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TECHNOLOGICAL INNOVATION IN THE HOSPITAL - THE EXAMPLE OF 'PREOP'

1. INTRODUCTION

PREOP is, as the reader has surely guessed, an acronym. The initials stand for Planning, REsources and OPerations. As the acronym and its key words indicate, PREOP is intended to be a planning system for surgery departments at hospitals. It is modelled after a whole genus of Materials and Production Steering systems (known as MPS-systems) and project planning systems now quite common in industry.

PREOP's system engineers claim that PREOP represents a new generation of MPS-systems in that while such systems previously have been designed to calculate resource needs for a given production schedule, PREOP is designed to plan a production schedule for optimal utilization of available resources. PREOP was planned to cover two major functions - planned surgical admissions from hospital waiting lists, and daily scheduling of operations for admitted surgical patients. Both functions were to be based on two registers: a calendar register of available staff, coded for category, qualifications and organizational placement; and, a register of surgical procedures and their resource requirements (staffing, preferred operating rooms, standard anticipated duration). PREOP is, in other words, a so-called knowledge based system.

In this article I will first give a brief history of PREOP, its conception, its funding, the development process at Lillehammer hospital and its standing at that hospital and in the hospital market in general at the time when its funding authorities considered it ready for implementation. I will then give two interpretations of that history from different theoretical points of view, and finally propose a critical synthesis of the two.

In the innovation literature, case studies from the health services are rare. In fact, there are few case studies from any client oriented public service sector, the bulk of case studies being from industry, the military, or (if we see the creation of scientific knowledge as a type of innovation) the natural sciences. (1)

There are of course some exceptions. There is some tradition for diffusion studies on health technologies (2). These studies, however, are frequently based on assumptions about the diffusion process which scholars in the STS field are less willing to "black box". Diffusion is frequently seen as a unilinear process ending, sooner or later, in adoption. So-called "product champions" and the strength of their influence are seen as key factors in explaining the slope of the classic S-curve describing cumulative adoption.

There is also a substantial literature concerning the evaluation of medical technologies, their safety, efficacy and cost-effectiveness (3). This literature is also based on the assumptions of the diffusion tradition, with the addition of norms both with respect to the quality of technologies and to the methods for evaluating that quality.

In the STS field there is more focus on the interactive process of innovation, in which products (and thereby also their safety, efficacy and cost) are changed as they are adopted and put to use, and actors' influence changes as they allign themselves with or against new technologies. Within this tradition there are a few studies of the invention process for medical technologies (4); but, as far as I have been able to determine, only a very few of the innovation process as medical technologies are taken into use (5).

Readers not familiar with the Norwegian health services will perhaps need some background information on the setting in which PREOP's innovation process took place: In Norway, hospital services are the responsibility of the counties and the state. Norway has about 100 somatic and psychiatric hospitals. Eleven are state-owned and financed over the national budget. Eighteen are "privately" owned by non-profit organizations, but nonetheless financed over county budgets. The rest are county-owned and -operated.
This means that hospitals are operated within (more or less negotiable) budget limits set by national and coutny governments. As currently practiced, these budgets are not directly linked to production plans or actual production levels. Production - the treatment of patients - thus represents an expense, not a source of income, as seen from the standpoint of hospital administrators who are responsible for holding their budgets. From a professional standpoint, however, patients are a source of work gratification and career advancement. And from a political standpoint, patient

satisfaction is a source of electoral support. On the other hand, hospitals account for approximately two-thirds of county budgets; secondary schools, roads and public transportation the remaining third. Thus, hospitals cannot be held exempt from budget cutbacks in times of economic pressure.

Typically, a county will have one psychiatric hospital, two or three local hospitals (each with departments for general internal medicine and general surgery, a maternity ward and x-ray and laboratory service departments) and one central hospital with more specialized services. Some counties choose to divide specialty services among the local hospitals, rather than favor one to be a central hospital, as geography is often the most troublesome theme in Norwegian politics. (For similar reasons, Norway ranks very high in terms of high-tech medical equipment and services per capita.(6)) Several counties will share a regional hospital (there are 5 such) with a more complete range of specialist services. One of the national hospitals also serves as a regional hospital; the rest are specialty hospitals. The hospitals range in size from 9 beds (Longyearbyen hospital on Spitzbergen) to over 1600 beds (a regional and central hospital in Oslo). Lillehammer, with about 350 beds, is one of the largest local hospitals.

Hospital doctors are almost all full-time hospital employees. Some have private after-hours practices, but these offer only ambulatory services. Private specialist practitioners do not make use of hospital facilities, but may refer patients to the hospital to be treated by the doctors there. General practitioners may also refer patients to hospitals, or patients may be admitted directly from the emergency ward. Hospitals are required by law to accept all patients referred from their catchment areas or presenting as emergencies. It is, however, up to the head doctors of the respective clinical departments to assign priority to each patient. Low priority patients sometimes find themselves relegated to interminable waiting lists.

Lastly, a few remarks on hospitals' inner life: The vast majority of hospital employees are organized, mostly in professional organizations which also serve as unions. Professional loyalties and professional authority are strong. Although hospitals' organizational maps may look like classic pyramids with an administrative director at the top, the central administration is often weak in terms of numbers and power, and both professional and semi-professional groups have considerable autonomy.

2. METHODS

In my research on PREOP I have followed a standard ethnographic approach (7). My study of the PREOP case was carried out in the last year that PREOP was funded as an innovation project. Thus I was able to make some direct observations. I observed PREOP in use on two occasions and attended five meetings where PREOP was debated by prospective users at three different hospitals. As an employee of the Norwegian Institute for Hospital Research (NIS), where PREOP arose as a project proposal, I had also made some casual observations earlier in PREOP's history, for instance when PREOP was discussed at a coffee break or demonstrated in the PC-room. I had, however, not been a direct observer during PREOP's formative years. Thus, in order to gain insight into the invention and innovation process as PREOP was designed and installed, I had to rely on documents and on interviews of key actors.

Key actors were identified through the so-called "snowball" technique, starting with obvious candidates and "rolling up" from them others they suggested as important. They were for the most part interviewed individually. Those interviewed were:

- the hospital director
- the four members of the PREOP project group at the hospital (the personnel officer, the head anaesthesiologist, a charge surgical nurse, the secretary at the surgical department)
- the head surgeon
- the head nurse of the surgery department
- the head nurse of the surgical wardsl
- the junior sugeons' medical association representative
- the PREOP project administrator at the Norwegian Institute for Hospital Research (NIS)
- the director of NIS (who had launched the PREOP concept as a result of a project in the mid-70's)
- a former NIS researcher who had written PREOP's funding application on behalf of Oppland county's hospital administration
- the two systems engineers who programmed PREOP
- a group of eight surgical and anaesthetist nurses
- the four surgical wards' charge nurses

The views of national and county health authorities were surveyed through documents in PREOP's project archives (application, contracts, correspondence, minutes of meetings).

The interviews were loosely structured around a few open-ended questions. Interviewees were asked to describe their work and its major gratifications and frustrations. They were asked how they envisaged PREOP as influencing their work. They were asked what their rol (if any) had been in the development of PREOP, what changes they had observed in PREOP as it developed, and whether their opinions of PREOP had changed over time.

3. PREOP'S CONCEPTION

In 1972, the Norwegian Institute for Hospital Research studied the need and conditions for an information system which an electronics firm had proposed developing for the county hospital in Molde, Norway.(8) Focussing on how information routines affected productivity (defined as a function of quality of treatment, number of patients treated and resource utilization) the research team found that over half of all patient days spent in hospital were spent waiting - waiting for tests, waiting for test results, waiting for specialist consultations, waiting for operations, waiting for alternative placement. The remaining 49% of patient days were predominantly single-activity days (one test, one consultation, etc.) even though many activities were neither time consuming, serial in relation to one another or otherwise mutually excluding. Nor was there necessarily a capacity problem for all of the activities patients waited for. Operating theatres, for instance, typically ran at about 50% of staffed capacity.

The researchers proposed developing an information system which could reduce waiting time during hospitalization. This would be quite "profitable" in terms of increased productivity. They recommended that system development efforts be aimed at the planning of individual patient stays, booking of activities and planning of services' capacities. Although there was thought to be some political support for these ideas (the director of the national health service attended several seminars where the results of the project were presented and seemed supportive of the conclusions) the project was not followed up at the time.

Harald Buhaug, leader of the Molde project, concludes in retrospect that these ideas were beyond the capacities of the programming and information processing technologies available to Norwegian hospitals at the time. To program such functions in FORTRAN would have been prohibitively expensive and cumbersome, even as stand-alone functions - and the concept at the time was to use tham as the core of a complete integrated hospital information system. To run them as batch jobs on distant mainframes, as was standard practice at the time, would have been impractical and - to the defiantly autonomous professional groups one would be seeking to coordinate- singularly unappealing.

The idea was revived about 10 years later when another researcher at the hospital research institute (Stein Karlsen) happened to see a colleague of a friend at a sister institute, Institute for Production Technology, running tests on a PC-based MPS-system for a Volvo auto plant.

It was an attractive program - nice colors, graphics that made immediate sense - and Karlsen made a simultaneous mental translation from automobile production to surgical operations. As he explained the translation to the two production engineers, they told him that planning surgical production looked to be even simpler than planning automotive production. If his description of the process were correct, surgical production involved fewer steps, less complex relationships between those steps and fewer uncertainties with respect to production resource requirements. In other words, it could be done. It could be done as a stand-alone, PC-based system and perhaps later linked up with similar systems for other departments as they were developed.

In the ensuing year, Karlsen mentioned the idea of an MPS-system for surgery here and there, wherever he happened to be. And he was no moss-gatherer; he travelled far and wide and frequently in Norwegian health service circles. As leader of one of the research groups at the hospital research institute, it was part of his job to sell new projects. Both the hospital research institute and the production engineering institute were units of a larger research firm, SINTEF, within which joint projects were officially encouraged. And Karlsen enjoyed selling projects, finding intrinsic pleasure in matching research users' needs with researchers talents and ambitions.

Over the next year, several people expressed an interest in the PREOP idea, but none came forth with financing for it. Then a couple of major developments in the political economy of the health sector came to pass. New medical technologies offered relief for two large groups of patients for whom nothing much could previously be done - hip patients (arthrosis of the hip and femur fractures) and coronary heart disease patients. Whenever a new treatment appears on the scene, a number of people with nothing else in common than a diagnosis suddenly become a special type of social group - a hospital queue. At about the same time as these two queues came into existence, the demographic developments known as "the wave of the elderly" greatly expanded both. As such queues go, the queue for coronary bypass surgery has been a particularly influential one, that for hip replacement surgery somewhat less so.

Up to this time, increased demands for hospital services in Norway had been dealt with by expanding hospital services until the queues shortened and public discontent quieted. This time, however, the queues overflowed into the media at the same time as oil prices fell, lumber, fishing and shipping industries all went into slumps and a surge of right-wing populism demanded reductions in taxes and public spending. Instead of a crash program of hospital expansion, the Ministry of Social Affairs launched a program of applied research called "Action Waiting List". Hospitals were invited to apply for funds to conduct practical experiments in hospital rationalization.

Although such projects might require extra funding in an experimentational phase, the program's vision was that once routinized they would provide increased hospital productivity at no extra cost, thus shortening queues without drawing on politically expensive revenues. Although few hospital employees subscribed to this theory, many were more than willing to apply for funds which might finance expanded services while they lasted. Many were, however, inexperienced at applying for research funds and/or had little time available to write such applications. One county hopital administration (the counties own most of Norway's hospitals) hired Karlsen to write their applications for them.

Obviously, an enthusiastic project salesman hired for his expertise at writing research funds applications does not miss such a golden opportunity

to lauch his own project ideas. He mentioned his idea and the county administrators agreed that he include it in the application along with three of their own. Of the four project proposals, PREOP was one of three which received funding from the ministry. Thus, 10 years after its inception, the PREOP idea finally reached square one and the work of developing a system prototype could begin.

4. THE DEVELOPMENT PHASE

The original project proposal was to write up a set of system specifications for planning admissions from hospital waiting lists. These specifications could then be used by one or more software firms as a basis for programming the system. The specifications would be developed by relevant staff at the Oppland county hospitals under the guidance of engineers from the Institute for Production Engineering. Tom Qvistgaard and Geir Lundgaard-Soug were assigned to the project. They worked well as a team and came to be known, affectionately, as "Tom and Jerry" by the hospital staff.

The first step was to recruit a working group of staff from the county's two hospitals. This was done under the guidance of Qvistgaard and Lundgaard-Soug, who were accustomed to such teams from previous industrial projects. Typically, teams would consist of a top-level management representative (who would be its undisputed leader and settle any questions regarding the firm's commitment to and intentions with the system) and one or two representatives each from involved segments of middle management and labour (who would provide the necessary information on the production process, serve as ideological "hostages" and sometimes negotiate a portion of the system specifications in defence of the interests of their respective groups). Qvistgaard and Lundgaard-Soug did not see it as their prerogative to offer advice on, far less dictate, the constitution of these groups. That was always left to the management of the firm which had contracted them. In this case, although their contract was with the hospital research institute on behalf of Oppland county on behalf of the Ministry of Social Affairs, the hospital management was cast in the role of contracting firm.

Neither of the two hospital directors chose to be directly involved in the project. At Gjøvik hospital the head surgeon and a junior surgeon joined the

working group. At Lillehammer hospital four staff members were eventually recruited: the personnel officer, the head anaesthesiologist, a charge surgical nurse, and the head surgical nurse's secretary (on the understanding that her hours would be extended so the work involved would not interfere with other duties).

Then the two engineers proceeded to renegotiate the project goals. Rather than develop a set of system specifications, they wanted to develop a working prototype. This would be done by following the so-called Third Generation Model for system design, also known as Experimental Design. In this model the engineer presents the intended user with a running prototype early on. The user experiments with using the prototype and in so doing comes up with new or modified functional demands. The engineer modifies the prototype accordingly and the customer experiments again. This goes on until the customer is satisfied (or until the alloted time and/or money has run out, or the customer has given up hope of ever being satisfied with the engineer's work).

Qvistgaard and Lundgaard-Soug also renegotiated the product goal. Rather than an admissions planning system, they convinced the hospital's working group that they should first design a system for daily scheduling of operations for patients already admitted. The decisive argument for this intermediate step was that developing such a program would insure a sufficiently precise picture of the resource needs for each surgical procedure - a requirement for an efficient admissions-planning system. Furthermore, the county had already contracted for a waiting list system from Kommunedata (a commercial firm) and the admissions planning function would have to be worked out in connection with that system when it was installed (two years after the PREOP project started, as it turned out).

Qvistgaard and Lundgaard-Soug were also convinced that there was room for effectivity gains through improved daily scheduling, but that was not a deeply held conviction at the hospitals, even for those few who tended to agree with it.

At this point, Gjøvik hospital dropped out of the project. The head surgeon there was not willing to wait for the waiting list system the county had ordered and was about to have one programmed by a local one-man software

firm. The renegotiated project did not fit with those plans. From here on, only Lillehammer hospital, the two engineers, and a formal project administrator from NIS were involved in the project. The ministry's sole role was to pay the costs and maintain pressure concerning deadlines. The county administration, having set things in motion at Lillehammer hospital and agreed to the final version of the project proposal, withdrew from active involvement.

At Lillehammer hospital, the director was also reticent to become involved. As he himself put it:

"We have had very little involvement in this project, we from the administration. We've more or less let it stand on its own feet, so to speak."

The administration's appointed representative took it upon himself to lead the working group. He had a vaguely determinist view of the innovation process and instructed the other members of the group NOT to spread any information about PREOP to their peers as it would spoil the dramatic effect of unveiling the finished product. He expected curiosity to build up, crescendo-like, so that PREOP would receive due attention when it was ready for display. At that point, PREOP would sell itself and thereby modernize the organization.

The nurse in the project group saw her proper role as being one of a network-builder, but found this a difficult position. Was she expected to generate acceptance of PREOP from the nurses? Or was she to communicate the nurses' demands concerning PREOP to the engineers and administration? She felt she could accomplish neither as long as she was told not to leak any information about PREOP to her peers; and, if she was to perform neither function, then why was she in the group at all? The secretary's role in the project was mainly to operate the system during testing phases and point out any practical problems which arose. The key member of the group was the head anaesthesiologist. It was he who gathered the necessary production process information from the rest of the staff and translated that information into system specifications, knowledge base data and inference rules. In the interview, he pointed out two main reasons for his having chosen to participate in the project. One was the challenge of constructing a system that most doubted could ever work, one that would change the nature of planning in the hospital:

"When we began, of course it was said that 'Surgical activities - they can't be planned. It is absolutely impossible. A hospital isn't an industrial firm, so one can't plan in a hospital.' That has been put to shame time and again. As things went on, we have seen that one can plan a great deal within a hospital. One can even plan emergency admissions. According to the studies we have done here, there are few things which are as 'programable' as emergency admissions - they come at certain times of the day and in stable numbers over the year, with only small variations..."

The other was to reform the manner in which the surgery department served the surgeons and the surgical wards:

"If the surgical department saw itself as a firm with services to offer to the rest of the hospital, and "sold" these services by entering into "business commitments", then we might see a different attitude. The reality now is that the surgical department here, not to mention at most other hospitals in Norway, is running all the other surgical functions. The operating rooms have been seen as bottlenecks and thereby have been treated as "sacred cattle" and allowed to arrange their work as they themselves see fit. That may well be the best arrangement, but it's not given that that's true if they, for instance, cannot make allowances for things like the head surgeon's meeting with the administration when it is fully possible for him to be done in time for that meeting."

- head anaesthesiologist -

On the basis of the information and specifications received from the head anaesthesiologist, and using elements from the Volvo MPS-system and from a planning system Tom had once programmed for a Boy Scout service day, Tom and Jerry soon had a first prototype ready for testing. The working group offered critical response and Tom and Jerry returned to VTL for more programming. Tom and Jerry were good at this type of system design. They worked fast and were able to return to Lillehammer with new versions with most of the new demands met a week or two after each experimentation period was summarized.

A number of changes were made in PREOP in this process. The secretary had tested PREOP by attempting to have PREOP reproduce daily operating schedules made with existing routines. It turned out that the rules the head anaesthesiologist had elicited from the surgeons and nurses were not being

followed in daily practice. This was adjusted for by adding new rules, allowing for operator selection of which rules to follow and allowing for operator overrides on key parameters such as priority levels, choice of surgeon, choice of operating theatre etc. It was also found that, contrary to the hospital staff's initial expectations, operating theatres did not represent a bottleneck to productivity. The key limiting factor was surgeons. Other hospitals might have other bottlenecks, and it was thought that a major reconstruction of PREOP (to allow for different orders in the priority of booking factors) might be called for when adding on the admissions planning function later on.

By the third or fourth version, the little project group, some of whom initially had thought it couldn't be done, were quite pleased with themselves and their product. The next step was to try to get it tested in real use by the staff as a whole.

5. PREOP MEETS ITS USER ENVIRONMENT

Meanwhile, the nursing staff had found the secrecy surrounding PREOP very off-putting. When a version of the prototype was finally unveiled to them, they fully expected to dislike it:

"We are all disappointed over the way this has been presented to us. It has been 'Here you are. Here it is. Now we've sent a secretary for weeks on weeks to learn this, and now the rest of you can try to pick it up from her.'"

- charge anaesthestist nurse -

The nurse quoted above is referring to the presentation of PREOP to the staff. PREOP was presented at an open meeting - come one come all - which was squeezed into the head surgical nurse's front office. Tom and Jerry and the secretary from the working group demonstrated PREOP several times as on-lookers came and went. They also gave quick lessons on how to operate PREOP to whomever dared try their hand at it in front of the on-lookers present. PREOP was then left running for two weeks so anyone who so desired could try operating it. After this "learning by playing" period, a meeting was to be held to determine whether to try PREOP out in actual daily

planning. PREOP was tested for two weeks, then sent back for more modifications, mostly concerning printout formats. Then another meeting was held to try to build up enthusiasm for another test run.

It was at this point that I held my first round of interviews. In spite of both their sense of insult and their widely held doubts as to whether surgical scheduling could be handled by a computer at all (let alone as an improvement over manual scheduling), many of the hospital staff had come to have some positive expectations towards PREOP:

"The first time around I thought it was just hopeless to use. But, then we had another round and I started to see the advantages."

- charge anaesthetist nurse -

The advantages each group or individual saw were, however, different ones and were related to different aspects of dissatisfaction with existing manual scheduling routines. I will therefore briefly digress to describe how surgery schedules were made and followed at Lillehammer.

We can begin with planned admissions, which were handled by the head nurse of the surgical wards. She followed some rules of thumb, along the lines of "one hip replacement every Wed. and Thurs." which applied to the subspecialties of orthopedics, urology and opthamology. General surgery covered a larger variety of procedures, so for the two general surgery wards as well as for remaining space in the other wards she ordered admissions according to her best estimate of resource demands and availability.

Patients were generally cleared for operation the day after admission. A surgeon would give an order to this effect during rounds on the ward and the patient's name would then figure on a list sent from the ward to the head nurse of the surgery department in the afternoon. The head nurse then set up a tentative schedule for the following day, which her secretary typed and copied. The next morning, these copies, with the addition of any emergency admissions arrived during the night and still waiting for surgery, were discussed in three fora almost simultaneously. As the surgical and anaesthetist nurses were distributing assignments and planning their day, the surgeons at the doctors' morning meeting were also distributing assignments. For many patients, no surgeon had been assigned up to this point. In filling in these blanks, changes in the schedule would frequently have to be made as

a surgeon might otherwise wind up assigned to two different operations at the same time. (Such collisions were often discovered by the nurses after the doctors' meeting.) Other changes might be made for training purposes or because a surgeon wanted to follow up a patient he or she had operated on previously. Or there might be changes of patients' priority or changes of order for surgeons' convenience.

Immediately after the doctors' morning meeting, while the surgeons attended x-ray demonstrations, the anaesthetist nurses called the first patients down to the surgical department, their charge nurse and the head surgical nurse having hurriedly made the necessary adjustments to the schedule and copied the revised schedules for distribution.

During the course of the day, more adjustments would be made by the surgical and/or anaesthetist nurses as they made room for emergency admissions or adjusted for delays. There was no such thing as running ahead of schedule, as the schedule was simply an order of operations for each operating room. Expected operating times were not specified. Anaesthetist nurses called patients down from the wards as they and the surgical nurses with whom they were teamed for the day were prepared to receive them. Surgeons were called to the department as their patients were ready.

According to the interviews, each of the key groups at the hospital was dissatisfied with some aspect(s) of these routines and/or of the schedules resulting from them:

The nurses of the surgery department found the frequent reschedulings stressful:

"A good day is a day when the surgery schedule is dimensioned just right according to the number of nurses you have and the doctors who are on duty. If you're lucky, then all this fits together and the nurses can work their operating rooms, pace themselves and their programs and be finished when it's time to go home.

A bad day is a day that starts with the patient listed for 8:30 and whom you've already called down, the surgeon says 'That's not the patient we want first. And besides, that's not the surgeon who's doing that operation. We've decided someone else will take that patient.' And then it's up to us nurses to get things switched around and mixed together so the program has a chance

of working out. The surgeons just say 'I'm operating that patient' with no regard to whether they're already scheduled for another room at the same time."

- charge anaesthetist nurse -

Scheduling and rescheduling were also conflict-laden. Surgeons and sometimes ward nurses would complain and would accuse the surgery department staff of fortuitousness or favouritism. The surgical and anaesthetist nurses countered that it was the surgeons' fault for neglecting their responsibility to make such decisions:

"The surgeons, they don't really participate much when we get emergency admissions and it has to be decided which operations must wait. It's the charge nurses and the head nurse who have to make those decisions." "Yes, that's wrong, that the nurses' leaders should be organizing the surgeons in their work in fact."

- surgical nurse and anaesthetist nurse -

"(Using PREOP) would be just fine for me, because then I could just say that the machine had 'spit it out' and not I. Because all the surgeons want first priority, but it's left up to me to make the decisions - children first and that sort of thing. And there have been conflicts. So it's fine to get computers in those situations."

- head surgical nurse -

The ward nurses were upset that the surgery department's autonomy made it impossible for ward staff to plan their own day. Major variable tasks for the day are set during doctors' rounds. As doctors' rounds were frequently late and/or interrupted, the ward staff lost most of the potential for control over the order and pace of tasks. They viewed this as a sign of disrespect for the work of the wards:

"We don't seem to be able to make our point that we need the doctors to go their rounds at some more or less fixed time of the day - that the doctors have work to do on the wards as well."

- charge nurse, surgical ward -

The head anaesthesiologist and head surgeon complained that the surgery

department nurses were not sufficiently loyal to the surgeons' needs to coordinate surgical work with other duties:

"For instance, the other day I was supposed to attend a meeting at 2 o'clock or from 2:30 at the latest (...) That implied that I had to be finished with my two operations. As we were finished with my first operation, we saw that we had taken longer than expected. If my second patient had been called for right away, dropping my lunch break which I could have done without, I could still have attended that meeting. But things didn't work out that way. Now, I didn't swear and shout about that, but there were others who were upset that I was delayed in surgery."

- head surgeon -

The administration (and the two engineers and to some extent the head anaesthesiologist) were convinced that, with better planning, "dead time" at the surgery department could be reduced and the number of operations performed could be increased:

"If we could only get them to openly admit what our statistics show, that only 40% of manned operating theatre time is being utilized, then we would be getting somewhere."

- personnel officer -

Surgeons, on the other hand, were reticent to change scheduling routines lest the number of operations performed might DEcrease. This would mean longer training periods before interns had fulfilled the operating programs required to become specialist surgeons. It would also mean less opportunity for the specialists to improve their skills and thereby their professional standing.

Aside from the head anaesthesiologist, I heard only one voice from the surgery department staff who in any degree accepted the administration's argument:

"The one problem I feel is when we all go to eat and the operating room stands empty. I think we lose a lot of time there until we get started up again."

- surgical nurse -

Nelson and Winter speak of organizational routines as truce, the parties having agreed or succumbed to a fixed pattern of action which regulates the

differences of interests between them. (9) This image comes close to the harmonious one of an actor-network based on common (or different but compatible) interests, but differs in that it implies a degree of antagonism held in check by a more or less stable compromise. I find it a fairly accurate metaphore for describing how the complex daily cooperative efforts of competing professional groups is managed in a hospital setting. It is handled through routinized behaviour representing standing truces for most everyday situations, and through more or less explicit, more or less formalized negotiations in situations for which existing routines seem inappropriate or inadequate. There are also some extraordinary situations which arise so regularly that they are routinized at an intermediate level in that there are routines for their negotiation, although the end results are not routinized into standard solutions.

Surgical scheduling practices can be seen as a set of routines and routinized negotiations which balance the interests, both common and conflicting, of the ward nurses; surgical nurses; anaesthetist nurses; surgeons; anaesthesiologists; admissions, emergency and intensive care staffs; and, one would hope, the patients.

Accepting this metaphore, the truce represented by the scheduling routines was a shaky one. All the key groups and individuals had some complaint about the way those routines functioned. Each saw PREOP as a potential ally for modifying those routines. But most did not see that potential as a very strong one.

Taken chronologically, the national and local health authorities had subscribed to the PREOP concept's original goal of increased productivity within given resource limits. This goal had, however, been abandoned by local authorities in the face of budget cuts. The hospital's continued interest in PREOP was explained as aimed at a smoother coordination of the surgical department and, interestingly, at opening up the department for discussions with the administration on the rationality of existing routines. The hospital director found it impossible to discuss such things with surgeons and nurses, who were quick to claim medical reasons for routines necessarily being as they were. If all these "medical reasons" were programmed into PREOP, he reasoned, and PREOP were run by a mere secretary, then the professionals would have to be more approachable. He could for

instance simulate various alternative schedules on the screen and say "Why can't you do things this way?"

If the director's impression that the professional groups are unwilling to discuss their routines with the administration is accurate, then they would obviously be opposed to PREOP being used to lay them open to debate with him. None of them, however, mentioned that possibility in the interviews, neither in a positive nor negative manner. Instead they focussed on their own interests in PREOP and some other fears and doubts.

The head anaesthesiologist saw PREOP primarily as an instrument to reform the surgical department into a more loyal service department for the surgeons. Of all those I interviewed, he and the two engineers were the most convinced that PREOP could actually work as an instrument of reform.

Surgeons would have been happy to have a system which made their day more predictable and productive, but doubted whether PREOP could achieve the necessary precision. Lacking that precision, they feared they would get less done and suffer for it professionally. For the most part they ignored PREOP.

Surgical and anaesthetist nurses had the same doubts about the possibility of PREOP ever being precise enough to be an efficient scheduler. The head surgical nurse thought it would be nice if PREOP were set to choosing surgeons and handling rescheduling in the course of the day, but at the same time she doubted whether PREOP could actually do the job.

So far, the nurses were unhappy with the schedules PREOP set up when it followed the rules elicited for it from the head anaesthesiologist. For instance, PREOP was programmed to assign certain types of operations to certain operating rooms and move the surgeons among these. The nurses preferred to have a whole team, surgeon included, continue in the same room as much as possible so as to limit the "domino effects" of delays, the pressures of a team "knocking" on a delayed team's door and the frustrations of having to wait for the delayed team to finish before getting on with one's own program. Keeping one team to each staffed room gave the nurses control over the pace of work, and that control was their sole defence against stress in a physically and emotionally gruelling job in which all

other forms of professional discretion were totally subordinated to surgeons and anaesthesiologists.

Nor were they happy with the prominent position the secretary had had in the project. They were certainly not prepared to accept her becoming PREOP's regular operator.

"There were even occasions when the secretary set up the schedule - when we were to have our breaks and so on. She is just not qualified to do that!"

- surgical nurse -

The nurses demanded that the head surgical nurse, the two charge nurses in the surgery department and possibly the corresponding nurses from the anaesthesiology department be PREOP's operators. They would have to be taught PREOP outside their normal working situation, without an audience hanging over them; and, they could not accept their secretary as a teacher. Alternatively, putting PREOP in the hands of the surgeons was conceivable, but not a solution they favored. It was finally decided that the head surgical nurse and one charge nurse would spend 3 days at the Institute for Production Engineering in Trondheim being taught how to operate PREOP.

PREOP had by that point become a highly flexible system in which the operator could choose among alternative parameter sets or override parameters as she saw fit. This was a result of Tom and Jerry having assiduously followed the precepts of Experimental System Design. They had not questioned the right of anyone the administration authorized, explicitly of implicitly, to make demands concerning PREOP's design. Nor had they pressed for anyone to make a final decision as to how, by whom and for what purposes PREOP would be used. Instead, they allowed for conflicting demands by allowing for operator-choices between alternative rule sets and operator overrides on parameters followed by those rule sets.

Having learned to master PREOP by means of overriding parameters, the nurses could force PREOP to set up schedules exactly as they had before, disregarding the rules the head anaesthesiologist had attempted to program into it. PREOP thereby became a fast but willstrong and contrary typewriter. Instead of becoming someones ally in renegotiating the existing truce, PREOP became a slave to the existing truce and thus reinforced it.

For a brief while the truce was amended to meet some of the ward nurses' demands. Doctors' rounds were to be defined as a high priority procedure which would be included in the daily schedule as were high priority surgical procedures, which meant they would occur early in the day and be more or less uninterupted. This amendment was programmed into PREOP and was operated so as to enforce the revised truce.

But after a few weeks, this "rule" was also overridden and the old truce remained basically unchanged. Not trusting PREOP to pack their operating schedules as tightly as before, the surgeons did not feel at ease putting rounds on the schedule, and as the first operation at that. They preferred to start surgery early, hoping to have finished their schedules before domino effects from emergency admissions and late-running operations were felt. And the surgery department nurses found that putting ward rounds on the schedule made it more difficult to puzzle together a schedule they thought would be workable. They preferred to let the surgeons squeeze rounds in between operations as best they could.

Patients were imagined by most actors to be interested in the earliest possible date for surgery and in being informed of that date as soon as they were put on the waiting list. They had, however, no direct influence on PREOP.

At this point, no one was particularly happy with PREOP, but no one felt threatened by it either and it remained in service. There was, after all, still the hope that an admissions planning function would be designed for it which might prove useful. There was the hope that PREOP might prove useful in making annual reports which would demonstrate how hard the surgical department was working, but the necessary updating, data storage and data agreggation features had yet to be programmed. There was also the fear that some other hospital would make better use of PREOP as it stood and leave Lillehammer's staff looking the fools (a fear expressed explicitly by one of the nurses). If they could arrive at sufficiently precise anticipated operating times (some doubted this was even theoretically possible; some meant it had already been acheived but that capitalizing on it was frustrated by staff resistance), then PREOP might produce so reliable daily schedules as to make coordination at the department smoother and working

conditions less stressful. But so far there was no stable consensus defining PREOP in any such glamorous way.

As PREOP fell into regular usage at the hospital without bringing about any changes in scheduling practice, the two engineers came to view the project as a failure, at least as far as Lillehammer hospital was concerned. They laid the main blame on the hospital administration, which they felt had been negligent in not making a clear decision to put PREOP to use once it was developed and in not making efforts to insure support for that decision. But at the same time, they felt it was not their job to tell the hospital administration how to do their job, nor to take over the administration's tasks for them. In accordance with engineering models for system development, the engineers' role was simply to accomplish the technical realization of whatever organizational demands which were given them in technical terms by whoever the hospital had authorized to make such demands. Theirs was not to question why, etc.

The initial intent of the PREOP project was to raise hospital productivity by planning admissions to fit available resources, thus reducing the number of patient days spent in internal queues. In the funding application sent by the county health administration to the Ministry of Social Services, it was estimated that PREOP would give the hospital a productivity increase of 15% in surgical admissions. When the project was funded, the engineers say, they assumed that productivity - being the official goal for the project on the part of the national and local health administrations - was also the goal of the hospital as a whole.

Not that they expected no opposition to that goal. They were accustomed, from experience with similar projects in industry, to there being some opposition from production workers resisting pressure to increase productivity and from individuals within management who had favored other strategies. But they were also accustomed to management having made their decision before system designers were hired. And, they were accustomed to management being capable of enforcing their decision. Thus they expected to be able to treat the hospital as a single unit with a single goal-increased productivity within given resource limits. So much the more so since the hospital's products - life and health - carry such high social value.

In this they were disappointed:

"The impression we are left with after this is that hospitals don't really want increased effectivity. Because there is no central authority within the hospital that wants anything at all. There are many different groups and individuals who want different things. (...) We took it for granted that the goal of the project was the highest possible level of productivity given available resources. That is the problem we are accustomed to meeting. But it was very different here."

The engineers were struck most with the degree of autonomy held by the various professional groups and sub-groups at the hospital. They were taken aback by the lack of authority held by the hospital director. And even when I interviewed them over two years after they became involved in the project, they found it difficult to accept the hospital's ambiguous attitude to productivity as an economic principle.

For public hospitals, financed in the form of fixed budgets, productivity represents costs rather than profits. A patient-day spent waiting is a "cheap" day which costs the hospital about the same as a day in a hotel. A patient-day spent in surgery and post-operative intensive care is an expensive day. By cutting waiting days for surgical patients, each individual patient stay becomes marginally less expensive, but average costs per patient-day rise. At the same time, space is made available for a new patient. Assuming that neither the professionals nor the public will accept that space either being left unused or being shut down, a new patient will be admitted - a new patient representing the new and higher average patient-day costs. Unless the funding authorities are willing to increase budgets, public hospitals cannot afford to increase productivity.

During the first two years of the PREOP project, Lillehammer hospital experienced budget deficits which, at the last minute, were covered by extraordinary budget supplements. As PREOP was nearing a stage where the hospital was expected to decide whether or not to put it into normal service, the hospital's budget was being cut back and it seemed clear that no supplementary budgeting could be expected. A decision had been made to shut down one of the four surgical wards, and with a 25% reduction of bed capacity, no one any longer expected a 15% increase in planned admissions.

Instead, the administration saw a number of other potential advantages to using PREOP. The engineers saw that PREOP could be used for such purposes, much like a wristwatch can serve as a compass (or as a plumb, or a tourniquet, etc.) in a pinch. But it was not what PREOP was primarily designed to do, nor what they preferred to argue for on PREOP's behalf.

We should also note that the engineers themselves contributed to the displacement of goals for PREOP. The goal of increasing surgical admissions was attached to the admissions-planning function of PREOP. But Tom and Jerry had early in the project convinced the hospital's working group that they should first design a system for daily scheduling of operations for patients already admitted. In focussing attention for two years on the development of this intermediate product, they opened up for a displacement of motivations for the project as a whole.

At an open personnel meeting to discuss whether or not to continue using PREOP, the two engineers argued strongly for hospitals' need to increase effectivity and PREOP's capability of meeting that need. They claimed one of the benefits Lillehammer had gained through the PREOP project so far was that PREOP had "introduced planning into the hospital." Several nurses and surgeons became incensed at that remark. They were not about to accept a couple of mere engineers telling them how to plan their work! That the engineers should claim they had never planned before was outrageous! Luckily for PREOP, "Tom and Jerry" had been considered congenial, cooperative, hard-working young men up to that point, so they were able to smooth things over.

It was finally agreed to go on trying PREOP for some unspecified but understood temporary period. The advantages most present at the meeting agreed on were not those the engineers considered central to PREOP. For instance, many hoped PREOP would assist the department in documenting how its resources had been used - a chore only done once a year, but important for arguing their budget needs and for distributing resources equitably among the groups employed at the surgical department. It was also agreed that the department would attempt to use PREOP to insure that surgeons could conduct their ward rounds uninterrupted and early in the day. So far, neither of these goals has been achieved, but PREOP is still in

At this point, the Ministry of Social Affairs had extended the PREOP project's funding twice. They were now impatient for results and to appease them PREOP was offered as a workable prototype free to any interested hospital. It was also offered to all software and hardware firms serving the hospital market. They would be free to reprogram it to run with their other systems and sell the finished versions as their own. Courses for new users or for firms planning reprogramming would be offered at consultant firm rates.

Several hospitals currently have demonstration copies and two have even tested PREOP in ordinary usage for a brief period. One computer firm offered PREOP as a "freebie" with purchases of PC-network systems, but had no takers. Another firm has written to PREOP's parent institutes that they plan to work PREOP into their hospital information system sometime in the near but unspecified future. With that in mind, the Institute for Production Engineering has continued to work on PREOP, testing and modifying the prototype in cooperation with the firm's main hospital customer, the regional hospital in Trondheim. The head nurse of the surgical wards there reports that PREOP is becoming an ever faster and more attractive system. There are, however, no reports that work is being done on the organizational conflicts PREOP will meet if new attempts are made to impliment it.

PREOP may yet capture a market, but that day seems far away.

6. READING PREOP I: THE TRANSLATION OF INTERESTS

As concluded above, PREOP is a management system which has not achieved market success. What could have caused it to be a failure so far?

According to the precepts of Translation Theory (10), if we wish to know how a given technology becomes (or fails to become) a success, we must follow the would-be innovator, observing her behaviour and her interactions with others. We must do so with no preconceptions as to who those others will be; events themselves will reveal which "others" (individuals, organizations, natural phenomena) are significant and what interests they perceive themselves to have. Nor should we concern ourselves with the intrinsic qualities of the technology being launched. Instead we should observe how it

is transformed as more and more significant others are enlisted into its network. Although we are likely to observe actors claiming rationality and accusing one another of irrationality, we must not involve ourselves in arbitrations concerning logical consistency or "truth". We are simply to observe the numbers of actors alligned on either side and the strength of the links between them. We may, however, assume rationality in another sense: We may assume all the actors to be "rational actors" serving their own interests as they perceive them. Their enlistment into the network is based on the successful **translation** of those interests to fit the interests of the new network, for instance by modifying an actor's perceived interests to coincide with those of the intended network or by shaping the network in such a way as to force her, in her own self-interest, to participate in it.

Most cases described through the Translation approach have been success stories. (Two exceptions are the VEL electric vehicle (11) and the TSR2 aircraft (12)) Although the exceptions noted do demonstrate that it is possible to analyze innovation failure in Translation Theory terms, they do not provide an exhaustive repertoire of conceptual tools for doing so. The VEL case demonstrates an instance where Nature "laid down her veto". The TSR2 case failed due to dissonances among the actors in the global network (the network through which a project aquires resources) and between the global network and local network (the network within which a project is carried out). These dissonances put strains on the aircraft which it was not able to sustain.

Neither of these descriptions of innovation failure fits the PREOP case. MPS-systems are an established technology. Although PREOP represents a new direction in this genus of systems, it was not so different as to risk running into technological barriers. Neither Nature nor the computer were likely to "veto" it. True enough, PREOP was eventually cut off from its global network, but not because they ceased to believe in it. They simply ran out of patience and decided to declare it completed.

PREOP's failure was primarily located among the social actors of the local network. I needed a list of means of failure Translation Theory might hypothesize at that level. I arrived at four:

a) Translation Theory portrays innovation as acts of combinatory, even manipulatory, skill performed by entrepreneurs. (13) Although this is probably a rhetorical exaggeration of imagery, one might nonetheless hypothesize that innovation failure might be caused by a failure of the would-be entrepreneurs to pay enough attention to network-building.

b) According to Translation Theory, networks are built through translations (in several senses) of interests. The would-be entrepreneur is seen as building a scenario based on a set of imagined interests of the actors needed in the network. The entrepreneur then appeals to these interests- points out their likeness to the goals of the project, or claims the project to be a means of getting around barriers to those interests, etc. (14). A second route to failure could be that the interests imputed to the actors in the network were mistaken and the scenario thus faulty. Perhaps the would-be enptrepreneurs even neglected to construct a scenario at all.

c) With respect to early Portuguese attempts at sailing the Atlantic, John Law writes: "In the struggle between the Atlantic and the galley, the Atlantic was the winner. We might say that the forces associated by the Europeans were not strong enough to dissociate those that constituted the Atlantic." (15) "Dissociate" is the key word. In order to establish an actor-network, entrepreneurs frequently have to disestablish som pre-existing network(s). The third hypothesis on routes to failure would be that the pre-existing network(s) proved too strong.

d) I propose that a fourth route to failure would be that the project's actor-network falls apart, not due to inattention or misunderstandings or opposition from outside, but due to conflicts between actors successfully recruited into the network. These actors could have been recruited into the network on the basis of some minimal, but ultimately insufficient com-monality of interests. In time it could turn out that others of their interests with respect to the project were so much in conflict with one another that they could not be retained within the same network. This is a more generalized way of describing what happened to the TSR2's global network, and in reframing the description as a general hypothesis it becomes applicable to local network problems as well.

In terms of these four general hypotheses, we can now formulate four hypotheses on what went wrong for PREOP:

- No one took responsibility for building a network for PREOP.
- The PREOP project lacked a scenario, or was based on a scenario built out of mistaken assumptions concerning the hoped-for actors' interests.
- PREOP met with a "brick wall" of established planning routines which the PREOP project was unable to disestablish.
- Actors recruited into PREOP's network turned out to have unreconcilable interests concerning PREOP.

Let us look at these four hypotheses in turn:

6.1. Inattention to network-building?

According to the interviews, it seems clear that no one took responsibility, other than intermittently, for recruiting support for PREOP. Of course, none of the actors thought of technology development as a network-building process nor of themselves as network builders.

The hospital director, for instance, saw himself (rather uncomfortably) as a decision-maker. When it came to the PREOP project, he was repeatedly relieved to find it unnecessary to take an assertive stand:

(...) These meetings, that there have been a very few of, with the project group and the engineers and myself: I've been prepared to say 'Listen here, this project is going to be carried out and we can't accept that individuals veto this.' But then we've found - - a gentler solution, you might say. Because they've said 'We've had such and such suggestions. Let's try to get them worked in and see how things go.' Of course we have the possibility of simply deciding this, but so far we haven't been in such a difficult situation that that has been necessary."

The engineers followed norms for engineering projects, which meant network-building was management's responsibility, not theirs. And the administration's representative in the project had a determinist view of the process in which there would be no need for network-building - the product would sell itself when it was finished. Its implementation was inevitable; the organizational consequences of that implementation foreseeable and inexorable.

Although the experimental system design method insured that some network-building activities (arguing the advantages of PREOP twoards various actors, coopting support by incorporating actors' recommendations into successive versions) implicitly were carried out, its extent and quality was dependent on the extent and quality of the project group's communications with their peers. In this project it had been decided the group should keep silent and build suspense.

The inattention to network-building was clearly harmful to the project. Although enough support was generated from individual actors to keep PREOP viable at least as a system development project, that support was never linked together into the consistent and solid network that would be needed for PREOP to succeed as a finished product.

6.2. Misread motivations?

The PREOP project was directed towards increased productivity in the surgery department - a goal which the two engineers assumed would be either widely accepted or enforced. Instead, the goal was opposed by nurses, who claimed they were already overworked as it was. It was ridiculed by surgeons, who could not see how PREOP could improve scheduling on the basis of uncertain data. And it was abandoned by the administration due to budget cuts, since production represents costs rather than income in a public hospital.

There remained other motivations on the basis of which these groups were more or less prepared to support PREOP. These motivations were, however, not central the PREOP concept, as the engineers saw it, and they have not attempted to incorporate them into some more complex scenario on which to build a network. One reason for this "neglect" is that they regard both scenario- and network-building as the responsibility of management. Management, in this case, views these other potential motivations as detrimental to the main productivity goals. Incorporating them is out of the question; and, given management's determinist view of technology, confronting them or coopting them to keep one another in check is unnecessary.

Again it would seem that we can confirm the hypothetical flaw in the network-building process.

6.3. Collision with a brick wall?

In one sense it would seem that PREOP met with a "brick wall", a pre-existing, indestructable network in the form of manual scheduling routines. Its indestructability was demonstrated in the personnel's unwillingness to change those routines sufficiently to admit PREOP as a new party to the "truce" they represented. The interviews show, however, that practically all parties were dissatisfied with the way scheduling, rescheduling and following schedules functioned. And yet almost no changes were made in the scheduling routines in connection with the introduction of PREOP.

I see two obvious explanations for why such a shaky truce nonetheless proved stable during the introduction of a technology aimed at changing it. One is that no one took responsibility for the necessary efforts at renegotiating the truce. This was clearly the case, as already discussed above, both because some felt it was not their job or not within their power to do so, and because some thought PREOP would do the job for them deterministically.

The other explanation is that while the terms of the truce itself may have been shaky, the power relations behind its formation were not. This is probably also the case, although my data aren't well suited to test such a hypothesis.

So while PREOP perhaps after all did not meet a brick wall, even the stick or straw wall it met was left undamaged because of the failure to build a stable new one in its place. This brings us to the fourth hypothesis - that networking efforts may fail because the interests they attempt to weave together are too antagonistic to be stabilized.

6.4. Carrying fencepoles?

A farmer and (suddenly former) Norwegian prime minister once said that maintaining a coalition government was like carrying fencepoles. Until recently, Norwegian farmers carried poles every summer when they built racks on which to hang their hay to dry, so most Norwegians got a clear picture of the prime minister's problem. Fencepoles are easy enough to stack together

and not all that heavy to lift, but no sooner have you walked a couple of meters with the bundle on your shoulder than the poles start pointing every which way, the odd pole slips out of the bundle and then the whole bundle tumbles out of your grip. Could PREOP be experiencing a fencepole crisis? Could that explain why its network has not yet come together? From my data that would seem to be the case.

In spite of inattention to networking, in spite of misunderstanding and ignoring hospital personnel's motivations, perhaps thanks to widespread and diversely natured dissatisfaction with existing schedules and scheduling routines, PREOP had gained a degree of support from most of the actors concerned. Some of this support was wholehearted. Some was ambivalent. But, most important, each group's support was directed at different aspects of PREOP. Points on which most actors agreed were either vaguely formulated, marginally related to scheduling or both. Each actor (individual or group) had come to see PREOP as a potential recruit to his/her/their own network and its goals.

Those goals were, however, antagonistic towards one another - each group aiming to defend and if possible increase their control over the production process in which they were mutually engaged. As it turned out, no group had sufficient power to enforce its will over the others, so PREOP wound up being reduced to a slave of the existing truce between them.

6.5. Problems with this explanation

While I find reading the PREOP story a fascinating and rewarding excercize, resulting in a rich description of PREOP's history, I find that the description and the theory on which it is based do not entirely sit well with one another.

In focussing on how a self-sustaining network is constructed, Translation theory dircts our attentions at the formation of concensus. This gives us an harmonious picture of the establishment of an innovation. But mightn't such a network be constructed through the use of force? Might not some technologies become established through agression and might not concensus represent a more or less reluctant truce?

One might counter that I have managed to include a good deal of agression and reluctant truce in my Translation reading of the PREOP story and that I have pointed out how some groups see PREOP as a threat. It requires, however, some self-discipline to do so. It requires also that I take some liberties with Translation Theory as a method. Latour advises against the researcher having any pre-conceptions as to who will prove to be the actors in a given network or what the interests linking them to that network will prove to be. In order to see nurses' and surgeons' hopes and misgivings about PREOP as reflections of their work situations, I had to use knowledge about those situations which I have gained from previous research experience. The interviewees themselves were not explicit on those points, nor can we expect them to be. (16)

Translation Theory discourages one from reading structurally based conflicts into an innovation story, by making that option both theoretically unattractive and methodically difficult. I will therefore attempt to read the PREOP story from an explicitly conflict-based point of view and compare the results.

7. READING PREOP II: CONFLICTS OF INTERESTS

I have chosen to use a Labour Process approach as a framework for a conflict-oriented reading of the PREOP story. The Labour Process approach to understanding innovation processes derives from marxist theory. According to Marx, a production technology embodies the social relationships under which it is used or intended to be used. Under capitalism, the key feature of those relationships is that the capitalist owns the means of production and the products of that production, while the worker owns his or her own labour power. In order to extract surplus value from the production process, the capitalist and the capitalist's proxy, management, must control the excercize of the workers' labour power.

According to Braverman (16) all modern management techniques for excercizing that control, however euphemistically named, can be seen as variations on Frederick Winslow Taylor's "scientific management". This basic technique, also known as "Taylorism" can, again according to Braverman, be reduced to three principles to be carried out in three consecutive steps:

1. "The dissociation of the labour process from the skills of the workers", accomplished by the acquisition of their accumulated knowledge.
2. "The separation of conception from execution", accomplished by translating the acquired knowledge into sets of simple rules and instructions.
3. "The use of this monopoly over knowledge to control each step of the labour process and its mode of execution", accomplished by dividing production plans into tasks and accompanying detailed instructions to be portioned out by management to labour.

Control is thus achieved through the deskilling of labour.

This control can take on various aspects. Francis (17) divides the concept into four "control issues". The first is coordination, adjusting the performance of varius sub-tasks to efficiently perform a complex whole. This type of control need not involve the use of power in the sense of "get(ting) B to do something that B would not otherwise do." (18) The second is control against free-riders - the use of power by management or co-workers to insure that all workers perform an equitable share of the total tasks. The third form of control concerns the negotiation of an efforts-rewards curve - for instance a wage scale. The fourth form concerns the negotiation of placement on that curve for a given group, individual or sub-task.

Francis's definition of control issues demonstrates that control is not created by management's attempts to monopolize it through de-skilling. Control is already excercized, in part by labour. The fourth form of control also shows that there may be conflicts over control among different labour groups and individuals.

According to Labour Process theoreticians, technology is a, some say the, major means of achieving monopoly over skills and thus control over labour power. Be that as it may for other technologies, for MPS-systems control is the explicit goal.

MPS-systems are designed to refine coordination to the utmost, fine-tuning the dimensioning of production steps to one another so as to minimize the time that capital is tied up in unfinished products and raw materials (control 1). Nor should there be much slack, if any, left in machine or

labour capacity for any production step. MPS-systems are abstracted assembly lines, with some of the assembly line's ability to enforce discipline and to determine the pace of work (control 2), but here applicable even to production systems based for instance on "autonomous work groups". MPS-systems also imply de-skilling, which may be a means of renegotiating controls 3 and 4 and may alsocause redundancies - here primarily the de-skilling and redundancy of middle management rather than of production labour.

The Labour Process approach assumes that workers have the opposite interests. Workers are interested in controlling their own workpace at maintainable levels which leave them energies for their off-working hours. Workers are interested in maintaining control over skills, both for the innate gratification skilled work provides and so as to be the more irreplaceable (more sure of a job, better paid). This includes maintaining coordination skills, such as knowledge of the production process as a whole, and control over coordination - again both for the innate gratification of having control over ones work and for the bargaining power those skills, that knowledge and that control carry. Workers will therefore resist the introduction of new technology aimed at strengthening the owners' control over their labour.

How might this theory apply to the PREOP case? In Labour Process terms we would ask whether and in what manner PREOP was aimed at control over production. We would then ask by what means and how successfully workers resisted its introduction, and by what means and how successfully management thwarted that resistance. We would also, especially in the non-capitalist setting of a Norwegian county hospital, pay close attention to potential conflicts over control between labour groups. PREOP's failure to alter routines at the hospital and to capture a market in the hospital field would be due to the strength of workers' resistance to losing control and/or the weakness of central management or contesting worker groups in capturing it.

7.1. PREOP as an instrument of control

Like MPS-systems in general, PREOP is quite explicitly intended as an instrument of control. It is meant to enforce management's production goals

and cost limits through improved coordination. Surgeons' control over their workload - previously steered by their admitting enough patients and to be assured of having "raw materials" at hand and by "overbooking" operating schedules - would be centralized. Workloads would no longer exceed capacity. Budgets would no longer be subject to the strain of worker-controlled overtime usage. Nurses' control over the pace of work would also be centralized and it was assumed that the work pace would be stepped up.

PREOP was also meant to make tacit knowledge of coordination parametes available to all parties - including management. This knowledge has so far largely been monopolized by the professionalized workers. Incorporating this knowledge into PREOP's data base would mean that coordination control could be de-skilled and de-monopolized - a point neither management nor the professionals have missed.

Control over the content of work would also be centralized, enforcing some changes in the priorities of tasks. Surgeons' work on the wards would receive higher priority. They would be expected to carry it out early in the day, rather than postponing a good deal of it to overtime hours as is currently the practice.

7.2. Resistance and counter-resistance to PREOP

Whether or not PREOP met with worker resistance is a point of contention among the interviewees. The two engineers felt it did, and on some points the head anaesthesiologist and the administration agree with them. They argue that the surgical department staff are unnecessarily and exaggeratedly disloyal to PREOP's operating schedules, thus discrediting PREOP's ability to schedule realistically. But then, purported disloyalty to schedules negotiated autonomously via existing routines was one of the arguments for introducing PREOP as a tool for reform. Thus it is difficult to differentiate resistance to PREOP from resistance to older forms of coordination control.

The engineers and management also argue that the head surgical nurse has attempted to boycott the project, they think not in defence of her autonomy, however, but for fear of being unable to learn to operate a computer. The

head nurse counters that her other duties left her no available time to participate in PREOP's development. Once PREOP was ready for trial implementation, she took time off to learn to use it and has used it steadfastly since.

The surgeons and the surgery department nurses similarly say they have been cooperative beyond the call of duty. They claim to have maintained optimism and enthusiasm for PREOP, or at the very least patience with it, in the face of increasing evidence that PREOP simply won't work. They claim PREOP won't work because operating times just aren't predictable, and that the frequent need to reschedule operations is due to the unpredictable nature of surgical work, not to any resistance on their part to coordination and control or to PREOP, for that matter, if only it worked. That may be true. Or it may be, as the two engineers contend, that the health professionals are making unecessarily stringent demands for precision on PREOP's part, that no MPS-systems are more precise than PREOP but neither do they need to be in order to function adequately. Or it may be that management has failed here already in step one of the strategy for gaining control over production - that they have failed to elicit sufficient knowledge of the production process.

What about other forms of weakness on the part of management? The two engineers claim this is the main reason for PREOP's failure so far, that management has not been bold enough in making use of the knowlege PREOP places in their hands to take control of production planning. The administration are also willing to accept some of that blame.

Weak central authority is a widespread characteristic of the health services. Professional autonomy is a strongly held ideal in the health sector. Arguments concerning availability and quality of services hold greater legitimacy than those concerning budget limits. Health professionals have a virtual monopoly on availability and quality arguments, leaving management with the weaker budget arguments as their only strong point.

In PREOP's case, it came to be suspected that PREOP would either reduce productivity or increase costs. Thus, mament would either have to fight an uphill battle against the professionals' arguments for maintaining production levels, or fight an unarmed battle without recourse to budget argu-

ments. Whether or not we conclude that PREOP met with strong worker resistance, it seems quite probable that PREOP had weak management defence.

In a variation on this theme of weak central management, some of the surgery department nurses have laid blame for coordination conflicts on the head surgeon's laid-back leadership style, his willingness to defer power to the nurses as long as he can get his patients admitted and operated on. It has been observed in other studies that power relations among the professional groups vary from hospital to hospital due to differences in leadership styles, in leaders' standings within their respective professions, in the strength of solidarity within groups, etc. At Lillehammer the head surgeon seems content to concentrate on surgery, leaving others to battle over control over the department's labour process. The head anaesthesiologist is thus left fighting a lonely battle in his attempt to gather control and hand it over to the surgeons. And, whereas surgical and anaesthetist nurses at other hospitals often oppose each other on control issues, the nurses of the surgery department at Lillehammer stand well united. Thus, the nurses' taking control over PREOP and using it to reinforce their central position in the existing scheduling routines need not come as a surprise. On its own, PREOP could not deterministically achieve a change in the power relations.

8. CONCLUSIONS

It is clear that these two readings of supplement at least as much as they compete with one another. In the case of the PREOP story, I prefer the conflict reading as it more readily accomodates the structural interests which were found to pertain. The conflict reading predicted the presence of these interests, in general terms, and led us to look for the specific form they took at this hospital and for the power relationships among the groups involved. The Translation Theory reading, on the other hand, forced us to ignore any prior inkling of the presence of these interests and then rediscover them empirically. Furthermore, the thought that these interests might be irreconcilable, as I believe they are, does not sit well with Translation Theory, but is a natural premise for the Labour Process approach. Still, I see a considerable advantage to combining the two approaches and I see two ways to do so.

As I see it, the advantage of combining the two approaches is that the Labour Process approach provides a theoretical environment for dealing with structural interest conflicts and power relations at the onset of an innovation story. The Translation approach admits Nature as an actor in the power play and provides a rich description of the process through which power relations were played out and the conflicts resolved in a new truce or left unchanged by the end of the story.

How then to combine the two? I see two "windows" between the two approaches, or perhaps two sides to the same window, depending on which approach one takes as an initial standpoint. Starting with a Labour Process approach, as I would choose to do in this case, we could tie in Translation Theory through a theory on power. Finn Borum (20) discusses how groups can make use of different power resources. He lists 6 such resources or "power bases":

- group cohesion,
- available energy for goal-directed actions,
- expertise and ability to analyse the issue concerned,
- position within the organization (autonomy, authority, work-related dependence),
- political connections, and
- strategical competence in applying the above power bases.

I propose that Translation Theory might be particularly useful as a framework for describing how internal solidarity is maintained, how political alliances are formed and how strategical competence is played out in a given case.

Others may prefer to start from a Translation Theory standpoint, but then find that they need to deal with structural interests as opposed to or in addition to more purely actor-based interests. For them I suggest that the idea of pre-existing networks and Nelson and Winter's metaphore of routines as truce can provide an opening towards conflict-based theories such as Labour Process theory.

NOTES

1) In a 600-page review of the field published in 1977 (Ina Spiegel-Rsing and Derek de Solla Price (eds.), Sience, Technology and Society. A Cross-Disciplinary Perspective (London, England and Beverly Hills, CA: Sage Publications, 1977)) no reference to words such as "medicine" or "medical" appears in the index. References such as "industrial" and "military" command several lines. Although the field has broadened during the decade since, documents such as the proceedings of the Conference on the State of Science, Technology and Society Programs in Western Europe, North America and Australia (Worcester, MA, November 18-20, 1987) still convey the same impression of the dominant subjects of the field.

2) See, for instance, Barbara Stocking, Initiative & Inertia. Case studies in the NHS (London: Nuffield Provincial Hospitals Trust, 1985).

3) This is mostly published in medical specialty journals. Examples of technology assessment articles from a wide range of specialties can be found in the International Journal of Technology Assessment in Health Care (Cambridge University Press).

4) For instance, Edward Yoxen, "Seeing with Sound: A Study of the Development of Medical Images" in Wiebe E. Bijker, Thomas P. Hughes and Trevor Pinch (eds.), The Social Construction of Technological Systems (Cambridge, MA and London, England: MIT Press, 1987.

5) One example is a study of how CT scanners were introduced to two hospitals' radiology departments (Stephen R. Barley, "Technology as an Occasion for Structuring: Evidence from Observations of CT Scanners and the Social Order of Radiology Departments" in Administrative Science Quarterly, 1986: 78-108. Another is Bruno Latour's The Pasteurization of France (Cambridge, MA and London, England: Harvard University Press, 1988).

6) For a more thorough discussion of the politics of geography, taxes and health technology in Norway, see AR Sætnan, B Backe, A Kolstad and T Lamvik, "Look to Norway! (But Not Uncritically)" in International Journal of Technology Assessment in Health Care, 1988, 3: 359-374.

7) For a concise presentation of this methodology, also known as "thick description", see Clifford Geertz, The Interpretation of Cultures (New York: Basic Books, 1973). Bruno Latour and Steve Woolgar describe the application of ethnographic methodology to science and technology studies in Laboratory Life. The Social Constructin of Scientific Facts (Beverly Hills, CA and London, England: Sage Publications, 1979).

8) Harald Buhaug, Informasjonsbehandling ved Fylkessjukehuset i Molde- Problemstrukturering Del 1 (Trondheim, Norway: Norsk institutt for sykehus-forskning, 1973). Harald Buhaug, Planleggings- og styringssystemer i helsevesenet. Problemstruktureringsprosjekt (Trondheim, Norway: Norsk institutt for sykehusforskning, 1974). H Buhaug, A Holen, J Lund and S Skandsen, Informasjonsbehandling ved Fylkessjukehuset i Molde. Del 2: Utvikling og utprøving av et forsøkssystem (Trondheim, Norway: Norsk institutt for sykehusforskning, 1976).

9) Richard R. Nelson and Sidney G. Winter, An Evolutionary Theory of Economic Change (Cambridge, MA and London, England: The Belknap Press of Harvard University Press, 1982).

10) Bruno Latour, Science in Action: How to Follow Scientists and Engineers through Society (Milton Keynes: Open University Press, 1987).

11) Michel Callon, "Society in the Making: the Study of Technology as a Tool for Sociological Analysis" in Bijker, Hughes and Pinch (eds.), 1987, op.cit.

12) John Law and Michel Callon, "The Life and Death of an Aircraft: A Network Analysis of Technical Change", Paper prepared for International Workshop on the Intergration of Social and Historical Studies of Technology, University of Twente, Enschede, the Netherlands, September 4-6, 1987.

13) For instance, in The Pasteurization of France (Latour, 1988, op.cit.), Latour writes: "No, there was only one man, Pasteur, whose strategy was itself a work of genius. (...) Let us not forget Tolstoy's lessonø. Without any doubt, Napoleon and Kutuzov were at the "head" of their troops. Once the complex of forces that set them in motion is broken down, we have to recognize what those great men did and why Bonaparte and not Stendhal, or Kutuzov and not Miloradovich, entered Moscow. Pasteur placed his weak forces

in all the places where immense social movements showed passionate interest in a problem. Each time he followed the demand that those forces were making, but imposed on them a way of formulating that demand to which only he possessed the answer, since it required a man of the laboratory to understand its terms. (...) In other words, Pasteur sought that glory, and sought it well."

14) Latour, 1987, op.cit.

15) John Law, "Technology and Heterogenous Engineering: The Case of Portuguese Expansion" in Bijker, Hughes and Pinch (eds.), 1987, op.cit.

16) Harry Braverman, Labor and Monopoly Capital. The Degradation of Work in the Twentieth Century (New York, NY and London, England: Monthly Review Press, 1974).

17) Arthur Francis, New Technology at Work (Oxford, England: Clarendon Press, 1986).

18) Robert A. Dahl, "The Concept of Power" in Behavioral Science 1957, 2/3: 201-205.

19) See, for instance, Barley, 1986, op.cit.

20) Finn Borum, "A Power-Strategy Alternative to Organization Development" in Organization Studies 1980, 1/2:123-146.

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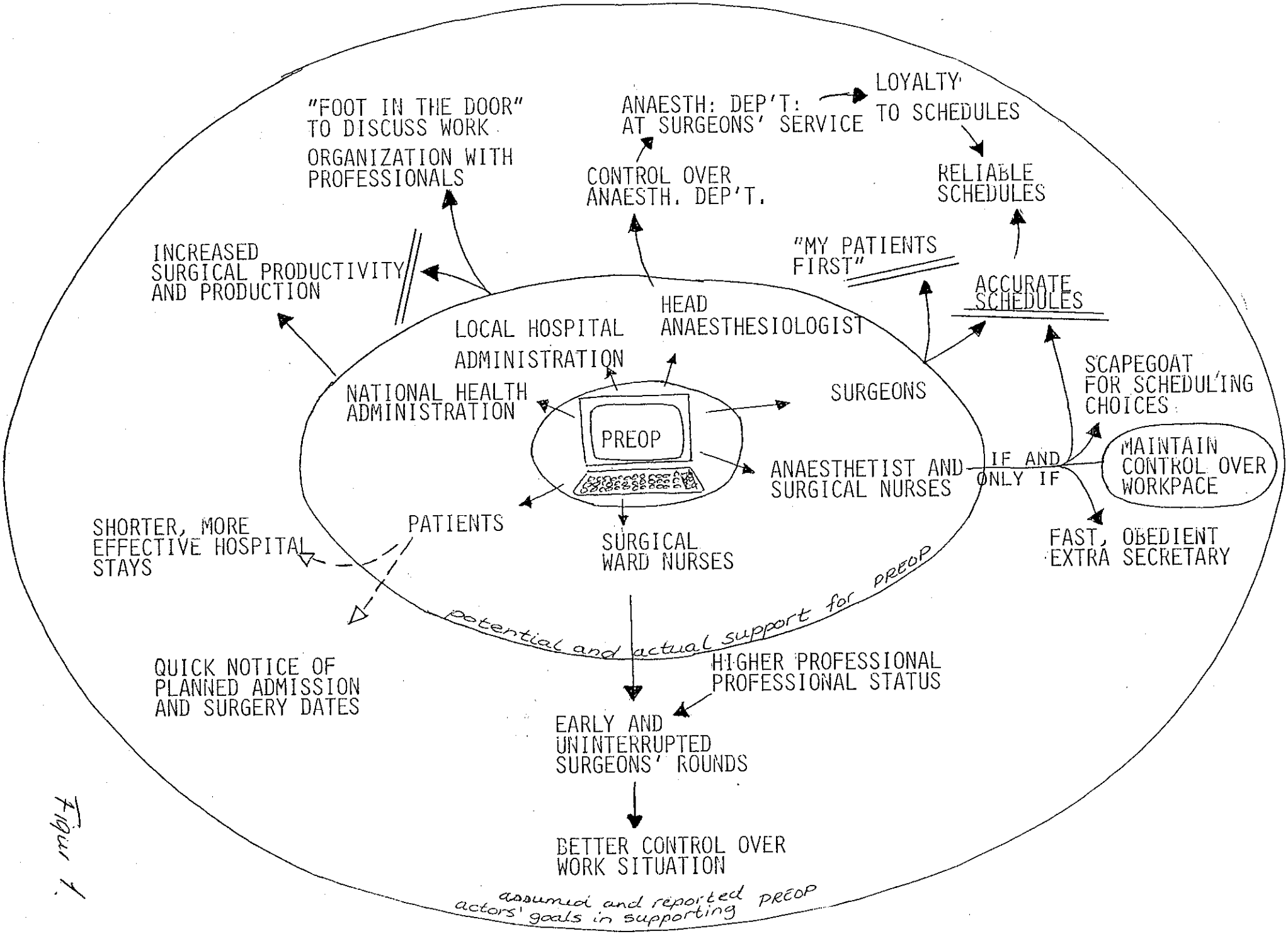
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assumed and reported PREOP actors' goals in supporting

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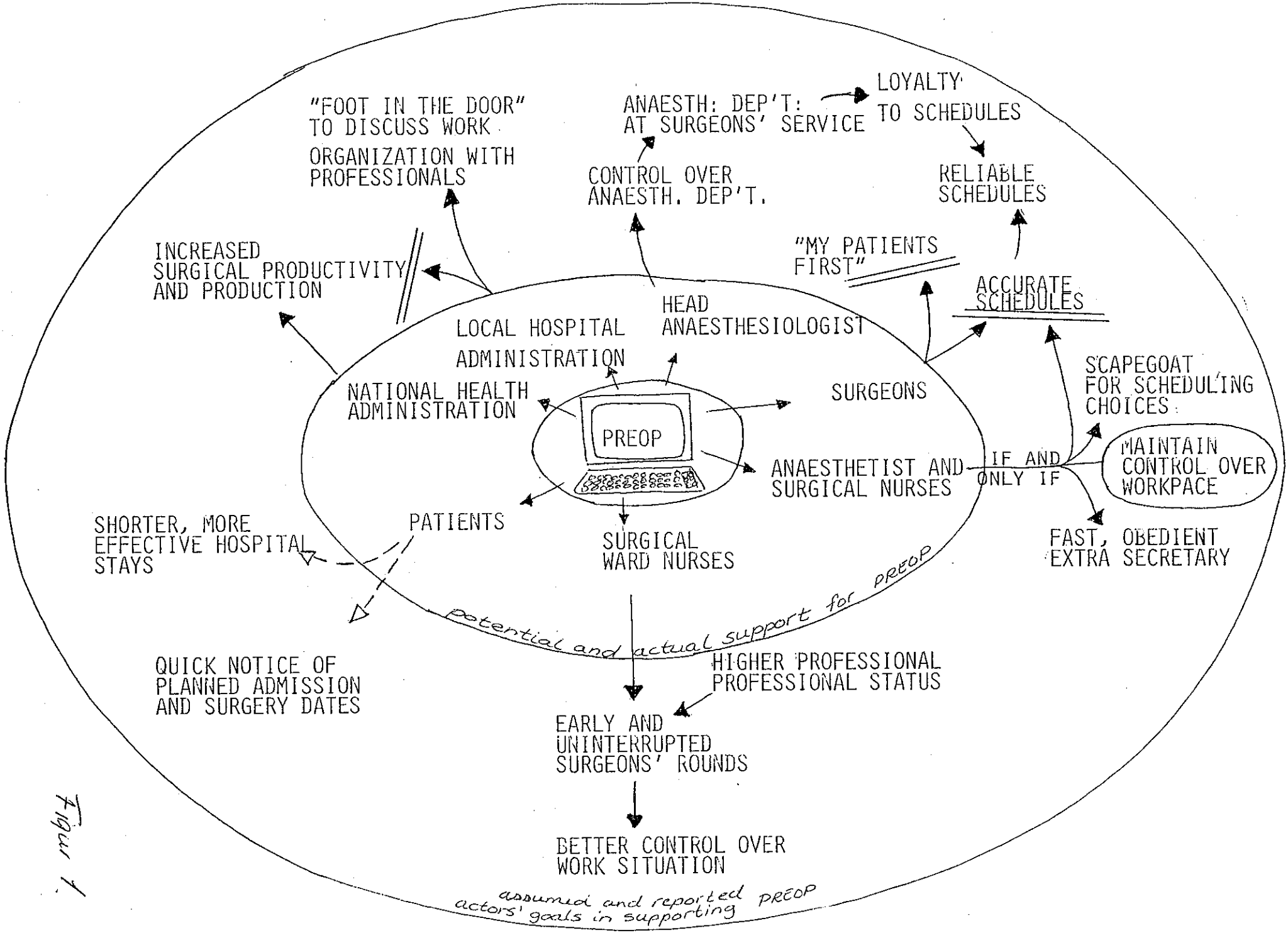
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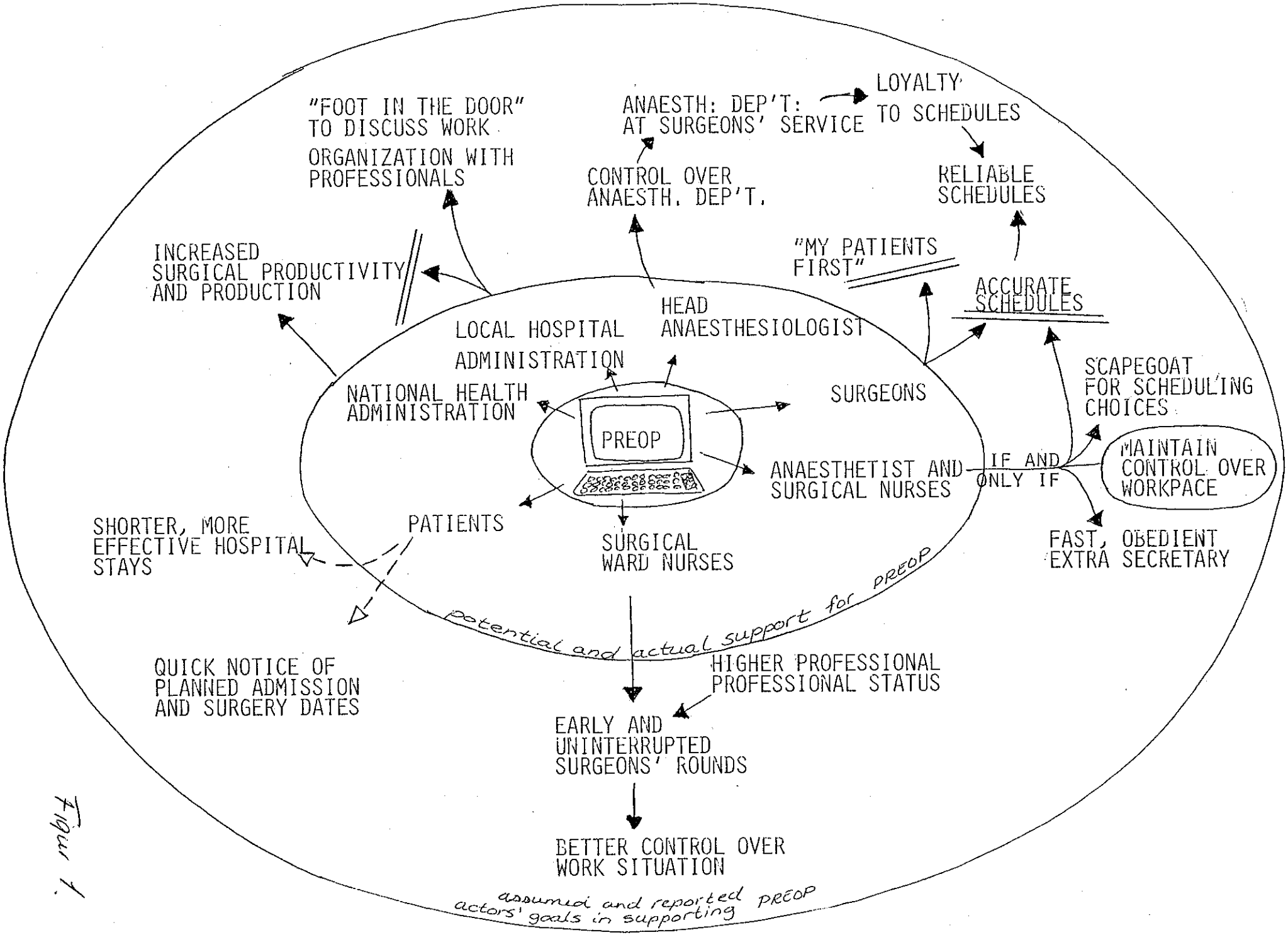
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