Guidelines for the Design of HE Buildings, ICT and AV Infrastructure

Best Practice Document

Produced by UNINETT led working group
on physical infrastructure
(No UFS121)

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June 2010

Document No: GN3-NA3-T4-UFS121
Version / date: June 2010
Original language: Norwegian
Original title: “UFS 121: Retningslinjer for prosjektering av UH-bygg, IKT- og AV-infrastruktur”
Original version / date: 23 June 2010
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UNINETT bears responsibility for the content of this document. The work has been carried out by a UNINETT led working group on physical infrastructure as part of a joint-venture project within the HE sector in Norway.

This translated version is based on the Norwegian counterpart approved by the Norwegian HE sector on 23 June 2010 after an open consultation period of four weeks.

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 23 8875, relating to the project 'Multi-Gigabit European Research and Education Network and Associated Services (GN3)'.

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Executive Summary

This document provides guidance in relation to the organisation of construction projects and on how ICT personnel in the HE sector should proceed in order to safeguard the needs of their respective institutions.

Construction projects within the sector may involve different forms of organisation and staffing. In order to achieve the best possible result, it is important that ICT personnel take an active part in their respective institution's construction projects. It is the job of management to be instrumental in ensuring that ICT personnel are given the opportunity to participate in building and systems design.

HE sector buildings may assume a variety of roles both within their own institution and within society as a whole. It is important that the role of the building is clearly defined, and that the institution's ICT security architecture and Uninett's technical specifications (UFS documents) and frame agreements are utilised as the basis for the programming phase.

The construction process is subdivided into different phases and it is important that ICT personnel participate by setting the criteria as early as the programming phase. Moreover, they should play an active role during the Schematic Design Phase and a corrective role during the Design Development and main project phases. An Acceptance Test will be carried out in connection with the hand-over phase.

Buildings are subdivided into a variety of construction elements. In order to understand the construction process and recognise which of these elements has a bearing on ICT systems, we recommend that the reader make him/herself familiar with "NS3451 ─ Table of Construction Elements" and the method by which Statsbygg (the Norwegian public construction and property management agency) assigns code numbers to its own contracts.

Introduction

This document gives an account of construction projects in the HE sector and how ICT personnel should proceed when dealing with them.

The target group comprises IT managers and IT operations personnel in the HE sector. The aim of the document is to make ICT personnel aware of the issues involved, with the aim of enhancing the quality of construction projects carried out within the sector. It is assumed that the recommendations in this document will form the basis of expansion, renovation and new building projects, and that they will be applied in everyday work contexts.

1 A building emerges

The construction of a new building or the implementation of major renovation projects demand expertise that is lacking in the majority of HE institutions. Such institutions are thus dependent on external public sector institutions and private sector consultants/contractors who in turn may lack insight into the HE institutions' activities and requirements.

A user organisation lacking experience in construction projects may thus experience such a project as a frustrating process involving a variety of priorities and options, the consequences of which it may not fully be aware. For this reason it can be easy to feel swindled by professional consultants and contractors.

It is not uncommon for construction projects carried out by public sector agencies to extend over several years. The field of ICT is in a state of constant flux, and this may result in the Principal Contractor lacking insight into the relevant design specifications (DS). Moreover, an extended construction process may entail the movement of personnel in and out of the project and a subsequent loss of overall insight into and detailed knowledge of the project in question. In order to safeguard a satisfactory end product, all correspondence, statements of requirements, design specifications etc., should be made in writing.

In general, consultants will be endowed with a satisfactory level of ICT expertise, but will often lack expertise and knowledge of, and insight into, ICT systems specifically applied in the HE sector. If the institution's ICT personnel fail to take part in preparing the requirement and design specifications, there is a high probability that errors will be made and deficiencies arise in relation to the needs of the institution.

It is important that the institution's technical personnel take an active part in the construction process and either secure for themselves representative roles or engage in active dialogue with their own representatives in the institution's construction organisation. Uninett has prepared technical specifications (UFS documents) containing recommendations covering the majority of fields that have a bearing on ICT systems (ref. attachment 1). It is important that these are applied as basic design specifications. By employing Uninett's recommendations, the institution will ensure that the systems selected will be those generally accepted within the sector. Moreover, the technical specifications will be revised on a regular basis and in this way ensure that the systems selected will be updated in line with developments within the field of ICT. Occasionally it will be necessary to deviate from the recommendations contained in current UFS documents. In such cases it is important that such decisions are recorded in writing so that they can be traced.

2 The role of the building

The design of the building must take full account of prevailing security requirements within the sector. This has a bearing on the systems selected for ICT rooms both in terms of the type of room (server rooms, telecommunications rooms, shielded printer rooms for various security groups, etc.), and their associated infrastructure (cable pathways, electrical power supply, cooling systems, fire prevention etc.).

Overall ICT security architecture requirements for the HE sector must be safeguarded during the design of the building, and it is the responsibility of management to ensure that the institution's security policy is adhered to (ref. UFS 122 Recommended ICT Security Architecture in the HE Sector).

Moreover, it is essential to determine which security levels should be built into the building's ICT installations, i.e.:

1. Linkage to the campus network and utilisation of the institution's existing ICT infrastructure (basic level)
2. Linkage to functions crucial to the institutions' activities (normal level)
3. Linkage to functions crucial to other institutions' operations (high level/national responsibility)

Some buildings will be planned for multi-purpose use. In such cases, the HE institution is frequently the largest user and thus has the most wide-ranging infrastructure requirements. It is natural that in order to meet security requirements within its own organisation, the HE institution will assume responsibility for the joint cabling infrastructure with its associated ICT rooms, access controls and distributed and wireless computer networks. Access to other users will be governed by working agreements with the users in question.

The building's role in the community as a whole must also be defined. Many institutions possess specialist expertise, stand-by personnel, laboratories, etc., that will be expected to remain operative/accessible in connection with natural disasters and emergency situations. Moreover, it is possible that the building is integrated into local/municipal contingency plans, or that it has an important role within the research network that requires it to remain accessible to other institutions in the event that these should lose their network connection due to failures in their own infrastructure. For this reason it is important that the building's infrastructure reflects its role in relation to both security and accessibility requirements.

In many cases the building complex will be used by other people than its own personnel and students or those otherwise connected directly to the institution. For example, it is possible that it will be used for public events, e.g., using auditoria, meeting rooms, etc., which both able-bodied and disabled persons may attend. In such cases, it is important that the infrastructure reflects an all-purpose design that is able to meet the needs of different user groups, while at the same time satisfying the institution's security requirements.

During the design and implementation phases, issues often arise that can be traced back to the fact that the role of the building was inadequately defined.

3 Challenges

It is not uncommon in connection with new construction and renovation projects to discover that the institution's management possesses an inadequate definition of the building's role, and that the various technical groups were called too late into the planning process. In particular this concerns the institution's own ICT personnel and resources available to the sector such as procurement contracts, technical specifications (UFS documents) and available external expertise.

Many different types of ICT room are integrated into HE sector buildings (ref. UFS 103, Requirements for the Design of ICT Rooms), and which constitute important elements within the building's collective infrastructure. These occupy space in the same way as other technical installations such as WHS facilities, electrical equipment, etc., and involve complex systems that require a continuous electrical power supply/cooling. This is in contrast to teaching areas which, due to ENØK considerations, can be run at reduced capacity outside normal teaching and or office hours. In cases where the Principal Contractor/management define ICT rooms as user areas, the rooms will be regarded not as part of the technical infrastructure but will be considered together with offices, teaching areas, etc.

In addition to ICT rooms, both auditoria and teaching rooms have special design and construction requirements. This applies to everything from floor access points, cable pathways, ceiling-mounted and hanger loads, lighting, viewing and audio conditions and ventilation. It is important that the functions of both the building and its rooms are clearly defined so that each is designed appropriately. It is possible that inadequate definition of the functions of rooms/buildings will result in defective constructions that are difficult to rectify during the production phase.

Experience from a variety of construction projects demonstrates that the Principal and implementing contractors frequently do not understand, or even care about, the specified requirements, or they may choose to ignore such requirements on technical/economic grounds. In such cases, the Principal Contractor and the institution's own project management team have a special responsibility for ensuring that guidelines/design specifications set out in the respective UFS documents relating to HE sector buildings (see attachment 1) are adhered to. Inadequate collaboration/flow of information between contractors may also cause problems, resulting in construction errors, numerous and long clarification meetings, frustration, and additional work and expenditure in connection with the rectification of defective constructions and inadequate procurements. After occupation, a building with inadequate functionality will require rebuilding work incurring additional expenditure for the institution in question.

Good collaborative relations during the planning and design phases will result in a win-win situation for both the construction project and the user organisation. It is the responsibility of the Principal Contractor to achieve a good collaborative spirit between all the parties involved in the construction process so that errors are avoided, and he can thus hand over a deficiency-free building.

Table 1 provides an illustration of the general role requirements for HE sector buildings.

REQUIREMENT	LEVEL OF ROLE			REMARKS
	BASIC	NORMAL	HIGH/NATIONAL	
Security (shell security)	Locked door	Access control	Access control Break-in alarm Camera surveillance	UFS122 UFS103
Generic cabling systems	Min. Class E	Min. Class E	Min. Class E with secure cable distribution	UFS102
Electrical power supply, UPS	Public supply grid and UPS	Public supply grid, UPS and generator	Redundant public supply grid, UPS and generator	UFS107
Fire prevention	Fire detection	Early detection	Early detection and extinguishing	UFS104
Ventilation/cooling	Basic cooling system; cooling using external air	Redundant ice water and computer room cooling units with common pipe systems	Separate systems for each including redundant ice water and computer room cooling units	UFS108
Monitoring and logging	ICT management system	ICT management system	ICT management system	
Back-up			Separate back-up or two server rooms	UFS103
Building Management System	Basic system	Redundant system	Redundant system	Alarms transferred to ICT management system
AV equipment	General	General	General	UFS116

Table 1 Role requirements

4 Organisation

Under normal circumstances, it is the Norwegian Ministry of Education and Research that grants funding for new construction and renovation projects and, in general, it is Statsbygg (the Norwegian public sector construction and property management agency), acting under the Ministry of Government Administration, Reform and Church Affairs, that assumes the role of Principal Contractor. Statsbygg is the key Norwegian public sector advisory body in matters related to construction and property management, Principal Contractor issues, property managers and property developers. Statsbygg also has as its aim to be the preferred public sector Principal Contractor, but it is also possible that other models may be selected. An example of this is the "design-build package" model by which a contractor will assume Statsbygg's role in addition to administering the construction work or carrying out the leasing of premises whereby the lessor builds and equips the premises in accordance with the requirements of the institution in question.

Figure 1 illustrates an example of a project hierarchy that may be employed in connection with a major construction project.

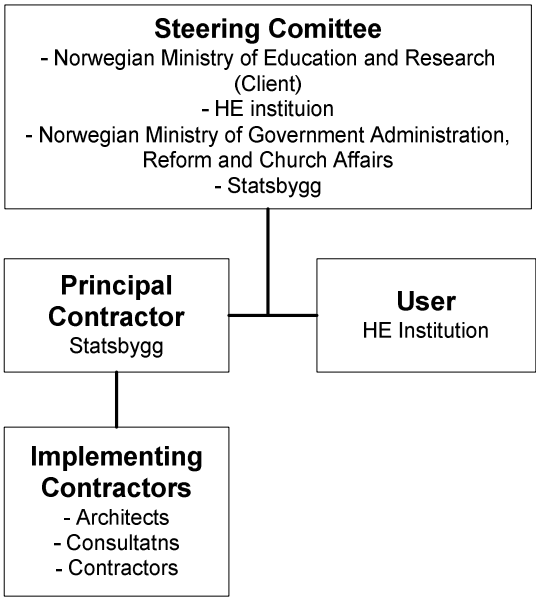

Figure 1: An example of a project hierarchy.

Steering committee. A forum for the mutual dissemination of information, collaboration and the coordination of principal decisions.

Principal Contractor. Responsible for implementation of the project within the stipulated framework and objectives in relation to expenditure, quality and schedule.

User. An important function in terms of defining criteria during the planning process and in connection with the hand-over and start-up phases on completion. In addition, in connection with resolving issues that have a bearing on the future running of the building.

Implementing contractors. Implementing contractors may include architects, consultants and other contractors responsible for carrying out the planning and construction process. Depending on the selected organisational model, the architect and consultants may report to the Principal Contractor or to another designated design-build contractor (design-build package model).

In the design-build package model, the design-build contractor will assume total responsibility for design, procurement and construction/installation. To the extent that a design-build contractor employs an architect and/or consultants, these will report to the design-build contractor.

5 Phases of the project

A construction project is subdivided into different phases. Figures 2 and 3 illustrate the phases during which ICT personnel should take advantage of the opportunity to intervene.

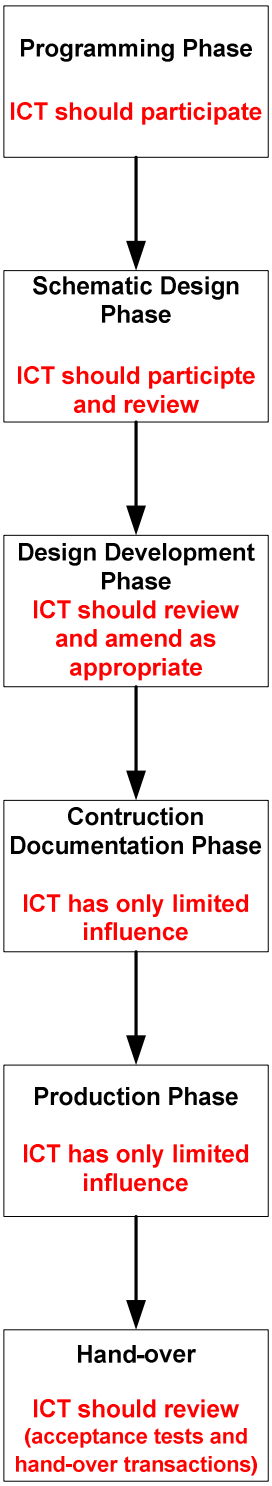

Figure 2: Phases of a construction project

The Programming Phase. This phase involves a definition of the substance of the building and the principal components of the budget. The definition is determined by the Principal Contractor, frequently with assistance from users such as the ICT department of the institution in question. It is also possible that consultants may be hired to direct or assist in the determination of the definition. It is common at this stage that ICT systems are discussed in very general terms and perhaps only in relation to the systems involved and the approximate space requirements of key ICT rooms. User-oriented ICT rooms must be programmed by the users in question. However, rooms linked to the building's infrastructure (technical rooms) shall not be programmed since the size/extent of these will be determined based on a collective programming process, and their definition will emerge during the later phases. The term "technical rooms" here refers to rooms that will be used to house technical systems/infrastructure such as WHS, electrical installations, UPS systems, generators, telecommunications rooms, main equipment rooms, entrance facility rooms, cable shafts and pathways, etc. Technical rooms form part of the building's gross/net ratio. Rooms such as server rooms, AV technical rooms, back-up rooms, computer rooms, auditoria, data labs, storage rooms, etc., that are crucial to the institution's production activities should be programmed. UFS documents dealing with building-related infrastructure should form the basis of the programming of such rooms.

The Schematic Design Phase. The Schematic Design Phase will be more detailed than the Programming Phase, and various options will be considered. The phase will be concluded with a recommended solution for which a budget will be drawn up. During this phase it is important that ICT personnel highlight their needs/functional requirements and the standards (e.g., UFS documents) that shall form the basis of the project implementation. This work may be carried out by external consultants. The Schematic Design Phase must be reviewed and commented on by ICT personnel before the final version is completed.

The Design Development Phase. The Design Development Phase is based on the options selected during the Schematic Design Phase, and entails the preparation of an even more detailed description of systems and functions. Similarly, a much more detailed budget will be drawn up. During this phase it is important that the institution's ICT personnel ensure that all requirements are accounted for and that the correct standards (e.g., UFS documents) have been used to define basic specifications. The level of detail involved may be sufficiently comprehensive to enable a design-build contractor to implement the project without additional information. If a design-build model is employed, the users will have only very limited influence during the Construction Documentation and Production Phases. It is therefore crucial that the institution's ICT personnel are given time to review the Design Development documentation and to submit their comments and the checklists they will use during subsequent acceptance of the installation. If a design-build contractor model is employed, the exclusion of functions during the Design Development Phase, and which must be incorporated during later phases, will result in much higher costs than if such functions had been adequately incorporated during the Design Development Phase. In general, Design Development Phase documents are prepared by external consultants.

The Construction Documentation Phase. This phase involves the preparation of documentation used as the basis for tenders used to invite bids and prepare contracts, together with the production of drawings. In the case of design-build projects, this work is carried out by external consultants or contractors. During this phase the institution's ICT personnel have little or no opportunity to influence events. However, they should demand to be allowed to inspect all material used as a basis for preparation of the tender documents in order to ensure that the requirements set out during the Design Development Phase are taken fully into account. They should also request to be permitted participation in assessment work, including attendance at status meetings, and the opportunity to assist in the preparation of short-lists for the selection of systems and suppliers.

The Production Phase. This phase involves the actual construction and installation of ICT systems. The institution's ICT personnel will have limited influence in terms of changing the systems already selected. This is often due to strict schedules and the fact that changes may impact on other technical aspects of the construction process. In general, the implementation of adjustments/changes during this phase will result in major budget over-runs, i.e. higher expenditures than those described in the Design Development Phase and in material used as a basis for preparation for the tender documents. During this phase it is crucial that ICT personnel supervise the installation process, draw attention to faults and deficiencies, and ensure that the guidelines set out in the UFS documents and their own checklists are followed up.

Hand-over. In general, the Principal Contractor/design-build contractor possesses a lower level of ICT expertise than the institution's own ICT personnel, and it is during this phase that it becomes essential that the institution's own ICT personnel take an active role in the testing of the respective systems, and that before the systems are handed over they ensure that these comply with the specifications stipulated during the Design Development and Construction Documentation Phases. They must also make sure that lists specifying deficiencies are drawn up together with deadlines for their rectification. ICT personnel should carry out their own repeat tests after the contractor has completed the rectification work.

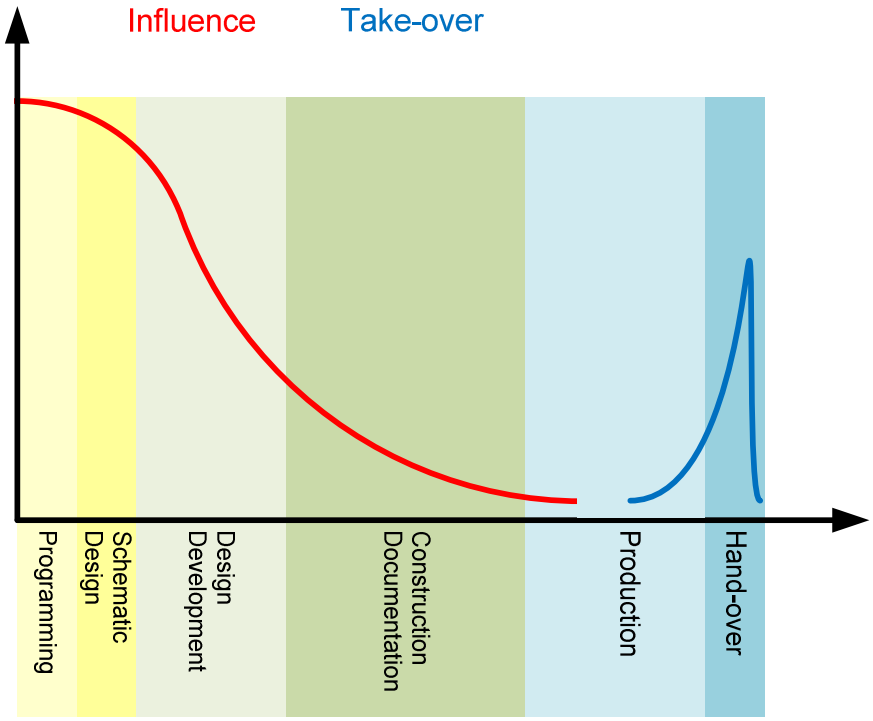

Figure 3: Level of influence exerted/work carried out by ICT personnel during a building project.

It is important to gain an insight into and to participate in the decision-making processes within your own institution. It is also important to check all documentation/descriptions (from both internal and external sources) against your own institution's current and future ICT requirements. Be aware of factors which ICT personnel take for granted (such as design), but which are not necessarily taken for granted by a contractor. A high level of detail in the specifications will result in the best end product.

Current trends indicate the increased use of digital coordination tools during construction projects. An example of such tools is the BIM (Building Information Model) which, among other things, incorporates the object-based design method. Tools such as these entail introducing a greater level of detail at an earlier stage (the

Schematic Design Phase) than is the case in traditional planning and design methods. This underlines the importance of ensuring that an institution draws up detailed specifications of its own requirements as early as possible. Statsbygg employs the BIM.

In connection with hand-over, UNINETT will be able to provide assistance with instruments and expertise. Unless otherwise agreed, ICT equipment incorporated into the project should be obtained using UNINETT's procurement contracts. UNINETT can provide assistance in connection with the planning, configuration and installation of telephony systems, network equipment, servers and AV equipment.

6 Construction elements

The NS 3451 Table of Construction Elements has been prepared by Standards Norway to define the various construction elements that are normally incorporated in a construction project. The standard stipulates a subdivision of construction and installation elements in order to systematise, classify and code information pertaining to the physical components of a building and its associated exterior installations/systems. This subdivision is employed in the various descriptions used in documents during the planning and design phases (Programming, Schematic Design, Design Development and Construction Documentation). The Table of Construction Elements is also commonly used to stipulate the fields of expertise linked to the various consultants involved in a construction project.

The NS 3451 Table of Construction Elements sorts construction elements into up to four levels. Attachment 2 provides a list of the construction elements with 2- and 3-digit code numbers that are employed. Certain words, expressions and terms employed in the Table of Construction Elements are often not the same as those commonly used by ICT personnel. For this reason, the remarks column provides a summary of those construction elements that are relevant for ICT installations.

Under normal circumstances, Statsbygg in its role as the Principal Contractor will not carry out the Construction Documentation Phase itself, but will employ consultants. During a large construction project, the following major construction elements will be included:

NS 3451 TABLE OF CONSTRUCTION ELEMENTS		**CONSULTANT**
MAIN ELEMENT NO.	**TECHNICAL FIELD**	
2	Construction	Architect
2	Construction	CCE (**C**onsultant **C**onstruction **E**ngineer)
3	WHS installations	CWHSE (**C**onsultant **WHS E**ngineer)
4	Electrical power	CEE (**C**onsultant **E**lectrical **E**ngineer)
5	Telephony and automation	CEE (**C**onsultant **E**lectrical **E**ngineer)
6	Other installations	CEE, or others as appropriate
7	Outdoor installations	Joint responsibility

In addition to the aforementioned consultants, Statsbygg may purchase consultancy services such as construction management (ref. section 7, item 4), and a Project Manager. The task of the Project Manager is to assist the Principal Contractor in such matters as safeguarding/assessing the needs of the users, checking consultants' work/descriptions, follow-up of contracts, supervision of the construction site and participation in the final inspection and tests. Normally, a Project Manager is employed in connection with major construction projects.

The various parties may represent different firms which are assembled by the Principal Contractor into a team. Commonly, the CCEs, CEEs and CWHSEs will be employed by the same firm. Good collaboration within the design team is essential to achieving a satisfactory final product.

Statsbygg will employ the Table of Construction Elements as the basis for numbering such elements in its contracts. For example; “C501 ICT Cabling”. Here, the “C” stands for contract, the first digit “5”refers to the first digit in the Table of Construction Elements (which in this case is “Telephony and automation”), while the next two digits are part of a series (from 01 to 99). A text field indicates the precise name of the construction element in question, which in this case is “ICT Cabling”, i.e., generic cabling. The numbering of elements in the contract, i.e., the serial number and text giving the name, may vary from project to project.

7 Procurements

The HE sector is subject to the regulations governing public sector procurements (ref. the Act relating to Public Sector Procurements; LOV-1999-07-16-69). (http://www.lovdata.no/all/nl-19990716-069.html) – in Norwegian.

The majority of new construction and renovation projects within the HE sector are on a scale that entails that these regulations must form the basis for all procurements. This applies to architects, consultants, contractors and equipment suppliers.

In order to ensure the hire of consultants with the best possible ICT expertise, it is important that ICT considerations are allocated sufficient focus in the tender invitation text and during the evaluation of applicants.

On behalf of the HE sector, UNINETT has entered into frame agreements which provide an opportunity to procure high quality equipment at low prices (20-30 % discounts). Information regarding the frame agreements available to the sector can be found at http://forskningsnett.uninett.no/innkjop/ (in Norwegian).

The frame agreements may include the following equipment, materials and services:

1. Network equipment
2. Wireless network equipment
3. PCs, Mac, and servers
4. Mobile telephony
5. Land-line telephony (traffic)
6. Telephony systems
7. Data storage equipment
8. Software
9. Printers and multi-purpose machines
10. AV-materials and AV installations

In addition to a low price, the use of frame agreements ensures that the equipment procured is that with which the sector is familiar and which can be integrated with existing systems and incorporated into current service and maintenance agreements.

It is important to ensure that the frame agreements are used in construction projects. This issue must be brought to the attention of the Principal Contractor at the earliest possible opportunity during the project (i.e., Programming, Schematic Design and Design Development Phases). In terms of the project budget, equipment procured via frame agreements must be charged to the construction project. For certain systems, configuration work should be carried out by the user, e.g., network equipment that must be configured in compliance with standard practice within the sector and its management system.

The use of frame agreements also applies in those cases where the design-build contractor model is applied. In such cases, a variety of contractors will have competed in order to supply the components that combine to form all the construction elements incorporated into the project, and it is therefore not necessary to issue tender invitations for individual construction elements. It is common for design-build contractors to select suppliers/subcontractors supplying the different construction elements that meet the requirement specifications, and which provide the simplest installation solutions for the greatest return. The institution can safeguard the use of frame agreements by stipulating this as a condition in the competitive tender documents for a design-build package, or in the contract document entered into with the design-build contractor. If it is not possible to safeguard the frame agreements in this way, the user may find it necessary to assume responsibility for installations that are neither wanted, nor can be appropriately carried out, by the design-build contractor, or pay compensation to said contractor for delivery of the preferred system.

Experience has shown that many design build contractors have only limited expertise in dealing with ICT systems such as telephony, computer networks, servers, workstations, AV systems, etc., to the extent that the contractor will often regard it as an advantage to exclude such systems from the design-build package delivery in favour of their being supplied by the user. Be aware that such contractors commonly have little understanding or expertise regarding the construction conditions required to provide ICT systems with a satisfactory installation and operational environment. For this reason, it is very important to provide a detailed ICT requirements specification that incorporates these factors. In cases where ICT systems are excluded from a design-build package and will be procured by the user, it is important to make sure that such an eventuality is covered by the construction budget, and that such systems are not charged to the operations budget.

8 Checklist

1. Are the roles of the building and its various rooms adequately defined?
2. Does the building include premises that will be leased? Is the responsibility for such premises clearly defined, i.e., who has operational responsibility for the joint infrastructure?
3. Will the building's auditorium, meeting rooms etc., be used by the general public, and has all-purpose access been taken into consideration?
4. Has an organisational hierarchy been drawn up for the construction process? Is the institution in question represented in the organisational hierarchy?
5. Are ICT personnel represented in the institution's construction programme/committee?
6. Do ICT personnel have access, consultative entitlements and the right to object to the various documents and budgets included in the different design phases?
7. Will UNINETT's frame agreements be used?
8. Have the components of the construction budget been clearly defined? What equipment will be procured by the user? Has the ICT department drawn up a budget to cover the procurement of material defined as user equipment?
9. Has the institution prepared its own design specifications that can be utilised as a basis for construction documentation? Will UFS documents be utilised?
10. Is there a current ICT strategy/security policy that stipulates guidelines relating to current and future requirements that can be utilised as a design basis?
11. Have plans been prepared for the different ICT rooms that will be incorporated into the construction project?
    a. Total number, type, size and other construction-related technical requirements such as raised floors, etc? This information must be communicated to the project management team/Principal Contractor at the earliest opportunity because this is crucial to the building's total space allocation plan.
    b. Electrical power requirements (normal power supply, stand-by power supply, uninterruptible power supply, redundancy)?
    c. Cooling and ventilation requirements (redundancy)?
    d. Fire detection and extinguishing requirements?
    e. Security requirements (access control, camera surveillance, etc.)?
12. Has a plan for a generic cabling system been drawn up (type of cable, termination configuration, racks, etc.)?
13. Do ceiling constructions have sufficient strength to support ceiling-mounted equipment (ICT rooms and stages)?
14. Are meeting rooms and auditoria designed to enable the installation of AV materials such as display surfaces, unimpeded views, etc.)? Lighting requirements, etc.?
15. Do ICT cable pathways have sufficient capacity to accommodate installation and future expansion? Have floor access points been installed in meeting rooms and auditoria?
16. Have environmentally-friendly systems been selected:
    a. Equipment with low energy consumption (virtual servers, modern switches, etc.)
    b. Use of free cooling systems (involving the minimal use of compressors).
    c. Energy recycling during cooling production.

9 Be aware of

1. The Norwegian Ministry of Education and Research is empowered either to enter into long-term leasing agreements with private developers or build under the auspices of the state.

2. In its role as Principal Contractor, Statsbygg must adhere to a budget, a total number of students and the necessary user-designated space as stipulated during the Construction Programming Phase/Schematic Design Phase/Design Development Phase.

3. Statsbygg may act both as Principal Contractor and property manager. This means that Statsbygg may implement measures that are beneficial from a property management viewpoint, but less so for the user institution in question.

4. The majority of construction projects will be administered by a construction manager. The task of the construction manager is to ensure that the respective contractors deliver in compliance with their contracts, and in accordance with the construction schedule. When several contractors are working concurrently on a construction site, it is the task of the construction management team to coordinate the work and any interdependencies among the contractors involved. The quality of a completed building will often be a direct result of how well the different contractors have been managed by the construction management team, combined with the contractors' own collaborative capabilities.

5. The disposition of technical areas (rooms designed for WHS, ICT, electrical power supply, etc.) is determined at an early stage in the construction process and thus often becomes fixed in the Design Development Phase. During a construction process, various interests will be allocated space in accordance with their respective submitted needs. If, at a later date, it is found that the need of a given interest group was greater that its original submission, a new allocation will be made, often at the expense of the needs of other users. It is thus advisable to reserve adequate space as early as possible in the process. It is virtually impossible to be allocated additional space once a floor plan has finally been decided.

6. Rooms dedicated to ICT functions such as telecommunications rooms, server rooms, shafts, cable pathways, etc., must be regarded as part of the ICT infrastructure together with servers, network electronics, telephone exchanges, cabling systems, etc. The infrastructure components will have the following operational lifetimes:
    a. The lifetimes of ICT rooms, cable pathways, pipes, and ventilation ducts are equivalent to that for the building as a whole.
    b. Cabling systems, cooling and ventilation generators have a lifetime of 15-20 years.
    c. Network electronics, servers, and so on, have a depreciation period of 3-5 years.

7. Focus must be directed on systems that provide simple operational functionality at low operational cost, such as good ENØK systems, i.e., low lifetime costs.

8. If the construction project's budget is severely constrained, equipment that might normally be included in the project may be designated as "user equipment", for which costs must be covered by the respective institution's operational budget.

9. In general, all errors and deficiencies in the building must be rectified before hand-over. All rectification expenditures must be covered by the developer (contractor). Demand compensation if the rectification of errors/deficiencies results in reduced production or other forms of inconvenience.

10. A major building project involves many technical disciplines which in turn are subdivided into many contracts/agreements. A single contractor may be responsible for completing one or a number of contracts. If a given contractor lacks the expertise or the products required, he may engage subcontractors. The Principal Contractor will be in contact only with the contractor who has responsibility for the respective subcontractors.

10 Experiences from construction projects in the HE sector

10.1 University of Agder (UiA)

In connection with a new construction project ("Campus Grimstad") at the University of Agder (UiA) a PPC (Public/Private sector Collaboration) model[1] was selected, i.e., a private sector company acted as developer, while UiA subsequently rented the premises. This form of construction process is considerably different from a typical Statsbygg process, involving project development according to the Scrum Method, i.e., "step-wise planning and construction". The planning and construction of a given stage is not commenced until the previous stage has been fully completed.

We submitted our criteria for the project at an early stage and based these on pre-release versions of the relevant UFS documents. This was because we had participated in the development work and were familiar with its contents. The UFS documents were appended to the Schematic Design Phase documentation, but were subsequently disregarded by the Principal Contractor. Since that occurred we have spent a great deal of

[1] The PPC (Public/Private sector Collaboration) model involves a collaboration between public and private sector organisations in the implementation of a project or provision of services, in which the private sector organisation assumes a greater part of the responsibility linked to the development and/or running of the project/service in question. The public sector organisation provides a description of the subject of the project and the standards and levels of quality required. Within these terms of reference, the private sector organisation is granted the freedom to plan and carry out the work in the most appropriate manner. Ref.: http://www.ops-portalen.net (in Norwegian).

time in fighting to restore to the project our original and previously approved requirements, a process that has resulted in additional costs.

Our experience demonstrates that it is crucial that IT personnel participate in the planning process at the earliest possible opportunity. It is also important that IT personnel participate in the specification and design of what will be included in the final product (contract). If this doesn't happen you will risk ending up in a situation in which functions that you would normally take for granted have to be procured as supplementary orders, and at a considerably higher price.

In order to achieve the best possible quality, a small group of 4 people was established with the aim of supporting UiA's Construction Project Manager in dealing with electrical and IT issues. All requirements were set out in documents and circulated as part of an internal consultation process before they were presented to the construction project team. In this way the requirements became established within the institution's own organisation. The organisational hierarchy guaranteed us a certain influence in the construction project, while at the same time relieving some of the burden of responsibility from UiA's Project Manager – a win-win situation.

Participation in construction projects is time-consuming and must be carried out on top of other work assignments. For this reason it is advisable to request release from one's daily routine tasks, e.g., by encouraging the construction project to pay to make resources available from within the institution's ICT organisation.

When should ICT put the pressure on? "Start aggressively and just increase the pressure until you get what you want". I think this says it all. It's no use taking your eye off the ball and acting indecisively. Nothing is achieved by looking around at everybody else wondering who is going to take responsibility. Seize the opportunity/responsibility and don't let up. However, you must make sure that this approach gains acceptance - in any event with your IT Manager, such as we managed to do.

10.2 Hedmark University Collage (HiHM)

Hedmark University College has recently had experience with a construction project for which Statsbygg was not the developer. Our experience is thus not entirely relevant to the descriptions in UFS 121, where the main focus is on projects for which Statsbygg is the Principal Contractor.

We recognise many similarities with UiA, and offer the following specific additions to their advice:

1. *Make sure that you read the developer's requisition to the design-build contractor very carefully:*
    a. *Check this against your own requirement specifications/UFS document specifications.*
    b. *Report discrepancies in writing.*

2. *Follow-up by conducting inspections of the construction site to ensure that the developer's requisitions are in fact being carried out.*
    a. *Report discrepancies in writing.*

Similarly to UiA we also reached agreement with the developer on several points that the contractors failed to follow up. The contractors dismiss our reports of discrepancies and are only concerned with adhering to their own contract with the design-build contractor or developer.

The developer is only too happy to remain conspicuous by his absence during such disputes. If they involve themselves at all they demand that we produce comprehensive written documentation of decisions made at an earlier date. Frequently, the subject of the disputes concerns issues that are not covered in leasing agreements or contracts. For this reason it is important to produce other forms of written documentation. Verbal decisions are of little subsequent use.

11 Appendixes

11.1 List of UNINETT Technical Specifications (UFS)

An updated list can be found at www.gigacampus.no.

Physical Infrastructure

UFS	Title
UFS102	Requirements for Generic Cabling Systems
UFS103	Requirements for the Design of ICT Rooms
UFS104	Fire Prevention Requirements for ICT Rooms
UFS107	Power Supply Requirements for ICT Rooms
UFS108	Ventilation and Cooling Requirements for ICT Rooms
UFS121	Guidelines for the Design of HE Buildings, ICT and AV Infrastructure

Audio-visual (AV)

UFS	Title
UFS116	AV Functional Description for Auditoriums and Meeting Rooms
UFS119	Technical and Functional System Requirements for AV Equipment
UFS120	Operational Support System and Audiovisual Transmission

Network

UFS	Title
UFS105	Recommended Configuration of Switches in Campus Networks
UFS109	Cookbook for Configuring Cisco IOS Switches in Campus Networks
UFS111	Cookbook for Configuring HP Switches in Campus Networks
UFS110	Cookbook for Configuring Alcatel Switches in Campus Networks
UFS114	Fault-tolerant Campus Networks
UFS115	Recommended Client configuration for Optimal Long-distance Performance

Mobility

UFS	Title
UFS112	Recommended Security System for Wireless Networks
UFS113	Radio Planning of Wireless Networks on Campuses

Security

UFS	Title
UFS106	Best Practice for Packet Filtering in the HE Sector
UFS122	Recommended ICT Security Architecture in the HE Sector

Person-to-person communication

UFS	Title
UFS123	Telephony Routing Requirements in the HE Sector
UFS113	Telephony Services Requirements in the HE Sector

11.2 Extract from NS 3451 Table of Construction Elements.

Construction elements that may have a bearing on ICT systems are shown in the remarks column.

CONSTRUCTION ELEMENT		CONSULTANT	REMARKS
NO.	TEXT		
2	CONSTRUCTION	Architect/CCE	*ICT room requirements, ref. UFS 103*
20	Construction, general		
21	Ground/soil and foundations		
22	Supporting structures		
23	Exterior walls		
24	Interior walls		
25	Floors/decks		
254	*Floor systems*		*Raised floors*
257	*Suspension system ceilings*		*Cooling unit ceilings*
26	Exterior roofs		
27	Fixed furnishings and fittings		
28	Staircases, balconies, etc.		
29	Other construction-related elements		
3	WHS INSTALLATIONS	CWHSC	*ICT installation requirements, ref. UFS 108*
30	WHS installations, general		
31	Sanitation		
32	Heating		
33	Fire extinguishing		
331	*Manual extinguishing using water*		*Different types of fire extinguishing installations are described in items 331 – 335.*
332	*Fire extinguishing using sprinkler systems*		*Uninett's recommended fire extinguishing methods, i.e., hypoxic air venting, is not incorporated into the*
333	*Fire extinguishing using water mist*		*Table of Construction Elements, but will be described in item 339 by the consultant (Ref.*
334	*Fire extinguishing using powder*		*UFS 104*
335	*Fire extinguishing using inert gas*		
339	*Other fire extinguishing components*		
34	Gas and pressurised air		
35	Process cooling		
353	*Production cooling systems*		*ICT room cooling systems*
36	Air treatment		
362	*Air treatment duct network*		*Items 362-364 will be utilised for ventilation of ICT rooms (battery rooms)*
363	*Air distribution equipment*		
364	*Air distribution equipment*		
37	Comfort cooling		
38	Water treatment		
39	Other WHS installations		
4	ELECTRICAL POWER	CEE	*ICT installation requirements, ref. UFS 107.*
40	Electrical power, general		
41	Basic electrical power installations		
411	*Cable routing systems*		*ICT cable runs and racks are often included under electrical power (ref. item 511.*
412	*Earthing systems*		*Utilised for the earthing of ICT installations*
42	High voltage supply		
43	Low voltage supply		

CONSTRUCTION ELEMENT		CONSULTANT	REMARKS
NO.	TEXT		
433	*Electrical power distribution for general use*		*Electrical power supply to smaller ICT rooms*
435	*Electrical power distribution for production applications*		*Electrical power supply to larger ICT rooms and computer centres*
44	Lighting		
442	*Lighting equipment*		*Lighting in ICT rooms*
443	*Emergency lighting equipment*		*Emergency lighting in ICT rooms*
45	Electrical heating		
46	Standby power supply		
461	*Electrical power generators*		*Diesel generators for uninterruptible electrical power supply*
462	*Uninterruptible power supply*		*UPS with batteries to supply uninterruptible power*
47	Not utilised		
48	Not utilised		
49	Other installations		
5	TELEPHONY AND AUTOMISATION	CEE	*ICT installation requirements, ref. UFS documents 102, 116, 119 and 120*
50	Telephony and automation, general		
51	Basic installations for telephony and automation		
511	*Cable routing systems*		*Cable routing is normally accounted for under electrical power, item 411*
512	*Earthing*		*For issues concerning earthing not included in item 412, refer to NEK EN 30510*
514	*Incoming cables for telephony systems*		*Cables to facilitate ISP/PSTN connections*
515	*Telephony cable junctions*		*Junctions in shafts and racks in ICT rooms (CR)*
52	Integrated communication systems		
521	*ICT cabling*		*Generic cabling systems, ref. UFS 102*
522	*Network equipment*		*Network electronics, ref. UNINETT frame agreements*
523	*Core equipment*		*Servers, storage media, etc., ref. UNINETT frame agreements*
524	*Terminal equipment*		*Work stations, PCs, etc, ref. UNINETT frame agreements*
53	Telephony and paging systems		
532	*Telephone systems*		*Telephone exchange including apparatus, ref. UNINETT frame agreements*
534	*Door telephone systems*		*Stand-alone devices or integrated with the telephone exchange*
535	*In-house loudspeaker telephone systems*		*Not normally used.*
536	*Paging systems*		*Paging system installation*
54	Alarms and signals		
542	*Fire alarms*		*Fire detection system, ref. UFS 104*
543	*Access control, break-in and assault alarms*		*Important for ICT rooms*
544	*Nurse Call Systems*		
545	*Time clock and working hours registration system*		*Computer network can be used for distribution.*
55	Audiovisual systems		
552	*Antennae for general use*		*Cable TV, can be distributed via the computer network*
553	*In-house television*		*Camera surveillance of ICT rooms (CCTV)*
554	*Audio distribution system*		*For audio distribution to several rooms or areas*
555	*Audio equipment*		*Equipment for in-house audio amplification in rooms, incl. telephony loops.*
556	*Screen display and AV systems*		*Information and AV systems, ref. UFS documents 116, 119 and 120*
56	Automation		
562	*Central operational control and automation*		*Transfer of alarms (environment) to ICT management system(s)*
57	Instrumentation		

CONSTRUCTION ELEMENT		CONSULTANT	REMARKS
NO.	TEXT		
58	Not utilised		
59	Other telephony and automation installations		
6	OTHER INSTALLATIONS		
60	Other installations, general	CEE or others	
61	Pre-fabricated rooms		
62	Personnel and goods transport		
63	Transport system for small goods, etc.		
64	*Technical stage equipment*		*Technical stage equipment*
65	Waste and vacuum cleaning systems		
66	Hard-mounted special equipment for production purposes		
67	Movable special equipment for production purposes		
68	Not utilised		
69	Other technical installations		
7	OUTDOOR INSTALLATIONS		
70	Outdoors, general		
71	Landscaped areas		
72	Outdoor constructions		
73	Outdoor WHS installations	CWHSC	
74	*Outdoor electrical power supply*	*CEE*	*Cable pathways/cabling between buildings.*
75	Outdoor telephony and automation systems	CEE	
76	Roads and assembly areas		
77	Park and garden facilities		
78	Outdoor infrastructure		
79	Other outdoor installations		

References

1. NOU 2006:6: When security is paramount. A survey undertaken by the Office of the Auditor General of Norway of the authorities' work to safeguard IT infrastructure; Doc. 3:4 2005-2006 (In Norwegian).

Glossary

AV	Audiovisual
BIM	Building Information Model
ENØK	Energy saving and efficiency measures
DS	Design specifications
CCE	Consultant Construction Engineer
CEE	Consultant Electrical Engineer
CWHSE	Consultant Water, Heating and Sanitation Engineer
UFS	Uninett Technical Specifications documents
HE institutions	Norwegian higher education institutions
The HE sector	The Norwegian higher education sector
UPS	Uninterruptible power supply
WHS	Water, heating and sanitation