

Complex logistics for Trondheim facility



Next year will see the completion of a 10-year new build and redevelopment project to create central Norway's largest regional hospital, in Trondheim, providing medical services for over 200,000 local people, and a further 450,000 inhabitants from the wider region. The new St Olavs Hospital will be Norway's first 100 per cent single-room healthcare facility, and is set to have close links with Trondheim's Norwegian University of Science and Technology. Designed to be as 'patient-centred' as possible from the outset, it incorporates a number of innovative technologies for enhancing and automating activities ranging from pill 'picking' and distribution, to logistics and waste disposal, as *HEJ*, and Bjørn Bakken, project manager, logistics, at hospital development company, Helsebygg Midt-Norge, explain.

Occupying a total floor area of some 223,000m², and located in Trondheim's central 'downtown' Øya area, the new St Olavs Hospital has been constructed for two 'end customers' – the hospital itself, and the Medical Faculty at the city's Norwegian University of Science and Technology (or NTNU), which will occupy around 75% and 25% respectively.

Built in three phases, the third due for completion by late 2013 (all phases to date have been delivered to date and below budget), the NOK 12.6 billion (£1.36 bn) healthcare development has been funded by the Norwegian Ministry of Health, and the country's Ministry of Education and Research. Overall responsibility for all elements of designing, constructing, and equipping the various new buildings lies with Helsebygg Midt-Norge (The Hospital Development Project for Central Norway).

While hospital facilities account for around 75% of the total floor space, the close links – both physical and academic – with the NTNU's Faculty of Medicine will see more medical students than hospitalised patients on the site at any given time. Indeed, as Helsebygg Midt-

Norge puts it, 'hospital and university areas are totally integrated throughout the campus'.

Background and history

Plans for the new St Olav's Hospital go back over two decades. In 1991, the Sør-Trøndelag 'county council' drew up a plan for the development and operation of a new Trondheim Regional Hospital. Norway's Government subsequently gave the go-ahead in 1993, an international design competition was held, and, in August 1995, the county council chose to use the winning sketch from Frisk Arkitekter and Ernst & Young as a basis for the Development Plan for RIT (Regionsykehuset i Trondheim) 2000.

In June 1997, the Storting (Norwegian parliament) approved plans for development of a new, integrated university hospital in Øya in Trondheim. The rationale was simple: Helsebygg Midt-Norge says that, by the early 1990s, the existing hospital had begun to 'experience difficulty managing care and treatment requirements', and, 'looking forward to 2020, it could be seen that an ageing population, higher incidence of chronic disease, and rising costs of care, would make the situation much more challenging'.

Maximum flexibility

The resulting 'vision' was for a new hospital environment 'with maximum flexibility', and a technical infrastructure that was 'future-proofed'.

Throughout the new facilities' planning, Helsebygg Midt-Norge and the hospital's senior management were keen that patients play an active part, so that the



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buildings and facilities could be designed 'from a patient perspective'. One of the key priorities was that, 'as far as possible, patients should come straight to the place where they are to receive treatment', and that, in place of the more 'traditional', centralised approach, services should 'as a rule, be available close to the patient'. Patients would thus 'have a smaller group of people to relate to, creating a reassuring and comforting atmosphere'. Excellent wayfinding was considered highly important, while, from a clinical standpoint, new organisational approaches, improved planning, and 'extensive use of modern technology', would combine to shorten average stay lengths.

This article draws substantially on an article written by Bjørn Bakken, project manager, logistics, at Helsebygg Midt-Norge, on the new St Olavs Hospital project, which appeared in the 2 May 2010 issue of *Nyhetsbrev*, the Swisslog company newsletter for the Nordic region. *HEJ* is grateful to Bjørn Bakken, to Swisslog, and to the International Federation of Hospital Engineering (IFHE), for their help in publishing it.

The 'Planetree' model

The 'Planetree' model of hospital design deployed at St Olavs puts patient-centred care at its heart – so that services and treatments 'come to the patient', and are provided, as far as possible, by a team of staff that the patient is already familiar with, rather than the more 'traditional' system, where patients 'are moved between departments and centralised facilities'.

As the hospital's own brochure puts it: "The new St Olavs Hospital attempts to combine advantages of scale for technology and supplies with the more transparent organisation and friendlier touch of smaller units. The overall design is an open, yet rigorous, structure of city blocks, with separate clinical centres tied together by single or double-level skyways. Between the blocks, tree-lined streets and parks provide green inroads to the central plaza (which is still under construction). Each building has its own inner courtyard, repeating the overall pattern, and providing protected, yet open spaces.

"Each individual centre is not a separate organisation, but focal points for related medical treatment. Within each building, similar activities are located on the same floor: underground service tunnels; ground floor outpatient clinics, cafeterias, and auditoria; second floor operating theatres, recovery, and imaging; third floor university offices and labs, and, finally, quieter patient wards in the top floors."

Reduced average stays

The previous St Olavs Hospital buildings, 80% of which will have been demolished to be replaced with new facilities by the project's completion, had some 900 'standard' hospital beds. This quota has been cut by 10% to 802, but a similar number of 'special' (day beds, observation beds, and patient hotel beds) beds have been added. The hospital says outpatient capacity will double, while average stay length will be reduced by 20%.

A phased construction

To ensure that existing clinical and teaching activities could continue, as far as possible, undisturbed, throughout the 10-year programme, construction was carefully phased. Key buildings and other elements completed to date are as follows:

Phase 1 – commencement autumn 2003, full operation August 2006

- A new five wing, 31,000 m² Neuro Centre, providing ENT surgery and treatment, ophthalmology, neurology, neurosurgery, audiology, clinical neurophysiology, maxillofacial surgery, rehabilitation, treatment for strokes/headaches, and multidisciplinary treatment of patients



The Laboratory Centre incorporates facilities including research laboratories, offices, a large auditorium, and other teaching areas, for nearly 300 students.

with spinal conditions. The largest new building in Phase 1, the Neuro Centre will also provide significantly improved facilities for medicine for the elderly. The Centre incorporates 141 beds, 32 day treatment spaces, and 10 recovery beds. It has five floors and a mezzanine level for technical services, with the potential to add an 'extra' floor. There are 12 operating theatres, and a radiology department with several diagnostic units and an MRI scanner. Research and teaching are integrated with patient treatment.

- A new Patient Hotel, with 19 guest rooms for mothers with newborn babies. St Olavs says the facility will also be suitable 'for patients undergoing treatment or observation who need a place to stay near the hospital, with access to clinical care', for example cancer patients undergoing short-term radiotherapy, and will additionally accommodate day surgery patients who live some way from the hospital. Supporting all the clinical centres, the 'hotel' is within easy walking distance of the hospital, with a link via a heated walkway or underground corridor.
- A new 'Supply Centre', incorporating equipment such as medical gases, compressed air, emergency and back-up power, and refuse collection facilities.
- A complex 'technical infrastructure', the key elements of which include automated guided vehicles (or AGVs); a pneumatic tube system for delivery of medicines and other hospital supplies; sophisticated information and communication technology; automatic waste handling, and building automation and building safety and security systems.
- A new Women and Children's Centre, the latter for patients under 18, housing surgical facilities. The Centre, which will also care for women about to give birth, and those with gynaecological conditions, accommodates Norway's National Centre for Foetal Medicine,

and the hospital's unit for infertility treatment, plus child psychiatry services. There are 107 beds, nine operating theatres, and a radiology department with four diagnostic units, plus 47 day treatment places, 16 beds for post-operative care, 14 delivery rooms, 22 neonatal cots, four intensive care beds, and four 'observation' beds.

- A new five-floor Laboratory Centre. The building comprises research laboratories, offices, a large auditorium, and other teaching areas for nearly 300 students. Alongside chemical, microbiological, and pathological laboratories, there are clinical and large-scale research laboratories specialising in molecular biology, genetics, and DNA analysis.

Phase 2-1: commencement late 2006, completion 2009/2010

- The Mobility Centre, accommodating orthopaedic, rheumatology, and plastic surgery patients, plus imaging, clinical services, and outpatient sample collection. The Centre will also provide facilities for medical school activities undertaken by the Department of Neuroscience, the Department of Circulation and Medical Imaging, and the Department of Cancer Research and Molecular Medicine. The three-wing, 16,500 m² facility is connected to the hospital's oldest '1902 building', the Women-Children Centre, and the Emergency and Heart-Lung Centre.
- The Gastro Centre will offer 'internal medicine' and surgery, and treatment for gastroenterology and endocrinology patients, plus related disciplines such as urology, nephrology, and vascular surgery. It will have the highest concentration of radiology, intensive care, and anaesthesia services, and include units for dialysis and non-invasive pulverisation of stones (lithotripsy). The existing Oncology Building, completely remodelled and refurbished, forms one wing.
- The '1902 building', incorporating the oldest parts of the hospital, has been

extensively refurbished, and now features clinical services and staff functions not 'decentralised' to the individual centres.

- The Emergency and Cardiothoracic Centre incorporates specialties in both surgical and internal medicine, such as cardiology, cardiac surgery, thoracic surgery, and pulmonary medicine.
- The Emergency Centre accommodates observation beds and access to the theatres, X-ray, laboratory, and intensive care facilities, either in its own department, or shared with the Gastro Centre. Close by is a base for X-rays, anaesthesia, and the central intensive care unit, while the rooftop incorporates helicopter landing facilities.

Phase 2-2: Commencement May 2011, completion October 2013

- In what was reportedly Norway's largest project of its type undertaken to date, the 'Old Tower Building' at St. Olavs Hospital was demolished. The project began in June 2010, and was concluded in late April 2011.
- The Knowledge Centre, yet to be completed, will be the main teaching centre and community contact in the new hospital, and will house elements including a 400-seat auditorium and medical library.

By 2013, a large open, plaza, the Olav Kyrres Plaza, named after the third King Olav of Norway, will also be established at the centre of the new hospital site. Also planned, but not yet financed, is a new Psychiatric Centre, that will provide acute, geriatric, and short-term psychiatric care.

The project manager's view

Providing, managing, and co-ordinating the wide range of essential services and supplies required by such a sizeable



The Gastro Centre treats patients with diseases of the stomach and intestine, as well as patients with cancer, diabetes, and a number of other conditions.

facility is a complex task, but already in place is a sophisticated logistics strategy to ensure that everything from laundry and sterile items to cook/chill food reaches its destination smoothly, as project/logistics manager at Helsebygg Midt-Norge, Bjørn Bakken, explains: "The development and updating of hospitals generally presents a host of different supply chain opportunities and challenges. To maximise the efficiency of such operations at St Olavs, we have based the logistics and transport system around six key principles." These are:

- **Transport** – use of automated transport systems (AGVs, medicine distribution, and waste disposal) for goods and return goods.
- **Supply** – a central common Goods Received facility with a system of local goods storage, for instance of linen and bedding items, in cabinets in corridors.
- **Information** – IT-based ordering, purchase, and stock control.
- **Production** – 'collective localisation of central production units'.
- **Modules** – common modules for transport and storage.

- **Organisational** – ordering and supply is not performed by healthcare personnel when this does not involve medical items.

Bjørn Bakken said: "The general principles were defined and adopted based on cost of investment, operational costs, organisation, quality and safety, plus capacity and flexibility."

Transport

The 'Transport' principle (or strategy) is based around TransCar automated guided vehicles, and a TranspoNet pneumatic tube system, both from international integrated logistics solutions provider, Swisslog, plus vacuum refuse disposal systems. The intention is for the Swisslog AGV system, with its associated control system, 21 AGVs, 11 charging stations, and 101 collection and delivery destinations, to make over 1,000 transport runs daily.

Consumables, sterile circulation items, patient and staff clothing (clean and dirty), waste (small items not disposed of in the vacuum waste disposal system) food, drugs, and post, will all be transported by Swisslog TransCar AGV 'carts'. The AGVs transport the carts along pre-programmed routes from the Supply Depot to the AGV collection and delivery stations in each centre, and then return. The system utilises wireless IP interfaces for, for instance, automatic door opening and calling lifts as the 'carts' approach. Lights are turned off when no motion is detected, and a laser navigation system enables the 'vehicles' to identify obstacles and 'scan the building's contours' for reference.

The hospital's TranspoNet pneumatic tube system, with its control system and 190 receive/despatch stations, has a capacity of just under 2,000 'dispatches' daily, and a payload of up to 5 kg. The system transports samples from departments to a common sample reception facility in the laboratory, and takes blood from the blood bank, and drugs from the pharmacy, to the various departments.



The Emergency and Cardiothoracic Centre is the largest facility within the new hospital, with a floor area of some 40,000 m². On the top of the building is the hospital's helipad. Inset: The striking red façade of the Emergency Department.

The hospital's vacuum waste disposal system, meanwhile, which was supplied by Envac, and installed by Nordic building system and construction services company, YIT, has four 'sections', dealing with residual waste, paper, confidential papers, and plastic. There are 2-3 shafts with sorters in each centre, each one of which has a disposal shaft on each floor. Waste is sucked down into the waste disposal centre in the Supply Depot, collected in containers, and picked up by the local refuse collection service.

Supply

St. Olavs Hospital has a central Goods Received facility within its Supply Depot, where all deliveries to and from the hospital are made. Goods are transported from the facility to the other centres and local storage locations, including cabinets in corridors for wards and bed 'clusters'. There are only two types of storage facility used: the first is a central external store that serves several hospitals in the Helse Midt-Norge region, and the second a series of local storage locations, including cabinets in corridors, and medicine storage rooms, within the individual hospital departments.

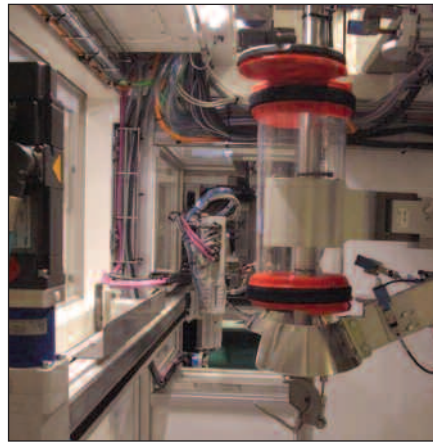
The wards are designed as 'courtyards' of eight beds each, each with its own storage location for consumables and patient clothing. This means there are a larger number of local storage locations than at the old hospital, partly because of the configuration of the buildings, and partly to reduce the distances healthcare personnel must travel to obtain the required items. The operating suites have a shared central area, and sterile store rooms linked to several theatres.

Information

Information exchange for transport and logistics is IT-based, with a cohesive system which covers identification, ordering, purchasing, and stock management, for each category of goods. Bjørn Bakken says: "The OLFI ERP system has not been supplied as part of the updating project, as these are systems that St Olavs Hospital and NTNU are responsible for." The hospital has implemented a new system for food deliveries (ordering, stock management, production planning) and, in the process, also new systems for sterile circulation goods, drugs, and new accounting and logistics systems (consumables and patient clothing).

Production

The 'Production' principle is defined as 'collective localisation' (physical proximity in the same building) for production units, entailing a substantial flow of materials to and from the central Goods Received facility, and, from there, to the centres and departments. The system harnesses



Courtesy of Bjørn Bakken, Helsebygg Midt-Norge

The SwissLog pneumatic tube system (PTS) 'carrier' in the loading position. Both the upper and lower 'lids' are open, with one arm with a hook around the carrier, and the other picking up one of the barcoded rings containing a unit dose from the PillPick system.

an external infrastructure for goods deliveries, and shared use of the internal infrastructure for the hospital's main supply chains. In practice, it means that Goods Received, the kitchens, sterilisation, and refuse disposal centres, are located near the Supply Depot, with areas for loading and setting up linked to the AGV terminal for internal transport.

Module

The 'Module' principle is based on the use of a unit principle in which storage and transport are adapted for a 40 x 60 module, or multiples of the same, or broken down into individual modules. This ensures standardisation, flexibility, and capacity utilisation of transport facilities and storage. There are exceptions, such as item groups such as waste and food ('gastronome-standard').

Organisation

The new hospital is designed to prevent healthcare personnel having to perform supply work which diverts time away from patient care, unless their healthcare skills are actually required.

The hospital supply chain

Consumables

The hospital will incorporate no central stores, as there is a regional central warehouse just 10 kms away, which supplies all hospitals in the 'Helse Midt-Norge' region. Consumables are ordered by each department from the central warehouse or supplier, depending on whether the goods are held in the warehouse, or are specific requirements. The central warehouse packs deliveries in an AGV cart for delivery to the departments or local storerooms. The carts are transported by road to the Supply Depot for onward internal transport by AGV within the hospital.

The central warehouse also stocks sterile items, and incorporates a system for sterile consumables consisting of an AGV cart with an inner cart which can be lifted in and out mechanically.

Sterile circulation goods

The sterile centre is located in the Supply Depot, with a non-sterile area for instrument washing, a clean area for packing and autoclaving, and a sterile store room. The latter is the hospital's main depot for sterile circulation goods. The sterile store room and sterile satellites in the operating suites have limited capacity, and must, as a general principle, only deal with acute and unforeseen needs. The sterile store room in the sterile centre also has an area for sterile consumables, such that the sterile centre can supply 'procedure carts' consisting of sterile circulation goods and consumables in the same consignment (cart) for a given operation.

The procedure carts (40 x 60 carts) are packed at the sterile centre, and a mechanical lift is used to lift two of them into an AGV cart. Upon receipt of an AGV cart in the operating suite, the 40 x 60 carts are lifted out and rolled directly into the theatre. The hospital plans to implement a new IT system to control ordering, production, and store rooms.

Patient and staff clothing

The new hospital has no central clothing depot of its own. Each department thus orders the required patient clothing from the laundry contracted to the hospital. The laundry packs consignments for each department in AGV carts, which are transported from there to the Supply Depot by road, for internal distribution by AGV. Patient clothing is placed in local storage areas, and the AGV carts are positioned in the waste disposal room on that floor for collection of soiled clothing, which is transported from the departments back to the Supply Depot to be returned to the laundry.

The project team has developed a system (based on hardware and software from Taxisys AS) for staff clothing identification system based around electronic cabinets and RFID-labelled garments. Each garment has an RFID tag sewn in, and the cabinets incorporate antennae which identify the RFID chip in each clothing item. Each centre has its own staff wardrobe area incorporating

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cabinets for different garments. Staff use their ID cards to open the cabinets, and remove the clothes they need, and the IT system then logs what has been removed. Soiled clothes are placed in return bins, which also log the RFID tag. Each cabinet has a predefined range, with ordering point and quantity for each type of garment. The system automatically generates an order, which is sent to the laundry, which packs consignments for each cabinet in AGV carts. These are then transported to the Supply Depot by road, for internal distribution by AGV.

Courtesy of Swisslog and St Olav's Hospital



The hospital is benefiting from two PillPick automated drug management systems, installed within the existing pharmacy.

Food

At St Olavs, catering teams employ the cook/chill concept for patient food. The Supply Depot houses the Supply Kitchen, which produces cook/chill food every day, which is then packed in insulated AGV carts, and transported from the kitchen to the kitchens in each centre. Groceries and other goods which have not undergone preparation or cooking in the Supply Kitchen are also transported to the centres' kitchens. These decentralised facilities finish preparing the food for each department before it is taken to the kitchen/dining room/lounge there at mealtimes. There is also a central canteen linked to the centre kitchens which can be used by anyone.

Waste disposal

Most of the waste not sent down the vacuum waste disposal system is collected in the waste disposal rooms on each floor of the various buildings. The waste is loaded into special AGV waste carts and taken to the waste disposal centre. Bjørn Bakken said: "What happens to it there depends on the type of waste. The waste disposal centre is equipped for autoclaving hazardous waste."

Drugs

No new pharmacy was built as part of the new hospital. A new retail pharmacy is planned for the new Knowledge Centre, but the hospital's requirements are currently met from the hospital pharmacy in the adjacent MTFB building, itself

'linked' to parts of the infrastructure, including the AGV and pneumatic tube systems.

Drugs such as antibiotics, cytostatics etc., which require special production facilities, are produced and dispensed from the pharmacy. It was decided to introduce a system of automatic medical supplies at St Olavs Hospital. The concept is based on logging prescriptions in the medical module of the patient journal, transferring them to the pharmacy's message and logistics system for planning, and then transferring them to the Swisslog PillPick system, which produces patient-marked doses, packs each consignment automatically in pneumatic tube capsules, and sends them automatically to the pneumatic tube 'station' on the ward where they are required. Swisslog and the project team worked together to integrate the TranspoNet pneumatic tube and PillPick systems – the first such combination of the two.

Doses are barcoded and, when drugs are administered, both patient and drug are scanned to 'quality assure' that the right patient is receiving the right drugs. The message and logistics system also provides stock control for the hospital's drug stocks in the medicine rooms, which are also supplied by dose consignments. Although the various system components are now fully installed, Bjørn Bakken explains that the overall 'total configuration', whereby prescriptions input by staff into the hospital IT system are transmitted direct to the pharmacy,

is not yet in regular use; the equipment is currently being used principally to deliver unit doses to medicine storage locations on wards.

Automated drug management

The hospital is benefiting from two PillPick automated drug management systems, installed within the existing pharmacy. The Swisslog pharmacy robot can automate the packaging, storage, and dispensing of tablets, capsules, ampoules, vials, cups, and syringes, in unit doses. Together, the two systems will eventually be able

to supply more than 13,000 unit doses daily. Over 10,000 of these unit doses will be tablets.

Swisslog says: "Each PillPick system is similar to the one already delivered and functional at the new Ahus hospital outside Oslo, but the duplication gives significantly higher capacity and reliability, suitable for the larger number of patients." The PillPick systems incorporate a newly developed transfer unit, which, in a fully automated process, places the rings that carry the patient-specific, 24-hour medication orders into pneumatic tube carriers. These barcoded therapy rings are transported by the pneumatic tube system directly to the relevant ward, ensuring a fast, safe delivery of the medicine to the patient. In emergency cases, delivery should occur within 15 minutes from the order entry.

Swisslog says the PillPick system will not only reduce potential medication errors, and cut down on waste caused by out-of-date medicines, but will also reduce the time nursing staff have to spend handling medicines on the wards, allowing more time to concentrate on patient care. St. Olavs will thus benefit 'not only in terms of quality, but also economically'.

The key 'challenges'

Bjørn Bakken said: "Throughout the process of planning and building the new university hospital, investment and planning have gone into improving and rationalising its supply chains. Different conditions, and the phasing in of new logistics systems in an integrated context with optimal processes, procedures, and organisation, have been a major challenge. One of the main objectives with a large healthcare development will always be to rationalise the running of the hospital, and to improve quality to ensure that the proportion of resources used for the core activity – patient care – is maximised. The challenges are in many ways the same as those faced by large corporations in business and industry." +

IFHE Annual Congress visit

The new St Olavs Hospital in Trondheim will be among those visited by participants in the IFHE's 22nd Annual Congress (HEJ – January 2012, and page 9 of this issue), to be held from 13-17 April this year on board the Norwegian coastal steamer, the Hurtigruten MS Midnatsol, as it journeys south down Norway's scenic west coast from Tromsø to Bergen. Delegate places for the Congress, being staged by Norwegian healthcare engineering association, the Forum for Sykehusenes Tekniske Ledelse (FSTL), are still available. For more information, and to register, visit: www.ifhe.info