PLANNING AND BUILDING OF A NEW HOSPITAL FROM VISIONS TO REALITIES - EXPERIENCES FROM ST. OLAVS HOSPITAL IN TRONDHEIM

Arne Nesje, SINTEF Building and Infrastructure, Norway
arne.nesje@sintef.no

ABSTRACT

The planning and building of modern hospitals are demanding processes and must be based on multidisciplinary knowledge and skills. The author has taken part in the building process of the new hospital in Trondheim, Norway, with focus on planning for efficient building operation, management and maintenance. The paper summarises experiences and presents some factors that can be used to improve other building processes. We present both the early visions of the project and the realities during the process.

KEYWORDS hospital, planning, building, operation management, case study

INTRODUCTION

New and advanced health treatment methods make hospital buildings more and more complex and specialized. At the same time there is a continuous need for flexibility and adaptability in the buildings because of continuous change of users, services, and equipment and treatment methods. St. Olavs Hospital is the new regional hospital for the Mid-Norway health region. The new hospital is built on the same area as the old one that is still in use. The planning process started in approximately 1994. The first clinical centre was completed in late 2005. The entire project will be completed in 2014.

The goal was to create a building concept with design, details, -materials and technical services that will reduce future operation- and running costs and optimize the management process. This paper describes the process from the design brief phase to the commissioning process.

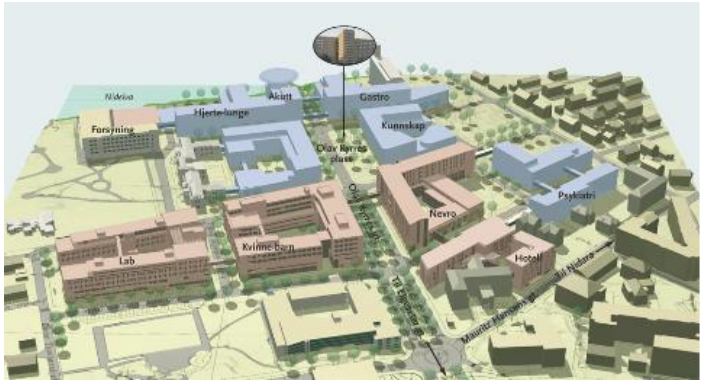

Figure 1. Building phase 1 is buildings in pink, phase 2 is marked in blue colour. (Source: HBMN)

Main topics are:

- the overall vision and the building concept.
- the planning process and project management
- the building process
- the "changing workplace"

The discussions, statements and the conclusions are mainly based on interviews with key personnel at STOLAV, HBMN and the contractors. These persons have been participators in the process and know the process very well, but from a different approach. The purpose with the paper has not been to evaluate the hospital and the process, but to gain more insight into the challenges that have been faced, and hopefully contribute to learning and improvement for forthcoming planning and building of hospitals.

Abbreviations used in the text: STOLAV= St. Olavs Hospital, HBMN= Hospital Development Project for Central Norway, HMN= The Central Norway Regional Health Authority, NTNU= Norwegian University of Science and Technology, HMN = The Health Authority, TD = STOLAV Technical Department

THE OVERALL VISIONS AND THE BUILDING CONCEPT

The vision for the Hospital: St. Olavs Hospital (STOLAV) will be one of the most innovative in Europe (Helsebygg Midt-Norge: The new hospital in Trondheim).
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The goal for the design team has been to design the hospital from scratch to fulfil patient needs. The architectural design which won the project focused on untraditional ways of organising patient treatment; "The Centre model". Patient benefit is the guiding principle for work on the new university hospital. It comprises one hospital in several buildings ('Centres'). Each Centre has focal points for the related medical treatment. The buildings, as well as surroundings, equipment, treatment and nursing will be based on what best serves the patient.

A slogan was "Better services at lower cost." One of the benefits of building a brand new hospital is the opportunity to reduce the operational budget by 100 million NOK compared with the budget of the existing hospital that is old and inconvenient to operate. This saving should be reached by new space- and cost-efficient buildings combined with medical treatment methods that can reduce the average length of stay.

The building phase 1 (1994 – 2005) consists of five buildings: Laboratory Centre, Women and Children Centre, Neuro Centre, Suppliers' Centre and a Patient Hotel. Building phase 2 (2005-2014) will consist of an Abdominal Centre, an Environmental Centre, an Emergency Centre, Cardiothoracic Centre, Mobility Centre and Psychiatric Centre.

More than 80% of the existing hospital buildings will be demolished. The Health Authority (HMN), owned by the State, has approved STOLAV for at least 197.500 square metres when it is finished.

PLANNING PROCESS AND PROJECT MANAGEMENT

In some mandatory documents (i.e. a technical programme, environmental programme, and aesthetic guidelines) HBMN has worked out the main design criteria and concepts. We will here focus on some of them and show how they influence the building process and the final results.

Main technical concept for all Centres (Technical programme for better standardisation, source "Helsebygg Midt-Norge: Rapport teknisk program")

Building phase 1 was organised in five main enterprises, one for each Centre. The goal was a high degree of integration, standardization and coordination of building services into all Centres.

Designing and constructing hospital buildings with different users' requirements creates many challenges. HBMN worked out the technical programme containing standards, regulations and functional demands and user needs that were used through the design and planning phase. Also the Environmental programme (MOP), aesthetical guide and HSE document were mandatory for the planners.

Each of the Centres had a separate planning- and design team with own architects and consultants. Each Centre was requested to collaborate to find as many standardised systems and solutions as possible. If they wanted to deviate from the principles in the technical programme, they had to justify and explain why.

Lesson learned: The design of complex hospital buildings with high levels of service requires very close cooperation between building services and hospital engineering services. Harmonisation has been reached to a satisfactory level due to the fact that different buildings shall fulfil different user needs. From an O&M (Operation and Maintenance) point of view, the design of each Centre could have been even more harmonised so they could simplify future services. Advanced technical systems need highly qualified caretakers. The caretakers must also be supported by many subcontractors and outsource services.

Considerable variations of systems that need different O&M procedures can mean that efficient service- and maintenance becomes more problematic and cost intensive.

The technical installations and - systems

A goal was to make energy efficient buildings and to reduce energy consumption compared with the existing situation. The indoor climate must also be of high quality and flexible to fulfil future needs.

Technical infrastructure should be designed with 20% overcapacity of HVAC (both in output capacity and space available for future needs) and 30 % output of electric power. During the building and commissioning process it seems that a lot of this capacity has already been used in the service shaft, services pathways and suspended ceilings.

Energy calculations made by the LCC tool *LC-profit* show that the average energy consumption is rather high (source: "LCC beregninger i forprosjektfase").

Figure 2. HVAC need space in modern hospitals (Source: HBMN)

Heat recovery systems are installed many places, but not all over. The reason was to reduce the investment costs.

Lesson learned: The goal to reduce energy will not be fulfilled in a proper way. Even if STOLAV has very favourable energy rates from the local district heating supplier, energy will be a high budget cost in the future. “The cheapest energy is the one you never use.”

Interviews we made in the commissioning phase mapped the following wishes from STOLAV Technical Department for improvement on technical services:

- More standardised, but also more energy efficient heating and cooling systems
- More standardised solar shading systems
- Standardised panelled ceilings
- Fewer suppliers and systems for doors and windows.
- Standardised (prefabricated) bathrooms that reduce risk for water damage. (Already implemented in phase 2)

High environmental profile shall be reached through the Environmental Programme.

The environmental programme (MOP) (source: “RIT200/Helsebygg Midt-Norge: Miljø-oppfølgingsprogram”) was a part of mandatory document in the planning- and building process.

The vision was of a high environmental level, both in design of the buildings and during the construction process. The environmental programme put focus on sustainability through:

- Optimise and standardise the choice of materials
- Health, environment and safety on site, including a reduction in inconvenience for the surroundings and existing hospital
- Energy efficient buildings and good indoor air quality and temperatures.
- Environmental demolition and reuse of existing building materials

Optimise and standardise the choice of materials

A materials guide (source: ”Helsebygg Midt-Norge: Veileder for materialvalg”) and a system that controlled the choice of building materials were developed *by HBMN.* The guide defined minimum criteria and recommendations for building products, to avoid hazardous chemicals,

high emissions or short durability. When the contractors had chosen a specific product they reported this to a controlling group with a mandate to check out both the product data sheet combined with experience in practical use. Recommended products were put into an intranet database. The database was organised by the HSE unit (Health, Security and Environment) as a service to the contractors so they could check out the environmental profile and could confirm that their choices were according to the owner's and client's specifications.

Such a database has obvious advantages. The owners give criteria for product quality and recommendations for choices. The selected products for different purposes are collected in a database so they are easy to find and easy to verify that the product is acceptable. In the database there is also information about maintenance needs and cleaning procedures for surface products. Experiences from building phase 1 are made available through the database for architects, planners and contractors in building phase 2.

Figure 3. What about wood parquet floor in the Blood Bank? The database shall give answer (author's photo)

Life Cycle Costing (LCC) calculations

Life Cycle Costing calculations should be made to take into account the cost and benefit through the total life cycle (investment, operation, maintenance, demolition / end of use). A Life Cycle Costing calculation for each Centre was done in the pre-engineering phase and was delivered by the consultants in collaboration with HBMN [9].The intention was that total cost figures could influence concept –and material choices.

Lesson learned: LCC-analysis was not actively used for comparing alternatives by showing cost/benefit for different choices. It became more a verification of the anticipated cost and a basis for making future operating and maintenance budgets.

Health, environment and safety on site

The goal was a building process with very low H- factor (number of injuries per $1x10^{6}$ working hours). The H-factor among the contractors in building phase 1 has been 13. The goal was 10, while the average within the construction industry in Norway is 20.

Lesson learned: The goal has not been reached, but the process has been far better than on an average building site.

Note: HBMN have announced that the injury risk shall be further reduced and the goal in building phase 2 is H < 5, which is very ambitious.

Figure 4. HBMN had high focus on reducing injuries and safety for the craftsmen (source: HBMN)

Reduce inconvenience for the surroundings and the users of the existing hospital

The goal was to give good quality information to the neighbourhood, patients and employees through newspapers, radio/ TV, internal papers, notice boards etc.

Lesson learned: The huge building process has taken place without too much unnecessary inconvenience for the surroundings and the existing hospital. Traffic jams are inevitable when such huge building sites are localised in an already heavy trafficked area. HBMN have been highly focused on the necessity of giving information and for us it seems they have succeeded.

Careful demolition, reduced waste and reuse of building materials

Lesson learned: The goal was to reduce the waste and to reuse building materials. About 80 % of the existing buildings are already or will be demolished. Before starting building the new Centres, about 100.000 m^2 (80 %) of old buildings were demolished. A lot of the heavy building materials such as brick and concrete have been reused on site as landfill and base course for pavements and parking places. This teardown and demolition process received a lot of publicity and have been characterised as an environmental friendly process.

THE BUILDING PROCESS (HIGHLIGHTED FROM KEY ACTORS FROM DIFFERENT SECTORS)

Co-operation with medical departments in the Hospital

HBMN was established as a project organisation outside STOLAV. That was a political decision and the idea was to be independent from the existing hospital to develop both new medical treatment methodologies and new buildings that can adapt to future needs.

HBMN coordinated all the processes. There was in average 80 - 100 people employed in the organization. They administrated the design-, bidding -, construction-, commissioning -and moving in process. Each Centre had their own planning- and management group that was responsible for running the process and keeping to the building budget. The intention was that all planning should take place in close cooperation with the medical and technical staff of STOLAV.

Lesson learned: Some of the representatives from STOLAV claims that HBMN have planned and constructed without taking user needs sufficiently into account and they did not listen enough to both the medical and technical experts with long experience in running hospitals. HBMN has recruited personnel with high professionalism and competence in construction management, but equal strong experience in hospital project of this size and complexity has been hard to find. Good knowledge in medical treatment methods and user needs are necessary and of great advantage in the planning process.

One example of challenges in the co-operation with the STOLAV organisation is the discussion about the choice of a "Centre – model", - where each of the individual buildings have focal points for the related medical treatment. The model have been opposed by some of the hospitals representatives, claiming that it would raise the cost of running the hospital (especially the need for a more medical employees, such as anaesthesia, X-ray and surgery personnel).

Co-operation with STOLAV Technical Department

STOLAV Technical Department (TD) is responsible for operating and maintaining the building and technical services.

TD has run the old buildings in full operation throughout the building process and at the same time, they have supplied operational and maintenance skills to the planning phase to secure involvement in choice of systems and materials. Resources have been used for technical support and technical inspections during the whole building process and in the commissioning process by the contractors.

TD is responsible for operation and maintenance system (O&M-system) for buildings and technical equipment and also to support the process by collecting and archiving "as built documentation".

A Facility Management System (FM-system) should be ready for use by the caretakers. This process has been delayed and there is still a lot of work to be done. The risk is that the information will not be complete nor continuously upgraded if the system is not finished and tested out in the commissioning phase. Such a situation causes potential trouble for future efficient operation and maintenance.

The medical users have high expectation levels for the completion of the buildings when they moved in. Modern hospital buildings are technically very complicated. The fact that calibration of the technical systems takes time can sometime be difficult to understand for the medical staff. A full scale test-run of a minimum of 8 weeks, where all systems should show stable conditions has become a criterion for completion of the contractors' work and taking over.

STOLAV generally refuses to take possession of the Centres before it has been verified that they have received what should have been delivered and the test-run shows that everything works properly. The risk for TD is to take over too early, as this will indirectly mean that they accept the quality “as delivered”. STOLAV must in such cases use the operating budget to finish the buildings instead of the cost being covered by the investment budget of HBMN.

Lesson learned: There must be sufficient time and personnel recourses in the budgets to make test-run programmes and execute tests together with the contractors and producers of technical equipment.

The cooperation with the contractors

The building process was organised by separate contractors for building shell, HVAC, electrical installations and furnishing for each Centre. HBMN coordinated the whole process by flow sheets, milestones and finish dates.

The planned time schedule gave few opportunities for delays. Each contract had a finishing date for commissioning. The technical contractors were also responsible for test-runs, calibration and implementation. They should also deliver maintenance and management documentation.

HBMN had their own construction management that should follow-up the progression of the contractors. Since all the enterprises had almost concurrent time schedules, this created a boom for the local building sector. The result was a lack of highly skilled craftsmen from the region and many were hired from abroad. Complicated installations and coordination require good language skills on site, which can be problematic to achieve.

At some points there have been about 1000 craftsmen at the same time on the building site. It has been a huge challenge for HBMN to develop systems to ensure enough control over the contractors’ work. This has stretched the already limited resources for follow up and control.

There will always be unforeseen delays, essential modifications, and discussions with the contractors - both on technical and financial issues. HBMN and STOLAV carried out their own controls on site and felt that the work quality was too variable. Due to delays, the test-run period was reduced from 6 month as planned, to a few weeks. That caused several problems at the first Centre. In particular, the commissioning phase and handover seem to have been underestimated and not considered the unexpected complementary work. There were generally more c*hanges, supplementation* and *claims* than anticipated.
Changes are the supply of orders to the contractors for interior work.
There will always be the need for interior modification and adjustments due to unforeseen changes of medical treatment and equipment. Since it takes approximately 5 years from when the internal furniture and medical equipment was planned until installation, new requirements were desired from the medical employees. Necessary changes have to be made and have been paid for by STOLAV.

Supplementation is necessary adjustments to optimise the construction and the interior design even if the contractors have built as shown on the drawings. This work will be paid by HBMN.

Claims are complaints to the contractors due to bad workmanship or deviation from drawings and design. Claims or guarantee work will be done by the contractors or suppliers.

Figure 6. Water leakage in the new bathrooms causes frustrations, delays and money (author's photo)

Lesson learned: High time pressure, delays, risks of day fines, overcrowded worksites and a lack of efficient controlling systems can easily lead to frustration both for employees, project managers and contractors. Several recorded needs for changes, supplementation and claims were recorded by HBMN in the commissioning phase connected to the handing over-, run test- and moving in process.

According to the project organization, the budget overrun is not higher than expected. Some extra and unforeseen costs were originally put in the budget. On the other hand, the contractors have done considerably more work than defined in the bidding process and contracts.

THE CHANGING WORKPLACE (NEW MEDICAL TREATMENT ORGANISATION MODEL)

The vision for "the Centre" model was: "For the patients benefit". Combined with moving into new hospital buildings, STOLAV shall organise the medical treatment differently from the existing traditional working methods. A new organizational model was planned for a large number of the medical employees. In 2005 there were approximately 8200 employees. There are about 930 somatic beds but this number will be reduced in the new hospital. There are 340,000 patient days. Outpatient numbers are about 286,000, and likely to increase due to more efficient and modern medical treatment requiring fewer inpatient admissions.
New medical organisation, including also new colleagues and treatment groups, combined with a moving process to new hospital building, new area, and new medical treatment equipments at the same time is potentially very demanding and challenging for the organisation.

New substantial investments in IT-systems should give new opportunities to send and receive information to the right place at the right time (source: “Helsebygg Midt-Norge: The new hospital in Trondheim”).

The moving process

“We should never have moved to the Laboratory Centre at the time we did. The pneumatic dispatch and the computer system were not tested out to full scale. We took a high risk by moving into a Centre without having a medical test-run period.” (Centre Director, source: Adresseavisen).

The medical employees felt the moving period problematic. Three processes should have happened at same time:

- A restructuring process where staff was to change work tasks.
- A new organisational structure without a sufficient training programme.
- A stressful moving-in process to a new building

Lesson learned: The restructuring process must be very well planned and prepared for before the physical moving process starts. A training/learning programme for new analysis equipment must be planned for and carried through before it become a part of the daily treatment routines.

By reorganising and moving to new facilities, it is only possible to make plans up to a certain point. Then, based on collected experiences, further plans can be executed.

Short test-run periods have meant that the technical systems such as HVAC, pneumatic dispatch, lifts etc. did not all work properly. This was especially the case with the communication and information technology systems such as phones and in-house networks, which must have 100% functionality. But also emergency preparedness and internal routines for handling unforeseen situations was challenging when not tested properly. If such systems are not reliable, people use great resources on ’back-up’ routines to get the job done.

Communication of information is highly essential in this phase. The system must define who is responsible for what, who shall be contacted, what must be done until critical elements function properly, efficient feedback systems etc.

With hindsight, it has been claimed that the organisation was not sufficiently well prepared and the building and medical equipment were not properly tested out. A smooth moving process must be very well planned. Especially the moving of the patients which must not be done until all the critical elements are tested out to full capacity, and the stability and functionality are controlled and verified. The STOLAV and HBMN strategy was to first move the laboratory Centre that does not have patients, which was judicious.

Start-up and moving problems can easily overshadow the total quality and diminish users’ enthusiasm for starting to work in the new Centres. It is not a favourable situation to mix building craftsmen working in the same area where there is ongoing medical treatment.

Parallel operating the old and new hospitals increased the cost.

It has not been easy to find detailed budget estimates from the early planning phase on how to save 100 million NOK (12,5 million Euro) compared with the running budget of the existing hospital. A detailed budget for extra costs for running the existing buildings and building new Centres on the same site has not been made. That should have been calculated so it was possible to take this cost into consideration. One critical aspect is resources for handling emergency wards. Today's single emergency unit serves most of the medical treatment and has fully equipped units for 24-hour use. It will be very expensive to offer the same 24 –hour emergency ward at each individual Centre. The scepticism from STOLAV staff at an early point suggested that this could be a problem. Especially the limited capacity of surgery-, anaesthesia and X-ray- services.

Note: To solve this problem a 24-hour emergency department will be built, that will be available for all Centres after 6pm. Before this is finished, services must partly be given in both the old and the new Centres.

"There is today no budget for running the Centres as they are planned for" (Quotation from STOLAV general director, source: Adresseavisen). The solution may be that the administration of STOLAV decides to let parts of the new hospital stay unused for some time. Existing and new employees intended for the new organisation will then temporary be transferred to other tasks.

Changes in HBMN organisation and building process of phase 2 (2006 – 2014)

The experiences described above have led to the discussion of an alternative method of organising building phase 2. A new organisation has started the planning and building process. They will take the ideas that are working well from phase 1 but make some modifications.

In phase 2 the design and construction process will be organised as a partnering process. That means a high involvement of suppliers and subcontractors with goals to improve quality. Greater involvement of all actors is needed to share the risk but also the reward. The model is intended to reduce costs, reduce the amount of defects and inaccurate work, and raise motivation between the partners.

Four new Centres with a total of 90,000 m^2 will be coordinated as one partnering contract. Transverse enterprises such as air-conditioning, piping and electrical installations will be planned by the same consultants for all buildings. To secure optimum communication and efficiency, the whole partnering group shall be located in the same building during the design phase.

"From defence and mistrust to partnering and confidence" (Quotation from HBMN general director, source: "Kursdagene 2006- NTNU: Nye samarbeidsformer. Case St. Olavs Hospital").

SUMMARY

The overall vision and the building concept

The overall vision with individual buildings that have focal points for the related medical treatment may seem to increase both investment- and operational cost, especially in the period until the total hospital is finished (2014). The slogan “Better services at lower cost” is probably a vision that will prove to be hard to fulfil. But the patients will probably be the long-term winners with single rooms with bathroom, high standards of service, good architecture and a pleasant environment. The challenge will be to get the necessary funding for running the hospital.

Figure 6. STOLAV offers single rooms for all patients (Source: HBMN)

The planning process and the project management

Many interviews indicate how difficult it is to combine many functions and requirements in one building concept. Different architectural, technical-, functional- and economic interests will often cause conflict.

The project organisation HBMN was organised outside the administration of both STOLAV and HMN. A closer connection and better cooperation with STOLAV may have resulted in more influence from the medical employees. It is probably fair to anticipate that the medical employees would have felt more ownership of the process and thus be more satisfied with the concept and the result. On the other hand the organisation of the project outside the hospital administration may have contributed to better control and more professional management of the construction project.

The management for planning and building (technical programme, environmental programme, aesthetical guide etc.) have improved the technical standard and reduced the risk of failure and bad workmanship. The need for control on site was probably underestimated.

For STOLAV technical department (TD) the building process has been time-consuming by giving support, making controls and preparing the take-over phase. But during this process they are also better trained to run and operate the new centres.

The commissioning phase has been a challenging phase. There were generally more changes, supplementation and claims than anticipated. The investment costs are nearly on budget, but the concept will have negative effect on the running costs of the hospital. The budgets for running both the old and new hospital until phase 2 is finished have not been calculated properly and can reduce the level of ambition in the further process.

The moving-in phase was a little postponed for some of the Centres. Only the Laboratory Centre has moved in on time. They realised immediately that the buildings services had not been tested out and adjusted properly. In addition they also realised that they should have had a better training programme for the new organisation before moving in. This situation was very challenging the medical employees.

With experience from building phase 1, HBMN decided to change the contract model for building phase 2 to a partnering process. That means higher involvement of suppliers and subcontractors with a goal to improve both quality and efficiency. A greater involvement of all actors is needed to share the risk but also reduce costs.

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