 to develop new practices by utilising new imaging technologies and minimally-invasive techniques. These new practices require close collaboration between medical and non-medical staff. The personnel of around 60 consist of medical doctors belonging to various specialities, nurses with different specializations, radiographers, engineers, mathematicians and physicists. Forty percent of staff members have a technical, non-medical background. This is unique for this hospital department, and it provides fertile opportunity to engage in innovative cross-disciplinary projects and close collaboration with industry. Here new time-consuming and risky scientific practices may be developed outside the ordinary departments with their pressure towards achieving a high throughput of patients.

## Boundary organizing in a medical research and development

This section will give an account of some main events at the Centre, characterizing its development and growth throughout almost 20 years. We emphasize the activities that take place at its boundaries, and the story is divided into three periods.

### *From a mere idea to Parliament support for an interventional clinic (1990–6)*

The idea behind establishing an interventional clinic gradually evolved when Dr Frode Lærum worked as a radiologist<sup>5</sup> in Minnesota, USA in 1980, and later as an assistant surgeon at the Department of Radiology at Aker hospital in Norway. During this period, *radiologists* started performing simple interventions on patients with small balloon-tipped catheters inserted into blood vessels to expand partly blocked lumens. *Surgeons* also started using imaging techniques for pre-examinations and imaging support during operations. This blurring of disciplinary boundaries led to conflicts, as both groups claimed ownership over the practice, and the patient groups who were eligible for it (Mørk et al., 2008: 16).



In 1991, Lærum and another surgeon, Dr Arvid Stordahl, were students at the Institute of Health Management and Health Economics at the University of Oslo. Both had experienced how many hospital departments seldom related to the medical practices of other departments, despite being located next to each other. They had also experienced that radical innovations often occur on the boundaries between disciplines (Fosse, 2007: 66). Hence, they decided to write a joint Master's thesis about how the increasing use of images required organizational changes. In their view, the solution was to establish interventional clinics headed by radiologists. However, through discussions at the University<sup>6</sup> they became convinced of the following:

Surgeons are not important. Surgery is important! Radiologists are not important, radiology is important! We have a social responsibility for focusing on practice rather than discipline. (Lærum, 2008)

They therefore wrote their Master's thesis on how changing practices often led to turf battles. This called for establishing clinics with advanced technology, where doctors from different disciplines could collaborate closely:

We need communication and work forms that take care of these challenges in new ways . . . the methods should focus on practice and the need for opening disciplinary boundaries. (Lærum and Stordahl, 1991: 29)

Lærum and Stordahl (1991: 94) argue that factors other than professional arguments, like status, often decided how treatments were conducted. Since knowledge institutions should reflect the future rather than the past, established boundaries had to be challenged. A process of problematization was thereby initiated, in which other actors were meant to recognize this challenge as a common problem that needed to be solved.

Later, it became a major concern to gain commitment from various actors and get their support for the idea of an interventional clinic. Hence, to mobilize sufficient support for their radical idea, 5000 copies of the thesis were distributed to medical practitioners all over the country. The book could thereby serve as a far-reaching boundary object for the Centre. A year later, Lærum and Stordahl published an article in an international journal where they argued that, owing to overlapping interests and responsibilities between different disciplines, a grey zone had developed. This called for defining frameworks for cooperation, and a clearer distribution of roles. Moreover, an independent hospital department combining features from an X-ray department with an operating department should be established. This was meant to enable different disciplines to meet in an unbiased way, and to facilitate a closer interaction across the boundaries between medicine, science and industry (Lærum and Stordahl, 1992).

When this radical idea was introduced to different departments at Rikshospitalet, it was mostly met with opposition and scepticism. Meanwhile, others, especially the Managing Director at Rikshospitalet, was very positive about the idea, as Rikshospitalet sought to become the most modern hospital in Europe when they relocated to new facilities in 1998 (Husom, 2007). Hence, in 1994, a working group headed by Lærum was established to mobilize support for such a clinic. It was considered critical to gain support from key actors within the medical community and among politicians. Therefore, Lærum and another well-regarded medical doctor visited all of the university hospitals in Norway. It was not essential to enrol actors from all hospitals, but they needed enough support to

provide a convincing account about how the medical community was positive about the concept. Within a short period, most of the university hospitals, the Norwegian Board of Health Supervision, Minister of Health and Care Services and the Norwegian Medical Association supported the idea. They also received a grant from the Research Council of Norway, which was crucial for gaining support from politicians (Fosse, 2007).

However, there were also counterforces. One hospital stated that the idea was 'an interesting intellectual exercise', but, in their view, the clinic should be established at their hospital as theirs was the only one in Scandinavia that had developed new methods in interventional radiology, along with a high volume of patients. Another hospital emphasized that as they had just applied for status as a National Competence Centre, they could not support Rikshospitalet's plans (Husom, 2007). Lærum summarizes this period in the following way:

When we presented a model for an interventional centre emphasizing horizontal communication rather than hierarchical structures and relational capabilities, it was like stirring up in a hornet's nest. (Sundar, 2003b: 66)

The Minister of Health was therefore contacted by the project group working for the Centre, and, in November 1994, with he himself representing the idea of a Centre, he<sup>7</sup> invited everyone who had taken part in these discussions to a meeting where they could provide 'well-founded criticism' about why an interventional centre should not be established at Rikshospitalet. Many people came, but nobody criticized the idea (Fosse, 2007).

Around the same time, Rikshospitalet was invited by a large international industrial actor (GE Healthcare) to test an open interventional magnetic resonance imaging (MRI) machine.<sup>8</sup> This invitation came as a result of Rikshospitalet's plans to establish a cross-disciplinary clinic, but a prerequisite was that the MRI had to be purchased in early 1996. Becoming enrolled in this way by GE Healthcare would increase the likelihood for establishing a Centre. Simultaneously, several hospitals were using advanced minimally-invasive therapies, but quite a few of the patients had been harmed. This called for clarifying the boundary between medical practice and scientific practice, a point that was brought to the attention of the Norwegian Parliament (Husom, 2007).

On the basis of all of these concurring factors, the Norwegian Parliament decided in 1995 to grant 90 million Norwegian krone (NOK) toward the establishment of an interventional centre (Parliamentary White Paper/St.prp. 1994–1995).<sup>9</sup> Dr Erik Fosse was hired as the project leader, and Head of Department.<sup>10</sup> The necessary funding was granted within an exceptionally short period of time, and it enabled the Centre to become an obligatory passage point for developing many of the new intervention-based practices at Rikshospitalet.

### *Establishing the Intervention Centre as 'a common toolbox on neutral ground' (1996–summer 2000)*

On 5 June 1996 the Centre opened with the following tasks:

1. Develop new procedures and methods.
2. Develop and establish new treatment strategies.
3. Perform comparative studies between new and established treatments.
4. Study the social, economic and organizational consequences of new treatments.

As the Centre was an R&D department, it was crucial to translate new practices developed at the Centre into medical practice elsewhere. Otherwise, the Centre would become a bottleneck (Røsjo, 1996). Both the specialized equipment and staff at the Centre should constitute a 'common toolbox on neutral ground' (Fosse et al., 1999). To create neutral ground, a certain degree of 'diplomatic work' was necessary. The Centre was located outside of the existing hospital buildings, and a new building was erected on 'neutral ground' in the hospital grounds, where no single medical discipline would have any special claims. The rooms where medical procedures would be performed were equipped to resemble combined operating theatres and radiological examination rooms, but they were formally classified as radiological laboratories. A balance between radiologists and surgeons in the staff, both generally and particularly at the top level, was also explicitly pursued (Mørk et al., 2008: 17).

Thus, opening both the disciplinary boundaries at the Centre and the organizational boundaries at Rikshospitalet was important during this period. The staff consisted of doctors, engineers, nurses and radiographers. The Centre also had several doctors who were part-time affiliates, yet remained mostly employed by their primary department. This strategy was chosen to facilitate closer interaction with other departments, while also enabling these doctors to work at the Centre. An engineer, who also had a medical PhD, was hired to be responsible for technology development. Furthermore, a steering committee with representatives from most departments at Rikshospitalet, and from other University hospitals, was responsible for making decisions about activities at the Centre (Fosse et al., 1997).

There were a number of economic, organizational and political disputes between the different departments involved in the activities at the Centre, regarding ownership of patients and procedures that needed to be resolved. These disputes were centred on which department should supply the Centre with the necessary personnel, who should pay for the technology and consumables used in the procedures and who should have the final word on patient treatment. However, these challenges were resolved through defining clearer common interests for better patient treatment, along with identifying the benefits of using the Centre and the roles of different actors.

The practices of boundary organizing therefore partly changed from securing support for the idea of a centre, both internally and externally, towards mobilizing the necessary internal support at the hospital. To legitimize the Centre, its leadership defined a number of clinical and technological problems that other actors agreed had to be solved. This often meant that other departments would run projects at the Centre, thereby getting them locked into specific roles (*interessement*). This also contributed to destabilizing organizational boundaries.

While being located in the 'old' Rikshospitalet (i.e. during the period from 5 June 1996 until 14 April 2000), the Centre conducted 1736 procedures on patients and 122 procedures on animals (Fosse, 2001). Internally at the hospital, several clinical studies were initiated within neurosurgery, laparoscopy (keyhole surgery in the abdomen) and a large randomized study on beating heart surgery involving 120 patients and 60 professionals from seven departments at Rikshospitalet. The latter project enabled the Centre to enrol important actors into its network. The open MRI worked as a boundary object between medical, scientific and industrial practices.<sup>11</sup> Projects were undertaken with industrial actors in areas such as robotic surgery and simulator technology. In 1999, two companies were started as spin-offs from the Centre; SimSurgery<sup>12</sup> would develop and commercialize simulation technology,

whereas Alertis<sup>13</sup> would develop miniaturized medical sensors. Consequently, this shows how boundary organizing was necessary for bringing the innovation potential further.

### *Expanding the Centre (2000–9)*

By 2001, more than 60 people were affiliated with the Centre, and there was a steady increase in projects. The Centre therefore needed to reorganize internally to be able to deal with all of the activities for expansion they were involved in. Hence, a matrix structure was introduced to make the prioritization of projects fairer, and to reduce the Head of the Department's span of control.

In 2002, the Norwegian government launched a reform that shifted ownership of the hospitals from the counties to the Government, and five regional health enterprises replaced the former 19 counties. These regions would compete for patients. This change was particularly difficult for Rikshospitalet, which traditionally had national responsibility for advanced medicine, and therefore received patients from the entire country. In order for the Centre to develop new practices, access to a sufficient number of patients was critical. Several actors from the Centre discussed this challenge with other hospitals and politicians (including the Health Minister), but without success. Thus, it was necessary with additional work to establish networks with other hospitals.

In 2003, it was evident that most of the technological equipment at the Centre needed to be changed. Two external evaluations of the Centre underscored the importance of acquiring new technology. An evaluation conducted by the Research Council of Norway emphasized that:

There is worry about a lack in 'buffer funds', the economy being entirely based on high throughput of study patients. The main threats are considered to be lack of acceptance of the concepts, and, in some cases, a lack of understanding by health care authorities. There is also a risk for competition from other centres. (Fosse, 2007: 162, 163)

In the same year, it was decided that Rikshospitalet would receive funding to build a national PET<sup>14</sup> Centre. The imaging research groups at the University of Oslo and Rikshospitalet, along with the Centre, realized that this was a great opportunity. The Centre seized this opportunity for expansion by taking a key role in planning the building of an advanced research facility for imaging, with the full support of the hospital administration. The new 'Visualisation Centre' would be an extension of the Centre with two new imaging operating rooms (ORs), the PET Centre, and the department of nuclear medicine. To mobilize political support for quickly making this decision the Centre argued that key personnel would otherwise be lost, industrial actors would choose other partners, Rikshospitalet could lose its academic status and harm could befall both the patients and Norwegian healthcare sector in general (annual report, 2004).

However, not all attempts at building alliances were successful. In 2004, the Centre applied for status as a National Competence Centre (NCC), since two other university hospitals had been granted such status in other areas. The status as a NCC would enable closer collaboration between hospitals. However, several university hospitals interpreted this as the Centre trying to become an obligatory passage point on a national scale. Consequently, the Centre did not receive the necessary support, and decided to withdraw their application (Fosse, 2007).

Success in establishing alliances on a European level was also viewed as important for obtaining access to leading scientists. The Centre therefore wanted to run an EU-project, and in 2004, they received funding for ARIS\*ER (Augmented Reality in Surgery). The project consisted of six academic institutions (including hospitals), and two cutting edge technology companies. The consortium enabled collaboration between clinical users and technology developers, between academia and industry and across disciplinary boundaries.

In 2007, Fosse published a book about the history of the Centre, which still is both distributed to visitors at the Centre, and is on the curriculum for Master's students at the Institute for Health Management and Health Economics at the University of Oslo. The book therefore came to represent the Centre. Hence, this reminds us of the Master's thesis 15 years earlier.

During this period, there were two important events that illustrate particularly well how the Centre had succeeded with boundary organizing. First, on 16 November 2006 the Minister of Trade and Industry and the Minister of Health and Care Services launched a new initiative for healthcare-related business development at the Centre, with over 50 important actors present. The initiative was part of the National Health Plan for 2007, aiming at facilitating innovation by creating links between industrial and scientific practices. Second, in December 2008, the Minister of Trade and Industry, the Prime Minister and the CEO from MediStim,<sup>15</sup> along with many other guests, visited the Centre in connection with the launch of a report by the Government about innovation in Norway.

In January 2008, the Centre arranged a seminar to discuss the future. One option was to become part of a clinical department at the hospital serving most of the Rikshospitalet by having more than 5500 patients yearly (in contrast to the Centre's 600):

We are a development department, but we are also a production department. We observe that the patient flow will be increasing, and we need to organize better to meet these changes. Nothing has been decided yet, but we have started looking at each other, and we must admit that we find each other a bit attractive! (Head of Department, IVC)

With this change in rhetoric the Centre emphasized that they were not only a scientific department, but also a production department. This could have potentially positioned the Centre for new expansion processes, provided that the context had changed. Still, this merger between the two departments never became a reality.

In 2009, the Centre still lacked 150 million NOK to realize their vision of building the full Visualization Centre. They had, however, managed to obtain funding from Rikshospitalet, the Research Council of Norway and the University of Oslo to change virtually all imaging systems. They had also managed to achieve buy-in from many different actors that were using the new technologies. Thus, once again they successfully problematized a common problem (i.e. the need for investing in new technology), and succeeded with *interesement* and *enrolment* of key actors.

## Analysis and discussion

Previous studies on boundary spanning and spanners have offered us insights into the role of different types of boundaries, such as disciplinary, organizational or knowledge boundaries. Meanwhile, most of them have focused on coordination and collaboration across single

boundaries. In addition, they have often assumed a certain level of stability, and tended to be rather apolitical. This was our motivation for bringing in studies from both science and technology, such as boundary organization (Guston, 1999; 2001) and translation (Callon, 1986).

In boundary organizations (Guston, 1999), actors are able to construct the boundaries in ways that they find favourable. Through introducing the 'boundary organizing' framework, we seek to explain how innovating organizations are able to not only span boundaries, but also to destabilize and alter boundaries. While there are similarities with Guston, particularly the emphasis on mutual collaboration and the use of boundary objects and standardized packages, we do not find principal-agent theory particularly useful. Instead, we draw upon ANT to emphasize the contested nature of innovation. Hence, we argue that the notion of boundary organizing complements the established concepts of boundary spanning (Fennel and Alexander, 1987; Levina and Vast, 2005) and brokering (Wenger, 2000).

We have studied an organization distinctly positioned between four different domains of practices. We find that the Intervention Centre not only had to handle the science and policy boundary as Guston discussed, but the boundaries between science and industry to an even greater degree. Further, and most importantly, the Centre had to deal with the boundary between science and medical practice, and boundaries within medical practice with its inherent subdivision into professional groups, institutional arrangements, etc. Medical practice and scientific practice have always been closely intertwined, and medical research is often conducted within the domain of daily hospital practice. The different practices pose different boundary challenges, where boundary organizing took place to handle these challenges. Table 1 provides an overview of some of these challenges and how they were handled.

In order to move closer to understanding the nature of the boundary organizing we will now take a closer look at the main events, the actors involved, boundary organizing practices, facilitating and countervailing forces and outcomes over time. Table 2 provides an analysis of these dimensions.

As we can see from Tables 1 and 2, the Centre in many respects succeeded in establishing itself with some of the 'boundary organization' characteristics (Guston, 1999); as a common arena for interaction between multiple partners, partly with support of a few powerful boundary objects (the thesis and the MR). Moreover, collaboration was enhanced by developing a standardized package consisting of strict project regulations stressing cross-professional and inter-organizational aspects in combination with scientific rigour. By problematizing things that were taken for granted and redefining both the problem at hand and the different roles, the Centre repeatedly managed to get attention and gain acceptance for starting to explore alternative practices. The Centre was thus seen to have the answer to the problem, and managed to translate it into a larger network of actors.

From our analysis of the case, we suggest that there are theoretical implications related to at least three aspects of boundary organizing:

## **Handling multiple boundaries**

In our case study, we found both strategic and accidental indirect effects of boundary organizing, and we suggest that these require further attention in future research. While



**Table 1** Illustrations of key boundary challenges

Domains of practices	Boundary challenges	Illustrations of boundary organizing practices to handle these challenges
Medical practices	Established practices have fairly well-defined boundaries between the different professional groups, medical disciplines, departments and even hospitals. This may hinder the introduction of practices that challenge these boundaries. Organizational boundaries limit access to established resources, and can make collaboration difficult.	<ul style="list-style-type: none"> <li>- Master's thesis was an important boundary object that was widely distributed.</li> <li>- Physical co-location of multiple disciplines.</li> <li>- The centre's project regulation and standardized templates that enforced considerations of cross-disciplinarity in projects.</li> </ul>
Scientific practices	The boundaries between scientific practices and medical practices can be unclear. As innovations often arise in a context of practical use, it may be challenging to disentangle the scientific investigation from the clinical use situation. Different motivations behind scientific projects and practical improvement initiatives may lead to conflict over priorities. This results in research projects struggling to find allies in the right 'camps'.	<ul style="list-style-type: none"> <li>- Established a Steering Committee with representatives from various organizations.</li> <li>- Strengthening translation of interests and knowledge by: (1) Having employees at the Centre employed in mother departments and service level agreements to have a closer link between medical practice and scientific practice; (2) Networked projects including users, patients and international partners; (3) Scientific methods in combination with project regulation standardizing ways of collaborating.</li> </ul>
Industrial practices	The boundaries between the industrial practices and medical or scientific practices are challenged when new practices are to be developed. This calls for defining new ways of collaborating.	<ul style="list-style-type: none"> <li>- Establishing a number of projects dealing with boundaries between industry-science (example MRI).</li> <li>- Challenging healthcare policy by introducing and exploring unconventional collaboration with industry.</li> </ul>
Policy practices	Innovation implies novelty. Hence, practices, regulation, funding and policy aspects are often not aligned. This again leads to obstacles for innovation, and need for policy changes in order to be resolved.	<ul style="list-style-type: none"> <li>- Taking a policy role to overcome boundaries between science-politics.</li> <li>- Mobilizing more sources of funding and resources (the Centre is jointly funded by government and industry).</li> </ul>

the unintended effects, like provoking counter-mobilization by competing organizations and networks elsewhere leading to failure in several expansion efforts, certainly could be found in this case study, our study points more clearly towards the strategic indirect effects.

We find that when the development of new practices involves the development or acquisition of new resources, strategic mobilization of alliances across one boundary may also facilitate support across other boundaries. This argument was also partly discussed by Guston (1999, 2001), who identified how some of the organizations were particularly good at changing their practices in order to acquire the needed resources. We suggest that this needs to be analysed across a wider range of boundaries. Furthermore, by emphasizing the



**Table 2** Detailed overview of boundary organizing practices at the Centre

Time	Boundaries and domains of practices involved	Actors involved	Boundary organizing practices	Facilitating/countervailing forces/politics	Outcome over time
1991–1996 From mere idea to Parliament support of an interventional clinic	Medical/scientific	Lærum, Stordahl, University of Oslo, medical community all over Norway	<p>Problematizing established medical practice in the Master's thesis and distributing 5000 copies of the thesis in book form all over Norway. Publishing article in an international journal. Increased interest in new practices with the increasing use of images.</p> <p>Becoming part of GE Healthcare's network. GE gave a deadline for when the MRI had to be purchased.</p>	<p>Medical community sceptical to the crossing and blurring of boundaries.</p>	<p>Managed to bring attention to challenges of existing practices and on the necessity of overcoming these challenges.</p>
	Industry/medical/scientific	GE, Rikshospitalet, politicians		<p>Other university hospitals negative, politicians positive, management at Rikshospitalet positive.</p>	<p>The necessary support for collaborating with GE Healthcare was mobilized via negotiations and finding common interests across the boundaries between medical/scientific practice and industrial practice.</p>
	Medical/scientific/policy	Lærum, Stordahl, Rikshospitalet, all university hospitals in Norway, politicians	<p>Developing a strategic actor-network by establishing a project group at Rikshospitalet. Attaining support by visiting all university hospitals in Norway, and getting the Health Minister to arrange a national meeting that became influential.</p>	<p>Professionals at Rikshospitalet and at other university hospitals negative to the idea, while politicians spoke on behalf of the Centre.</p>	<p>Managed to get the necessary support for establishing the Centre. Parliament gave a grant of 90 million NOK to establish an interventional centre.</p>

Time	Boundaries and domains of practices involved	Actors involved	Boundary organizing practices	Facilitating/countervailing forces/politics	Outcome over time
1996–2000 Establishing the Centre as ‘a common toolbox on neutral ground’	Medical/scientific	The Centre, other departments at Rikshospitalet, other hospitals, industrial partners.	Visiting the other departments at Rikshospitalet and contacting potential partners to further mobilize support for the Centre. Hiring people for part-time positions in cross-departmental projects to align with crucial and powerful professional communities and hospital departments with different specializations.	Other departments at Rikshospitalet and other hospitals were sceptical about the Centre.	Closer collaboration with other departments and hospitals, partly because they managed to define common problems to be solved. Establishing standardized project procedures and regulations to enhance cross-professional practice.
		The Centre, seven departments at Rikshospitalet, 120 patients, academic journals, medical community.	Conducting the off-pump study to compare traditional ways of doing surgery with beating heart surgery. Arranging meetings to present the project, published results in international journals, rallying interest from a broader public and getting support both from patients and other academics.	Both support and opposition at Rikshospitalet.	Managed to conduct the study and publish many articles and generate PhDs.
		The Centre, Norwegian Parliament, other university hospitals, Rikshospitalet, industrial partners.	Hospital reform introduced in 2002. Contacting politicians to explain how the reform had a negative effect on the Centre. Applying for status as National Competence Centre to mobilize larger network.	Politicians positive to the Centre, but not interested in granting it a special status. Other university hospitals did not accept special status for the Centre.	The reform led hospitals to compete for access to patients. Centre failed to become NCC.

(Continued)

Time	Boundaries and domains of practices involved	Actors involved	Boundary organizing practices	Facilitating/countervailing forces/politics	Outcome over time
2000–2009 Expanding the Centre and its networks	Medical/scientific/industrial	The Centre, EU, academic partners, industrial partners, Rikshospitalet.	Initiating a number of new projects, including the EU project ARISER to generate funding and raise status.  Applying for the establishment of a Visualization Centre when the grant for PET Centre was to be given, and establishing collaboration with the University of Oslo about joint projects in the MRI; to mobilize active support in terms of funding and access to patients.	Academic institutions and industrial partners supportive, but other academic institutions all over Europe also applied for funding.	Managed to get funding for the ARISER project with PhD students and post-docs.  The PET Centre received funding, but no Visualization Centre.
		The Centre, University of Oslo, Research Council of Norway, Rikshospitalet.			
	Scientific, policy and industrial	The Centre, Norwegian Government, Research Council of Norway, industrial partners.	Enrolling and mobilizing government to support health care related business development launched at the Centre.	A number of actors were positive.	Much positive attention to the Centre. The launch of a report from the government about innovation in Norway. Much media attention.
		The Centre, Rikshospitalet, University of Oslo, Research Council of Norway.	Contact with possible partners for getting funding. Investigating possible merger with another department at the hospital to gain access to more patients and resources.	University of Oslo, Rikshospitalet and Research Council positive, but also competitors.  Other department somewhat positive to possible merger.	Funding that enabled the Centre to change all their imaging equipment.  No merger with the other department.

number of patients that had been treated there, as well as the number of publications, PhDs and patents, the Centre demonstrated to politicians its usefulness when seeking funding for expansion, and in preparation for becoming a 'visualization centre'. This reminds us of Guston (1999), who talks about finding indicators that help generate arguments about the productivity of the boundary organization.

Orlikowski (2002) identified multiple practices for handling multiple knowledge boundaries. However, less is said about how practices relating to one boundary may also influence other practices. In our case study, multiple boundaries needed to be handled simultaneously to establish alliances that could pressure others to support the actor-network too. This can be illustrated by how the mobilization of conditional support from professional groups triggered political action, and how establishing a steering committee with a diverse set of participants enables mobilization of support when needed. Employees at the Centre typically held positions in their primary departments, enabling them to also collaborate within the boundaries of their own discipline. However, in Norway there is a great deal of scepticism in the healthcare sector towards the commercial focus of industrial actors. Hence, alliances with industrial actors should be balanced with sensitivity towards the concerns of other key stakeholders.

## Facilitating mutual benefit

Not only are boundaries negotiated, but if successful, the innovating organization will frequently change boundaries. In medical practice, boundaries between disciplines will be moved, some practitioners' competence will be 'destroyed', and reimbursement systems will need to change, as well as the distribution of roles/labour between departments and hospitals. Technological innovation in medicine is increasingly demanding a scale of funding that calls for novel partnerships between science, medical practice and industry to facilitate faster spread, commercialization, and returns on the investment.

In addition to medical practice, the other three practices became important in the process of actually realizing the Centre in its different versions. The interestment and enrolment of allies were in different ways crucial for getting support from influential actors, mobilizing resources, and overcoming resistance. In such situations, problematization is rarely enough, it is also about the mutual negotiation and alignment of interests; enrolling others is quite often also a matter of being enrolled into actor-networks in seeking to realize other ends than your own, which is illustrated with the obtaining of the MRI from GE Healthcare.

When the development of new practices involves the exploitation of established resources, we find that the enrolment and mobilization process typically utilizes a strategy of 'friendly networking' to interest actors and reorganize boundaries. This is consistent with Guston's (1999, 2001) emphasis on mutual benefit and mutual accountability as being preconditions for (relative) stability, and Wenger's (2000) argument that brokering is about making practices serve the interests of several parties across communities. When Levina and Vaast (2005) describe the negotiation of a common 'field' for boundary spanning to take place, this also seems to require the negotiation of interests. Potential partners need to be approached with an offer that would provide mutual benefits. In our case study, we observed how the controversial aspects of the idea of a centre were toned down, instead appearing as 'harmless', and emphasizing mutuality, collective usefulness, and the solving

of common problems to create trust. Other times, support from recognized practitioner 'champions' would trigger recognition and action from the potential partners in question. The initial phase of mobilizing support for the idea of a centre was all about convincing various actors about the common use of the Centre. By employing professionals both at the Centre and at their primary departments, while also developing 'service level agreements' with various hospital departments, the Centre also helped open the boundaries and build trust among key partners controlling access to both expertise and patients.

## **Mutual adaptation of practice**

When boundaries are sought to be reorganized in the process of expanding the actor-network, a process of internal reorganization may be presupposed. This problem goes to the core of how boundaries may be challenged and reorganized during the processes of destabilizing and (re-)stabilizing them. While Orlikowski (2002) and Levina and Vaast (2005) do not challenge boundaries as such, Fennel and Alexander (1987) argue for organizational actors being capable of adapting to the environment, and Wenger (2000) describes how specific boundary practices may emerge to handle long-term collaboration. First, we observed in our case study how the actor-network (the Centre) reorganized internally to adjust to changes in the environment. After it got started, the Centre had some success and started growing to such an extent that they almost lost control. In order to build capacity for further growth, the Centre changed into a matrix organization to enable better collaboration with new partners. It was necessary to stabilize the organization of new practices internally before being able to create synergies with new partners across organizational boundaries. Second, mutual adaptations of the involved practices are often necessary to keep new practices 'in place'. Over time, one will often not only see adaptation, but even mutual integration of operations, which again contributes to further stabilization of the new practice. The role of the standardized package during boundary organizing seems somewhat different from the original notion where the transfer of knowledge was at the core. Here, its core function is more one of disciplining collaborators to work with the actor-network's preferred interfaces, hence enforcing and enhancing the vision of the Centre.

Concurrently, we see how the Centre adjusted internally to prepare for expansion towards new partners and practices. This was not just a matter of mirroring and adapting to the outer world, but more a matter of building internal knowledge and practices that could handle the challenges and complexity of the environment. The meaning of the Centre, as well as the organizational practices, had to be pragmatically altered along with the demands of the situation.

## **Conclusion**

In contributing to an understanding of how to address innovating organizations and the challenges of translating knowledge breakthroughs into medical practices (Newell et al., 2006; Robertson, 2007), we presented a case study of a medical R&D department that has been highly successful in developing and translating new medical practices and its boundary practices.

Whereas studies using an institutional framework (Scott, 1981; Fennel and Alexander, 1987) have focused on organizational boundaries, practice-based studies (Wenger, 2000; Orlikowski, 2002; Levina and Vaast, 2005) have been more concerned with knowledge boundaries. Although all of these studies have examined how boundaries are spanned, few have looked at the actual changes of boundaries as such. Further, the challenges of simultaneously handling multiple boundaries, or the power relations in play, have not been a central concern. We therefore included Callon (1986) and Guston (1999) to develop our notion of boundary organizing. This notion focuses on the political and contingent processes of building alliances and networks via the destabilizing and (re-)stabilizing of different boundaries.

New practices will always mean different things for different actors, requiring an alignment of these interests, a finding that corroborates Guston (1999), Swan et al. (2002), and Nicolini (2009, 2011). What we have observed here is not only practices in the making, but also the making of the Centre, and altered boundaries and networks. Unless actors believe that supporting these new practices serves their interests, they may withdraw their support. We highlighted the handling of multiple boundaries, the indirect effects, the negotiation of mutual benefits and interests, and mutual adaptation as key aspects of boundary organizing.

There are some limitations related to this study that may help us suggest avenues for future research. Our findings were related to a medical R&D department, a context that differs in some respects from other organizational settings, and this may influence the boundary practices used. We would therefore encourage research that studied boundary organizing in other organizational settings in other sectors.

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## Notes

- 1 Since 2009 Rikshospitalet has been part of Oslo University Hospital (OUS). OUS was established on 1 January 2009 by the merger of three of the university hospitals in Oslo: Rikshospitalet (The National Hospital, including the former Radiumhospitalet), Ullevål University Hospital, and Aker University Hospital. The hospital is Scandinavia's largest with more than 20,000 employees, and it carries out more than 1.2 million patient treatments yearly.
- 2 The term 'production department' refers in this article to a traditional clinical department that mainly produces patient treatment rather than focusing on developing new practices.

- 3 Boundary objects refers to objects that 'are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites' (Star and Griesemer, 1989: 393). Moore (1996) broadens our traditional understanding of boundary objects by studying organizations as boundary objects.
- 4 This reminds us of Galison (1997), who coined the metaphor of the 'trading zone' as a way of describing how engineers and physicists from different paradigms managed to agree on rules of exchange to develop particle detectors and radar.
- 5 A radiologist is a medical doctor specialized in imaging. The radiologist interprets the image and reports on the findings during traditional pre-surgery imaging, without necessarily seeing the patient. During a radiological intervention, such as angiography, the radiologist is present, positions the catheters and evaluates the results based on the images produced (Mørk et al., 2008).
- 6 These discussions were in particular with Professor Ole Berg who has been a very influential academic in the field of health care research in Norway for many years. A small presentation of his accomplishments can be found here: <http://www.med.uio.no/helsam/english/people/aca/oberg/index.html>
- 7 The Minister of Health had been a Master's student along with Lærum and Stordahl, and was therefore well-informed of their ideas. Lærum had also travelled to Moscow together with the director of the University of Oslo, making it easier to get support from these two key actors.
- 8 Magnetic resonance imaging (MRI) is primarily used in medical imaging to visualize the structure and function of the body. An MRI provides detailed images of the body in any plane.
- 9 In Norway a Parliamentary White Paper is called Stortingsingsproposisjon (abbreviated to St.prp.). St.prp. (1994–1995) Om alkoholtilsynet, Nytt Rikshospitalet, oppfølging av PU-reformen og Trygdeetatens EDB-system 55.
- 10 The National Medical Association actually discussed whether a thoracic surgeon could be the leader of a department with doctors from other disciplines than thoracic surgery (Mørk et al., 2008).
- 11 With real-time imaging the surgeons received pictures during the operation, rather than having to move the patient to a radiological department.
- 12 In 2003, SimSurgery patented a useable simulation of sewing threads during surgery as the first company worldwide (Fosse, 2007): <http://www.simsurgery.com/web/>
- 13 <http://www.alertis.no/>
- 14 Positron emission tomography, also called PET imaging or a PET scan, is a type of nuclear medicine imaging. Nuclear medicine is a branch of medical imaging that uses small amounts of radioactive material to diagnose or treat a variety of diseases, including many types of cancers, heart disease and certain other abnormalities within the body. These imaging procedures are non-invasive and usually painless medical tests that help physicians diagnose medical conditions (<http://www.radiologyinfo.org>).
- 15 MediStim develops, manufactures and distributes solutions for cardiac and vascular surgery, and has sold more than 1500 devices in 59 countries worldwide. MediStim's early phase technology development did partly take place at the Centre.

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