# New Landspítali - University Hospital Project (NUH)

# Main Equipment Program

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# 1 Introduction

## 1.1 Goals

- To clarify the plan process, organization and staff/personnel for the project
- To clarify goals and program prerequisites
- To estimate equipment cost
- To establish superior strategies for choice of equipment and for reuse of existing equipment
- To clarify goals within capacity, productivity and operation economy in relation to planned equipment investments

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The document version 1 reflects the status at the end of the Sketch project, and there may be revisions in the following phases.

## 1.2 Differences between building and user equipment

In similar projects to that of Landspitali, it is common to divide equipment into two main sections:

- Building equipment includes all the equipment attached to the building, and equipment included in the building's infrastructure
- User equipment includes all movable equipment

This definition is unproblematic for most of the equipment. However, in some cases it can be difficult to draw a distinct line between building and user equipment and there may be uncertainty about responsibility for the equipment. A list of equipment should therefore be made to show where uncertainty has been experienced regarding responsibility in the past. The content of this "gray-zone" list should be clarified at an early stage of the project. This type of clarification will affect the budget and the responsibilities for planning different types of equipment.

Equipment that falls into the 'building equipment category' in the budget is normally planned by the projecting personnel (architect, advising engineer electro, and advising engineer for heating, ventilation and sanitary installations). Equipment that falls into the user equipment category in the budget is normally planned in a separate process with strong influence from the users. The user equipment is included in the Main Equipment Program and what we later will call the equipment project.

Experience shows that certain types of building equipment should be purchased in a process similar to user equipment, led by project leaders and user equipment advisors. In the Nye Ahus project, equipment such as flue lockers, safety cabinets and isolators are defined as building equipment but they are purchased by the equipment project in close dialogue with the users.

It is recommended that equipment areas that require a discrete planning and purchasing process across the planning and purchasing processes that are used in the building and equipment project are identified at an early stage of the project and are organized in an appropriate way.

## 1.3 Types of user equipment

In this project, we separate user equipment into five categories:

- Medical technical equipment (ME)
- IT equipment (IT)
- Furniture, movable articles and cloth/fabric (FU)
- Basic equipment (BE)
- Clinical software systems (CS)

### 1.3.1 Medical equipment (ME)

ME must be installed and maintained according to legally prescribed requirements. Therefore it is advantageous to define the distinction between ME and other user equipment categories. In particular the distinction between ME and IT can be difficult. Examples of ME are:

- Equipment for clinical purposes, patient treatment, and examinations
- Surgical instruments

### 1.3.2 IT equipment (IT)

IT that is directly connected to medical technical equipment and that is used to operate/run the equipment must normally comply with national regulations for medical technical equipment. IT that is mainly used in administrative/patient administrative routines is normally not regarded as ME (medical equipment). In addition, formative infrastructure connected to ICT such as wall cables, central equipment etc. is not regarded as IT/ICT equipment. This equipment is normally covered through the planning of building equipment.

Computer programs in user applications are normally not regarded as user equipment. Costs related to such programs are covered by the operations budget. However, integrated system solutions of data programs and ME are regarded as user equipment if the data program is part of the equipment’s functionality and the costs are integrated into the equipment price. The same practice goes for system data solutions, for instance in servers where formative functionality depends on the data program to be installed. In some cases it can be advantageous to create a specific category for medical ICT (MICT) in order to separate this type of equipment from usual IT equipment. Examples of IT equipment are:

- PCs
- servers
- patient terminals

### 1.3.3 Furniture (FU)

Furniture, movable articles and textiles include:

- Movable furniture (attached furniture is building equipment)
- Other movable equipment for which the architect/interior architect has the responsibility

### 1.3.4 Basic equipment (BE)

Basic equipment includes:

- Patient beds and bedside tables
- Transport equipment (trucks, trolleys, snow removal equipment etc.)
- Light kitchen machines and equipment
- Equipment for the operation and maintenance sections
- Moving costs for ground equipment

### 1.3.5 Clinical Software systems (CS)

All software systems used to support the clinical activities in the hospital are labeled as CS. In this project these systems will be planned, purchased and integrated with other technical systems as a part of the equipment project for New Landspitali.

# 2 Summary

Hospital building is a large and complicated process – large because the space and economic consequences are considerable, and complicated because many of the activities are integrated into and dependent on each other.

In this description of the planning process, we use "programming" to describe all the activities which lead to requirements related to building and equipment. "Design" is then the process of making solutions that meet these requirements.

The main phases in the equipment project after the MEP are:

- Preliminary program user equipment (2008)
- Detailed program user equipment (2009)
- Purchase of user equipment (2010 - )
- Receiving, inspection and assignment of user equipment (2012/2013 - )

In this project, we separate user equipment into five categories:

- Medical technical equipment (ME)
- IT equipment (IT)
- Furniture, movable articles and cloth/fabric (FU)
- Basic equipment (BE)
- Clinical software systems (CS)

Within these categories we find equipment with building influence – EBI. The basic definition of EBI in this project is recommended as:

**Equipment defined as EBI has properties that result in a need for the design team to take these properties and requirements into consideration when designing buildings and rooms in order to achieve an acceptable interaction between equipment in rooms and the building/room where the equipment is located.**

The progress for detailing EBI is:

<u>By the end of the preliminary program:</u>

- List of all articles planned in the project evaluated to be EBI, and technical specifications for these articles
- List of existing and useable equipment with technical specifications other than those planned, including technical specifications

By the end of the detailed project

- List of articles with updated/new technical specifications since the preliminary program.
- List of all technical EBI changes since the preliminary program.

Several advantages are gained by establishing an equipment pool over several departments:

- Simplified procurement (fewer types)
- Less costly procurement (discounts)
- Simplified maintenance
- Simplified procurement and storage of disposables
- Simplified training of staff
- Flexible operations
- Increased possibility of backup equipment

An important part of the planning for the new Landspitali is to evaluate the condition and value of the existing equipment in today's two hospitals and to assess how much of this equipment can be used in the new hospital. For Landspitali, this process will be influenced by the fact that much of the most modern and valuable equipment is leased on five- to seven-year contracts. First there must be a strategic decision – is the hospital still to operate with these leasing contracts or buy new equipment? Normally approximately 25 % of the total need for equipment can be covered through existing equipment.

Integration between IT systems and medical equipment is a main task for the project. This is critical for ensuring the efficient and high-quality operation of the hospital. To succeed, this requires close integration between the technical design team and the equipment project.

# 3 Technology development

## 3.1 General trends in medical technology development

A common experience is that it is difficult to give a valid general forecast of coming new medical technology or to extrapolate existing trends, even over a horizon of only three to seven years. Equipment development and technological industrialization has in general a horizon of the same order as the planning and accomplishment of a hospital planning and building project (six to eight years from basic concept to finished product). Some areas have a very fast development rate, though this is often not evident when the process starts. As a consequence, an equipment project has to be sufficiently open-ended so that early decisions do not exclude later and more efficient possibilities that may become apparent during the process. The process must be designed to allow both the implementation of new existing technology and new disruptive developments during the project period.

## 3.2 Current main trends in medical technology

- Analog image diagnostics are being replaced by digitally-generated images with better resolution and faster acquisition time. Traditional anatomic imaging is being supplemented by biological, functional and molecular imaging. Fast digital signal processing and high computer processing power present new methods for visualization and valuable image presentation. Information technology development is extremely fast.

- Gene technology and molecular biology are establishing a basis for new diagnostic end treatment technology (e.g. genetic engineering) and equipment. Biosensor technology renders new diagnostic methods possible. The development is very fast and has brought many surprises.

- Diagnostics and treatment, surgery included, are less invasive and more minimal and non-invasive. Robotic surgery will have a more central role. There is a convergence of existing technologies. One effect of this is interdisciplinary integration and a change in the character of the traditional medical specialities. An example: during recent years new development of twin tube CTs with high rotation velocity and multi-slice imaging has facilitated a new method in heart diagnostics, since ischemic areas (with low oxygenation) can be imaged directly. This development can drastically reduce the need for coronary care units (CCUs) in a hospital. It may thus become economically interesting to replace beds in the CCU by a CT.

- New materials technology is facilitating the development of completely new methods such as micro-machining and nano-technology. The consequences will probably evolve in all main areas of the medical technology discipline. Prototypes are now being replaced, and real products based on these technologies are being presented.

- The generation lifetime of new technologies and equipment is becoming increasingly shorter. The general technological development follows an exponential curve and the changes are becoming faster all the time. The equipment is becoming professionally outdated before it is technically outdated or obsolete. For instance, with the release of an ultrasound imaging equipment with four times the pixel resolution as that of the former model, the old equipment is immediately outdated professionally – even if it functions in the way it did the day before.

Due to the short generation lifetime of medical equipment, the teaching and training of the clinical users become an important issue. During the procurement process, contracts for training the staff in the new equipment must be handled as part of the process. Alternatives for continuous competence assurance might be to establish different training centers or simulators. Under such organization, the clinical users can practice on the equipment with no consequences for the patient.

In general there is a demand for cost containment within health care, which probably influences the professions involved. The workflow within the traditional professional medical specialities might change. The role of the physician is being transformed from that of a traditional craftsman to a role that more resembles industrial production. A paradigm shift in roles and working processes will obviously influence the need for equipment and which equipment is procured. Thus, in addition to designing flexible building structures, the equipment technology must be selected so that it will be sufficiently flexible to allow restructuring to new equipment and methods. The effect of this is a demand for modularity, standard solutions and backward compatibility.

All medical modality images in the hospital must be presented in a single standard such as DICOM. New equipment still not invented will then in principle be backwardly compatible to the former generation's standard and can be connected directly to the network and production.

Integration between IT systems and medical equipment is a main task for the project. This is critical for ensuring the efficient and high-quality operation of the hospital. To succeed, this requires close integration between the technical design team and the equipment project. In the sketch project, personnel from Nosyko (equipment project) has worked together with the design team to work out a document regarding ICT-MTE interface, se also Sketch project report, chapter 13.04.

# 4 Main guidelines for planning and purchasing user equipment

Hospital building is a large and complicated process – large because the space and economic consequences are considerable, and complicated because many of the activities are integrated into and dependent on each other.

In this description of the planning process, we use “programming” to describe all the activities that lead to requirements related to building and equipment. “Design” is then the process of making solutions that meet these requirements.

The planning process is characterized by some important issues:

- The programming of building and equipment lays the foundation for the design of the building. This means that the building should be constructed to provide for future activity’s need for space and equipment.

- The design phase is the most time-critical and expensive of the planning activities. This means that the time schedule for the programming of space and equipment must ensure that the design team is given the necessary information in time.

Participants in equipment planning and purchasing often want to buy the equipment as late as possible in the process in order to get the most modern equipment available on the market. This can be difficult for the design team who need accurate information about the equipment in time to adjust the technical design of the building to the equipment in the various rooms. To find the right balance between these two elements is a major challenge in the planning process.

## 4.1 Phases in the equipment project

The main phases in the equipment project after MEP are:

- Preliminary program user equipment (2008)
- Detailed program user equipment (2009)
- Purchase of user equipment (2010 - )
- Receiving, inspecting and assignment of user equipment (2012/2013 - )

### 4.1.1 Preliminary program user equipment

The main goal in the preliminary program is to establish the foundation for an accurate budget and to make priorities concerning the equipment the hospital wants to buy. The preliminary program also gives important technical information to the design team.

- The preliminary program consists of both a gross equipment program and a net equipment program.
- The gross program is first developed as a detailed plan for all kinds of user equipment in all rooms, independent of whether any of these items can be moved from the old hospital.
- All existing and usable equipment is then registered in the database. This gives us the net program which is all the equipment planned, minus the existing usable equipment that is to be moved.
- The net equipment program is in other words all the equipment that the project must *purchase.*

As soon as possible in the preliminary project, the equipment project will prepare an overview of all the equipment with building influence. (Short term: EBI see chapter 4.3) The technical information for this equipment is critically important for architects and technical designers.

By the end of the preliminary project, it is possible to prepare a calculation for all the equipment in the hospital, both gross and net.

The need for equipment is specified per room, and it is possible to see the gross equipment cost per room and department.

### 4.1.2 Detailed program user equipment

The detailed program for the user equipment is an extended and more detailed version of the information provided in the preliminary program. The main goal in the detailed program is to give every article in the database its technical and functional specification, to do more work on priorities for purchase, and to refine the calculation for buying equipment.

In this phase the existing equipment is linked to each room in the new hospital. In this way it will be possible to acquire an overview of what must be purchased for each room or moved from the old hospital.

All equipment is specified with its requirements regarding the building. Preliminary to this phase, the project must therefore have a strategy as to how integration questions should be met. In particular the integration between IT and medical equipment must be solved through an overall strategy and requirements for integration.

By the end of the detailed project the equipment project must have:

- A correct and updated equipment database that shows the equipment that is to be bought and the equipment that is to be moved from the existing hospital, for every room in the project.
- Technical specifications for all equipment articles as far as these are known.
- Functional, vendor-independent requirements for every single article to explain the required functionality and for use in the coming purchasing phase.

### 4.1.3 Purchase

Based on the detailed program for equipment, a detailed purchasing plan for user equipment is now drawn up. The plan lists the articles that should be included in each tender group when the tendering process starts, and when to purchase and receive equipment from different tender groups.

Competition documents are prepared for each purchase. The documents must contain:

- Overall tendering rules for purchasing equipment and information on the project
- Tender and contract rules
- Overall requirements for equipment, including integration requirements and how equipment specifications must be transferred from vendor to design team and constructors
- The building's requirements regarding user equipment
- Quality and quantity specification of the equipment articles included in the tender group
- Time schedule for the purchase, also dates for delivery, installation and testing
- Options
- Requirements regarding service contracts
- Requirements regarding learning period

Based on the competition documents, a budget is devised for each tender group.

After finishing the competition documents the buying starts. This activity consists of:

- Announcing the competitions and the results
- Answering questions related to the competition documents
- Receiving offers from vendors and evaluating them
- Evaluation: examining all offers against the requirements set in the competition documents, producing a proposition and getting this formally accepted
- Final meetings and negotiations with the chosen vendors
- Producing contract documents

- Arranging start-up meetings with vendors and design team at which all aspects of the delivery are discussed in detail, including the time schedule and information flow between vendors and design team

#### 4.1.4 Receiving, inspecting and assignment

This phase consists of the following activities:

- Receiving user equipment, including delivery and installation in each room ready for use and possibly also testing equipment at the factory before receiving it at the site
- Quality and quantity control of products, included testing
- Production control for some types of equipment
- Acceptance test in cooperation with end-users
- Assignment of equipment from vendors to the project organization

This phase is very demanding, and the need for competence and capacity must not be underestimated.

#### 4.1.5 Final work

After inspection and assignment, some of the equipment needs test periods before it is ready for use. This phase consists of:

- Test period for some equipment
- Teaching period for end-users and the hospital’s technical department
- Start-up of ordinary use of the equipment in the hospital

Finally, the equipment and documentation is handed over to the hospital.

- Assignment of the equipment from the project organization to the hospital, which subsequently assumes the responsibility for maintenance
- Produce and hand over documentation for all user equipment, including necessary data for the hospital’s equipment database

## 4.2 Equipment with building influence (EBI)

The expression EBI is used for all types of equipment with influence on the building’s structures and/or technical installations.

The basic definition of EBI in this project is recommended as:

**Equipment defined as EBI has properties that result in a need for the design team to take these properties and requirements into consideration when designing buildings and rooms in order to achieve an acceptable interaction between equipment in rooms and the building/room where the equipment is located.**

Equipment defined as EBI will then comply with one or several of these criteria:

- Connected to floor, wall or ceiling: floor connection entails equipment bolted to the floor
- Very heavy
- Very large dimensions
- Requires water and/or drain
- Requires connection to the ventilation system
- Requires connection to the gas or air pressure system
- Requires extra effect or emits heat
- Requires direct electricity connection
- Requires different voltage than standard
- Emits or is sensitive to ionic or electro-magnetic radiation
- Emits or is sensitive to acoustic noise
- Emits or is sensitive to mechanical vibrations

In other words, we do not include equipment that has no special requirements for the room when there is only a requirement for the normal electricity supply through a socket or similar.

See appendix 2 for the preliminary list of equipment per function.

## 4.3 Equipment with building influence in different phases of the project

The progress for detailing EBI is:

By the end of the preliminary program:

- List of all articles planned in the project evaluated to be EBI, and technical specifications for these articles
- List of existing and useable equipment with technical specifications other than those planned, including technical specifications

By the end of the detailed project

- List of articles with updated/new technical specifications since the preliminary program
- List of all technical EBI changes since the preliminary program

## 4.4 General building influence

### 4.4.1 Weight and dimensions

Among the user equipment, MR installations will be the heaviest. Normally rooms for MR installations should be able to handle equipment up to 8 tons. However, this is not enough with modern equipment. Three Tesla machines can weigh up to 12 tons and are increasingly common. In recent years MR machines called “open MR” have arrived. Several of these machines have a weight of between 10 and 12 tons.

For other user equipment, normal load in buildings for medical examinations and treatment will be sufficient.

In MR rooms, X-ray rooms with C-bows attached to the roof, and rooms with operating tables attached to the floor, horizontal floor alignment is a requirement. The same requirement applies for mounted X-ray equipment.

Floor-mounted X-ray equipment and operating tables need some sort of a cable excavation in the floor to the pedestal. In some cases core drilling to underlying levels will be preferable.

In rooms with mounted X-ray equipment there must be a ceiling height of 2900mm or more, preferably 3000-3100mm. For other equipment a ceiling height of 2700mm will be sufficient. However, large distributing units need a minimum ceiling height of 2900mm. Some of the roof-mounted equipment has limitations between the attachment spot (level segregation) and ceiling, i.e. 1200mm.

MR is also required to contain a safety drain for liquid helium. If an accident should happen, liquid helium can be transformed into gas at a low temperature. The safety drain can be up to 250mm diameter and requires a free safety zone of 3 meters radius from the outlet. In some cases the outlet will need to be above the roof.

### 4.4.2 Connections to walls and ceilings

Hanging equipment on walls or roof (level segregation) often presents challenges. The most common wall-hanging equipment is TV, image monitors and patient supervision monitors. The development within flat-screens has considerably reduced the weight and the distance from the wall for this type of equipment. As a result, wall and roof-hanging equipment can be attached to a slightly strengthened wall construction. Extra reinforcement in the walls is required for wall-hanging examination lamps, examination microscopes and heat lamps for infants.

Some of the wall-hanging equipment must be hung on specific equipment rails (building equipment). This rail can either be integrated into the room channel or mounted directly to the wall. For a flexible use of the rails, the attachment needs close attention. Attachment to gypsum and light wooden planks is normally inadequate.

Special mounted plates are attached to the concrete with expansion bolts to manage the load from roof-hanging central outlets, surgery lamps, and surgery microscopes. These types of equipment need accurate requirements regarding load bearing and stiffness at the attachment point. Likewise they demand great flexibility regarding the final placement of the attachment point. Roof segregation elements and other prefabricated surfaces often raise problems in exact equipment placement and secure mounting. The use of plastic molded surfaces is recommended in these areas.

Roof-hanging X-ray equipment should be attached to the rail system in the ceiling. In all rooms for X-ray examination an anchor rail or something similar should be mounted in a square pattern with 600mm x 600mm in length and depth, and 3000-3100mm height over finished surface. A rail system of this type must be included in the building enterprise.

Rails for patient lifters must be attached to the ceiling. Bracing-wire can be used, if supported. If rails without curves can be used, it may be easier to buckle the rails from wall to wall and attach them to the wall with special end-brackets. Rail lengths up to 5000 mm are possible. This solution requires reinforcements in the wall. Rails, bracing-wires and/or attachment brackets for patient lifters are normally a part of the equipment delivery.

### 4.4.3 Electricity, water and gases

MR and X-ray equipment demand electricity (400 V, 3 phase) and thus need an individual el-board in the examination room or the associated machine room. For X-ray equipment there are special requirements regarding low net resistance.

Some of the remaining equipment also needs 400 V, 3 phase, but here it is possible to use an electricity outlet or a direct set connection to a course from local 400 V distribution.

For many types of equipment or associated work-stations there is a legal demand for a continuous electricity connection.

Dialysis machines must have clean water attached and outlets towards the wall in an individual wall chasm for dialysis. There are special requirements regarding the pipe construction for centrally cleansed dialysis water. Materials must be chosen with care. The entire construction needs continuous circulation and must regularly go through disinfection with heat and/or chemicals. The machine room for central water-cleaning construction should be placed on the same floor or on the floor above or below the dialysis section. The room must be easy to access for the regular transport of 50 kg packages of chemicals. Some hospitals choose to install a pipe-construction for the dialysis concentrate supply from a central supply area.

Other equipment also needs to be connected to clean water, e.g. laboratory equipment, instrument washing machines, autoclaves etc.

Heavier roof-attached equipment is normally mounted to the room with special mounting-plates. The interface for electricity and gas and the outlet for roof-attached equipment with mounting-plates are normally placed by the mounting plate, but this can vary according to the different models/producers.

The interface for data and other signal cables depends on the model/producer in both the type and the placement of the connector.

A small number of types of equipment may have water and gas connection with “industry type” quick connections, while gas connections are normally of the “AGA mini” type.

### 4.4.4 Heating, cooling and ventilation

Heat from medical technical equipment will normally be expelled as room air. In some cases the equipment will be connected to water/iced water to maintain the need to cool the equipment. Examples of this type of equipment are MR constructions and some X-ray equipment (cooling of X-ray tubes and detectors).

Data for heat export for the individual equipment types are given under maximum charge. Normally the equipment will only be under maximum pressure for short periods of time throughout the day. The effective heat export will thus vary considerably during a working day.

Surgical cut-and-burn techniques normally produce smoke and smell and in some cases also contagious particles. These particles must be removed by suction devices at the workplace. These can be attached to special outlets in the room, often with a 40mm connection. An adequate alternative can be a local suction unit with air export to the room. These have built-in filters for smoke, smell, and contagious particles.

### 4.4.5 Radiation, noise, vibration

In most rooms where X-rays or nuclear-medical equipment are used there will be requirements regarding shielding from ionic radiation. Normally the requirement is a 2mm thick lead layer. In light walls and doors this shield can be achieved by adding lead plates.

In areas for nuclear medicine there will be work involving radioactive isotopes which demands special building requirements such as shields, ventilation, sluices, etc.

There will be a strong permanent magnetic field in the area around the MR machine, especially longitudinally. It is not common to undertake particular shielding of this field. The constructional solutions must be in a fashion that ensures that sensitive activity (people, heavy transport equipment of magnetic material, etc.) does not by accident cross given thresholds for the magnetic field. If for specific reasons preformed shielding of the magnetic field must be in place, this must be preformed as part of the building enterprise. Rooms with gamma-camera equipment should not be exposed to magnetic fields of more than 0.5 Gauss (normal earth magnetic field force).

When MR is being used it will emit electro magnetic radiation. The field force and the shielding are taken care of by a built-in cabin surrounding the machine (a room inside the room). The cabin will form part of the equipment supply for MR.

When an MR I used, this generates acoustic noise which needs noise isolation. The MR takes care of part of the noise isolation, but it is recommended that the building contractor estimates about 54 dBA noise isolation in the building construction surrounding the cabin.

# 5 Standardization and system solutions

To obtain an over all cost-effective equipment procurement, equipment groups and types should be standardized if possible. This is due to several reasons: standardization will have an effect on future operating costs and maintenance and even on patient security in clinical use (due to the standardized user-interface). A collection of similar equipment types renders possible a cost-effective “fleet-operation” management of operations. The equipment project must have a wider scope than a cost-effective procurement since the life-cycle cost of ownership is vitally important for the future owner and the future operations organization. In many cases the accumulated total cost of ownership and operating costs over the equipment lifetime exceeds the procurement cost.

Published experience shows a definitive advantage in standardization of “volume” equipment throughout the hospital. Typical equipment types suited for standardization are infusion pumps, patient-monitoring equipment, pressure cuffs and pulse oximeters. It has been shown that the utilization of equipment increases (e.g. measured by the number of disposable infusion sets per year), and thus the total need for equipment is reduced.[1] Even the user satisfaction with the equipment and the system increases with this kind of standardization. By establishing an equipment pool over several departments a number of advantages are gained:

- Simplified procurement (fewer types)
- Less costly procurement (discounts)
- Simplified maintenance
- Simplified procurement and storage of disposables
- Simplified training of staff
- Flexible operations
- Increased possibility of backup equipment

Another force in the direction of standardization is the fast-increasing move toward EPJ – electronic patient journal – which facilitates the automatic inclusion of data directly from the medical devices. The focus must be on the utilization of equipment and devices that communicate in a standard manner and according to standardized data protocols. Modularity and scale-ability must be the goal not only in the equipment project but also when the project is closed and the operations are running. Similar terms often used to describe the general building project are generality, flexibility and elasticity.

Within the fields of both laboratory equipment and imaging equipment, the vendors often develop their own proprietary user interfaces even if standard software is utilized in the core. The staff’s knowledge acquired in the use of the equipment cannot thus be transferred to another make and type of equipment. This has the effect of required training in an organization where the staff is

[1] Fahlstrøm E, Grimnes S, Johannesen N.H. An interdepartmental standardized equipment pool. Journal of Nursing Management, 4, 148-154, 2006.

called on duty and where the staff has to handle different equipment types. The influence is obvious in the initial training after procurement, but even has an effect in the future running of operations.

The equipment project must decide at an early stage which equipment is to be standardized, which is to be part of a pool, how economy of operations and cost-effectiveness of disposables are to be weighted, and how much emphasis is to be placed on future user training in the procurement phase.

# 6 Existing equipment

An important part of the planning for the new Landspitali is to evaluate the condition and value of the existing equipment in today's two hospitals and how much of this equipment can be used in the new hospital. For Landspitali this process will be influenced by the fact that much of the most modern and valuable equipment is leased on five- to seven-year contracts. First there must be a strategic decision – is the hospital still to operate with these leasing contracts or buy new equipment?

An important parameter for evaluating whether the equipment can be moved is the equipment's assumed lifetime of operation at the time of moving into the new hospital. It is difficult to define a specific technical, medical or economic lifetime for different types of equipment. When evaluating if equipment must be discarded or can be moved, a combination of the different criteria must be used.

In the section below we will discuss some of the important elements in the evaluating process for existing equipment.

## 6.1 Criteria for usability

The most important criteria for evaluating existing equipment is whether the equipment is suitable for the new function and is technologically updated. Age/lifetime is also an important criterion.

Technical lifetime is how long a device can have a satisfactory technical function in relation to the demands set to the equipment. Functional demands can be set as standards to the results produced by the device, picture quality, environmental demands (radiation, noise, etc.) The requirements are set by the hospital or government.

Medical lifetime is about the speed of medical development. Both technological development and medical development generate new standards and demands for medical equipment. New procedures for treatment are often less unpleasant for the patients. Old equipment will be then looked upon as outdated even if the devices are in good technical condition. Based on new standards and more ethical criteria, medical personnel will often find it hard to use old equipment and procedures instead of new.

Economic lifetime is about how cost-effective the equipment is. If the hospital can operate more cost-effectively with new equipment, even large investments can be profitable for the hospital in the long run.

In Norway, the normal lifetime for medical equipment is:
(Source: *Regional plan for purchase of equipment in hospitals – health region 2, 04.02.98*)

| Category | Average lifetime (year) | Normal lifetime (year from – to) |
|---|---|---|
| Radiation therapy equipment | 12 | 10 – 15 |
| X-ray equipment | 10 | 8 – 12 |
| Flexible scopes | 4 | 3 - 5 |
| Ultrasound | 7 | 6 - 9 |
| Analysis devices and laboratory equipment | 9 | 7 – 11 |
| Monitoring systems | 8 | 7 – 10 |
| Other ME * | 11 | 5 – 20 |
| Surgical instruments* | 15 | 5 – 20 |
| Equipment for cleaning and disinfection | 12 | 10 – 15 |

* These categories contain many different types of equipment with large variations in lifetime.

In Norway, there is a general agreement on these lifetime estimates. According to our experience from other big hospital projects, our opinion is that medical equipment older than six years is seldom economically or technically profitable. The reason for this is a combination of integration problems and maintenance costs. Normally approximately 25% of the total need for equipment can be covered through existing equipment. We recommend that the project's user group for the equipment project decides on this matter.

## 6.2 Registration and evaluation of existing equipment

At a later point in the process, there is a need for a manual registration and evaluation of existing equipment. First, we evaluate the equipment based on the information from the hospital's database. We then do a manual check of our "theoretical" evaluation by walking from room to room in the hospital. At the same time, other types of equipment are being manually registered.

In this survey it is important to focus on:

- Finding all the articles registered in the department.
- Evaluating whether the theoretical evaluation was correct, writing down divergences and stating the reasons for these. If the conclusion after the survey is "usable" or "uncertain", we must note divergences in technical specifications from the planned article in the database to the existing article (size, connections, etc.). Moving costs should also be noted at this point.
- Revealing whether there is equipment in the department that not is registered in the hospital's database.

All data from the survey must be registered in dRofus

When all the “usable” equipment is linked to the equipment plan in dRofus, the system automatically calculates the net purchase of equipment for rooms and departments and for the whole project.

During the project period, the hospital must regularly transfer updated data about new equipment and old discarded equipment. These data will then be loaded into the equipment plan in dRofus.

# 7 Cost estimate

## 7.1 Method – general comments

The cost estimate has been worked out by two different approaches:

- By calculating a cost per square meter based on experience from other (Norwegian) hospital projects
- From the room list in dRofus, the rooms in the hospital has been given a gross price for user equipment based on similar room types in other (Norwegian) hospital projects

Usually, at this stage (sketch project), the first approach has been used to establish a cost estimate for user equipment. Since all the programmed rooms have been established in dRofus, and by using cost for different room types, it is possible to work out a more reliable estimate. On the other hand, it must be considered that the cost estimate is made without a detailed examination of each room and function in cooperation with the users.

The cost estimate includes all the types of user equipment as stated in chapter 1.3.

Mainly, the need for user equipment is a direct consequence of the planned functions in the hospital. In addition, the cost level is affected by the use of existing equipment and how sophisticated equipment that is required. In this cost estimate, the use of existing equipment is set to 25%. Equipment quality level similar to the latest Norwegian hospital projects is used.

In the cost estimate for equipment the leasing policy of Landspitali is taken into account. This applies to ICT equipment, the most expensive diagnostic imaging equipment, the robot for automatic dispensing in the pharmacy etc.

## 7.2 Estimate

The cost estimate for user equipment is presented in the Sketch project report.

# Appendix 1 Equipment with building influence (EBI)

See attached Excel-sheet with EBI equipment listed per function

# Appendix 2 Expensive equipment per function

See attached Excel-sheet with common expensive equipment listed per function. The list is for early phase information only. It is based on experience from Norwegian hospital projects, and can be different from the actual need for equipment in this project.

| Count of Function | Function | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Types of equipment with building influence** | 02 - Research and developement | 03 - Technical division | 06 - Paediatrics | 07 - Gynaecology and Obstetrics | 10 - Medicine I, Standard bed ward | 11 - Medicine I, Cardiology | 12 - Pulmonology and Allergology | 13 - Neurology | 14A1 - Nephrology | 14A2 - Endocrinology | 14B1 - Dermatology | 14B2 - Infectious Diseases | 14B3 - Rheumatology | 15 - Haematology and Oncology | 16A - General surgery | 16B - Gastroenterology (Gastro medicine) including endoscopy | 17 - Orthopaedics | 18A - Cardiac and Thoracic Surgery | 18B - Vascular surgery | 18C - Neuro Surgery | 18D - Urology | 19A - Otolaryngology (ENT) | 19B - Ophtalmology | 19C - Plastic surgery | 20 - Geriatric | 21 - Operating Theatres | 22 - Anaesthesiology | 23 - Emergency department | 24 - Hospital Pharmacy | 25 - Diagnostics, Imaging | 26 - Radiation Oncology | 27 - Rehabilitation | 28 - Laboratories and Blood bank | 32 - University Offices and laboratories | Grand Total |
| X-ray equipment X-ray rooms | | | | | | 1 | 1 | | | | | | | | 1 | 1 | 1 | | | | 1 | | | | | 1 | | 1 | 1 | | 1 | | | | *10* |
| Welding equipment | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | *1* |
| Ultra low temperature freezers | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | *3* |
| Surgical lasers | | | | 1 | | | | | | | | | | | | 1 | | | | | | 1 | 1 | | | 1 | | | | | | | | | *5* |
| Robotic systems for catheter navigation | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | *1* |
| Radiotherapy installations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | *1* |
| Physiotherapy exercise equipment | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | *2* |
| Operating table system with floor-mounted base | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | *1* |
| MRI systems | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | *1* |
| Monitoring networks and data servers | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | | | | | | | *5* |
| Machinery for tool rooms and workshops | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | *1* |
| Lamps for surgical procedures and examinations | | | 1 | 1 | | 1 | | | | | | | | | 1 | | 1 | | | | | | | | | 1 | | 1 | | | | | | | *7* |
| Hot cells and other equipment for work with radioisotopes and radiopharmacy | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | *3* |
| Heavy laboratory centrifuges | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | *3* |
| Hemodialysis equipment with concentrate and water treatment systems | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | *1* |
| Gamma-, SPECT- and PET-cameras | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | *1* |
| Full body light therapy systems | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | *1* |
| Extracorporeal shockwave lithotripters (ESWL). | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | *1* |
| ECG telemetry systems | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | *1* |
| Diagnostic instruments for hospital laboratories | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | *1* |
| CO2 incubators | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | *3* |
| Ceiling supply systems (Distribution units) | | | | | | 1 | | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | | 1 | | | | | *5* |
| Ceiling- or wall-mounted surgical microscopes | | | | | | | | | | | | | | | | | | | | | | 1 | | | | 1 | | | | | | | | | *2* |
| Ceiling lift systems | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | 1 | | | *26* |
| Blood bank refrigerators | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | *1* |
| Biological safety cabinets | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | *3* |
| Animal caging systems | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | *2* |
| Anesthesia machines and work-stations | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | | | | *2* |
| *Grand Total* | *6* | *2* | *1* | *3* | *2* | *7* | *2* | *1* | *2* | *1* | *2* | *1* | *1* | *1* | *3* | *3* | *3* | *1* | *1* | *1* | *3* | *3* | *2* | *1* | *1* | *9* | *3* | *6* | *3* | *1* | *2* | *2* | *7* | *7* | *94* |

# NUH - Main Equipment Program

| Nr. | Function | High cost equipment |
|---|---|---|
| 1 | **Administration** | Computers<br>AV equipment<br>Furniture |
| 2 | **Research and development** | Computers<br>AV equipment<br>Simulators for advanced training, both hardware and software<br>Biomedical equipment in one ICU and two operating rooms |
| 3 | **Technical division** | Computers<br>Specialized test equipment for MDD<br>Workshop machines for carpenters and mechanics<br>Wheel-based equipment for gardeners |
| 4 | **General services** | Ovens<br>Chillers and freezers<br>Boiling pans<br>Frying tables<br>Food processors and machines for mixing, slicing, peeling ...<br>Dishwashing equipment<br>Meal distribution trolleys |
| 5 | **Security and transportation,<br>Cleaning, bed central, inventory** | AGVs<br>Bed cleaning machine<br>Cleaning machines (floors) Outsourced?<br>Laundry machines (mops) Outsourced?<br>Surveillance system (part of the buliding equipment) |
| 6 | **Paediatrics** | Ventilators<br>Incubators<br>Patient monitoring system<br>Ultrasound<br>Respiratory testing equipment |

| Nr. | Function | High cost equipment |
|---|---|---|
| 7 | **Gynaecology and Obstetrics** | |
| | Obstetric bed ward | Same as standard bed ward |
| | | Cardiology |
| | | Ultra sound |
| | Inpatients | Same as standard bed ward |
| | | Cardiology |
| | | Ultra sound |
| | Gynaecology bed ward | Same as standard bed ward |
| | Inpatients | Same as standard bed ward |
| | | Monitor, lightweight |
| 8 | **Psychiatry for children and youth** | Computers |
| | | Furniture |
| 9 | **Psychiatry, adults** | Computers |
| | | Furniture |
| | | Kitchen for training |
| | | Equipment for vocational rehab. |
| 10 | **Medicine 1 Standard bed ward** | Hospital beds |
| | | Computers |
| | | Syringe pumps |
| | | Volume pumps for IV infusions |
| | | Patient lifters |
| | | Patient monitoring system (intermediate beds) |

| Nr. | Function | High cost equipment |
|---|---|---|
| 11 | **Medicine I Cardiology** | |
| | Cardiomedical bed ward | Same as standard bed ward |
| | ICCU/emergency unit | Infusion equipment<br>Centrally placed monitor<br>Telemetry<br>Defibrillator |
| | Cardiology laboratory | Same as simple surgery units without anaesthesia equipment |
| | Cardiologic catheterization | |
| | Echocardiography laboratory | Same as outpatient clinic<br>Ultra sound equipment<br>Various EKG equipment<br>X-ray equipment<br>Defibrillator<br>CT and MR |
| 12 | **Pulmonology and Allergology** | Same as standard bed ward<br>Monitor<br>Spirometry<br>Flow |
| | Sleep laboratory | Registration equipment |
| | Pulmonology/Allergology outpatient unit | Same as outpatient clinic<br>Various spirometers<br>Various pulmonary function equipment e.g. Plethysmograph<br>Treadmill etc.<br>Monitor<br>Various pulse oximeters<br>Bronchial provocation equipment<br>Various ventilators<br>Fluoroscope |
| | Office/research | Same as standard office units |

| Nr. | Function | High cost equipment |
|---|---|---|
| 13 | **Neurology** | CT<br>Computers<br>Furniture |
| 14A1 | **Nephrology** | |
| | Nephrology bed ward | Same as standard bed ward |
| | Outpatient unit | Same as outpatient room<br>Ceiling support system<br>Cystoscopy racks<br>Flexible scopes<br>Washer decontaminator for flexible scopes<br>Special examination tables<br>Flowmeters<br>Ultra sound<br>Urodynamic equipment |
| | Dialysis | Dialysis equipment<br>Dialysis chairs<br>Central for dialysis fluid<br>Disinfecting equipment |
| | Office unit | Same as standard office unit |
| 14A2 | **Endocrinology** | |
| | Endocrinology bed ward | Same as standard bed ward |
| | Oupatient unit | Same as standard outpatient unit<br>Small laboratory with simple analysis equipment |
| | Office unit | Same as standard office unit |

| Nr. | Function | High cost equipment |
|---|---|---|
| 14B1 | **Dermatology** | |
| | Dermatology bed ward | Same as standard bed ward |
| | | Bathtub |
| | Outpatient unit | Same as standard outpatient unit |
| | | Some lab and sterilization equipment |
| | | Big and small UV light machines |
| | | Various dopplers |
| | | Ultra sound bath for local treatment e.g. hands |
| | | RIV equipment for footbath/treatment of wounds |
| | Office | Same as standard ofice unit |
| 14B2 | **Infectous Diseases** | |
| | Infection medicine bed ward | Same as standard bed ward |
| | | Local decontaminators related to bed ward |
| | | Disinfection robots |
| | | Local autoclaves for transform contagious waist to non-contagious waste |
| | | infusion equipment |
| | Outpatient unit | Same as standard outpatient unit |
| | | Safety cabinet |
| | Office unit | Same as standard office unit |
| 14B3 | **Rheumatology** | Research equipment |
| | | Other: see Standard bed ward |
| 15 | **Hematology and Oncology** | |
| | Hematology/Oncology bed ward/day unit | Same as standard bed ward |
| | | Safety cabinet |
| | | Local decontaminators related to bed ward |
| | Outpatient unit | Same as standard outpatient unit |
| | Office unit | Same as standard office unit |

| Nr. | Function | High cost equipment |
|---|---|---|
| 16A | **General surgery** | |
| | General surgery bed ward | Same as standard bed ward |
| | | Patient lifters |
| | | Special beds for adiposity patients |
| | Center for ca. mammae | Same as standard outpatient unit |
| | | Mammography |
| | | Ultra sound |
| | Outpatient unit | Same as standard outpatient unit |
| | Office unit | Same as standard office unit |
| | | Meating area with equipment |
| 16 B | **Gastroenterology (Gastro medicine) including endoscopy** | |
| | Gastro medicine bed ward | Same as standard bed ward |
| | Gastro medicine day ward | Monitor |
| | | Rest chairs |
| | Gastroenterology outpatient unit ERCP | Various types of X-ray equipment |
| | | Decontaminator for flexible scopes |
| | | Flexible scopes: |
| | | Bronchoscope |
| | | Gastroscope |
| | | Colonoscope |
| | | Drying cabinet for flexible scopes |
| | | Washer decontaminator |
| | | Rack with diatermy, light sources, monitors etc. |
| | | Monitors |
| | | Examination tables |
| | | Surgery unit |
| 17 | **Orthopaedics** | Mobil fluoroscopy |
| | | Other: see standard bed ward |
| 18A | **Cardiac and Thoracic surgery** | See 10 - Standard bed ward |

| Nr. | Function | High cost equipment |
|---|---|---|
| 18B | **Vascular surgery** | Ultrasound machines<br>Other: see 10 - Standard bed ward |
| 18C | **Neuro surgery** | See 10 - Standard bed ward |
| 18D | **Urology** | ESWL<br>Urodynamics, cystometry and pressure/flow equipment<br>Cystoscopy racks<br>Ultrasound machines<br>Other: see 10 - Standard bed ward |
| 19A | **Otolaryngology (ENT)** | ENT units<br>Examination microscopes<br>Dental unite<br>Orthopantomograph<br>ERA and OAE equipment<br>Video stroboscope<br>Audiology equipment<br>Other: see 10 - Standard bed ward |
| 19B | **Ophthalmology** | Opthalmic diagnostic and treatment unit<br>Fundus cameras<br>Phaco systems<br>Opthalmic lasers<br>Ophthalmic Ultrasound |
| 19C | **Plastic surgery** | Operating table<br>Operating lamp<br>Other: see 10 - Standard bed ward |
| 20 | **Geriatric** | |

# NUH - Main Equipment Program

| Nr. | Function | High cost equipment |
|---|---|---|
| 21 | **Operating Theatres** | Ceiling support systems<br>Anesthesia work stations<br>Operating tables<br>Operating lamps<br>Operating microscopes<br>Endoscopie racks<br>Surgical lasers<br>C-arms<br>Ultrasound<br>Image management and distribution system |
| 22 | **Anesthesiology** | Patient monitoring systems<br>Ventilators, CPAP and BIPAP equipment<br>Infusion management systems<br>Intensive care beds<br>Ceiling support systems |
| 23 | **Emergency department** | Diagnostic imaging systems (Digital radiography, CT, Ultrasound and MR?)<br>Patient monitoring systems<br>Trauma and treatment tables |
| 24 | **Hospital pharmacy** | Automated drug management<br>Isolators<br>Safety cabinets<br>Air tube filling station |
| 25 | **Diagnostics Imaging** | PACS system<br>Image work stations<br>Diagnostic imaging systems like MR, CT, Angio, Fluoroscopy, Digital radiography, PET/CT, Spect/CT, gammacamera and Ultrasound |

| Nr. | Function | High cost equipment |
|---|---|---|
| **26** | **Radiation Oncology** | LINAC<br>Simulator<br>Dose planning system<br>Dose verification system<br>Dosimetry equipment<br>QA equipment and phantoms |
| **27** | **Rehabilitation** | Training equipment<br>Computers and AV |
| **28** | **Laboratories and blood bank** | Automatic sample handling system<br>Different analyzers<br>Equipment for sample preparation<br>Microscopes<br>Blood collection and apheresis system<br>Safety cabinets<br>Deep freezing equipment |
| **29** | **Sterilization** | Work tables<br>microscope<br>Various equipment for packing<br>plasma autoclaves<br>steam autoclaves<br>Autoclave baskets racks/and wagons<br>Automatic "feeder" for autoclaves<br>cabinet washing machine  for trolleys<br>distribution trolleys<br>Washer decontaminator with automatic fedeer<br>Washer decontaminator for endoscopy equipment with automatic fedeer<br>Various equipment for the interior of washers<br>Storage shelves/trolleys |
| | Office, meeting rooms, rest rooms | Same as standard |

# NUH - Main Equipment Program

| Nr. | Function | High cost equipment |
|---|---|---|
| 32 | **University Offices and laboratories** | All kinds of "heavy" equipment for biomedical research |
| 33 | **University teaching facilities pre and clinical** | Manikins<br>Simulators<br>Skill lab equipment pending on skills<br>Computers<br>Audio-visual equipment |
| 34 | **University post-graduate programme** | Projectors<br>Screens<br>Computers |
| 35 | **University offices teaching studying facilities support** | Computers<br>Printing equipment<br>Copy machines |
| 36 | **University Conference Center** | Audio-visual systems for auditoriums<br>Projectors<br>Screens<br>Video conference equipment |
| 39 | **Logistics** | Mostly building equipment :<br>AGV's<br>Vacuum systems<br>Air tube system<br>Medicine distribution system |