Streamer
European research on energy-efficient healthcare districts

# Framework for management of information flow, design actors and collaboration in virtual design and construction

Deliverable 4.1

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**Streamer - Optimised design methodologies for energy-efficient buildings integrated in the neighbourhood energy systems.**
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# Framework for management of information flow, design actors and collaboration in virtual design and construction

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## Colophon




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# Publishable executive summary

To achieve the aim of STREAMER project, 50% reduction on the energy use and carbon emission of new and retrofitted buildings in healthcare districts, there is a clear need of breakthrough in the design process, supported by an increasing implementation of interoperable tools for BIM and GIS computer-based modelling. Additionally, to reach the goal it is also necessary to involve the design actors in all the phases of the design and to develop a new way of collaborative design.

This deliverable, D4.1, “Framework for management of information flow, design actors and collaboration in virtual design and construction” paves the way in preparing the foundations for collaborative design in healthcare design projects.

The complication of healthcare design projects, with the large panel of multidisciplinary actors for the design and the multiplicity of the space areas, as well as the integration of the medical process in the operation of the building push to settle the design process on comprehensive and measurable indicators. For the same reason, clear information and labels must be established, from the early stage of design, to translate the requirements into clear and usable objectives for the different stakeholders involved in the design.

The introduction of participatory design, using the methodology of virtual design and construction, will lay the foundation stone of the decision making process. Virtual design and construction is based on a multiple approach, comprising the product (district or building), the organisation (involved actors associated to their roles) and the process of design (different stages). Decision making process, composed of multi-criteria analysis, will allow for a consensus reaching objective. Again the transparency and measurability of the criteria are key factors to allow collaborative and comprehensive progress in the review decisions.

BIM and GIS models integrate the right level of information according to the requirements, as well as the design stages, and then support the collaborative process in distributing the accurate level of data to interoperable tools. This allows a huge reduction in latency and at the same time reduces the risk of inconsistencies.

At the end, all these recommendations will be the pillar for the starting point of the next phase of this task, the development of the process roadmap of participatory semantic-driven design.

# List of acronyms and abbreviations

BIM : Building Information Modelling

dPoW : digital Plan of Work

FM : Facility Management

GIS : Geographic Information System

HVAC : Heating, Ventilation and Air Conditioning

IFC : Industry Foundation Classes

IPD : Integrated Project Delivery

KPIs : Key Performance Indicators

LOD : Level of Detail / Level Of Development

LOI : Level of Information

MCDA : Multi-Criteria Decision Analysis

MCDM : Multi Criteria Decision Making

OBS : Organization Breakdown Structure

OSM : OpenStreetMap

PBS : Product Breakdown Structure

PD : Participatory Design

POP : Product, Organization and Process

POR : Program of Requirements

PTS : Program for Technical Standard

RAP : Room Appliance Program

VDC : Virtual Design in Construction

WBS : Process Breakdown Structure

# Contents

# 1. Introduction

STREAMER aims to reduce by 50% the energy use and carbon emission of new and retrofitted buildings in healthcare districts. To do this, STREAMER'S approach is to develop innovative tools in order to design efficient energy healthcare districts. It deals on one hand with the novel digital approach of BIM and GIS, linked with modelling tools such as energy simulations and calculations. On the other hand, this numeric approach will modify the processes of design, and particularly the relations between the different actors involved in the projects. Above all the processes, the umbrella of the information is becoming more and more important.

We will focus on the design phase of the project, from the decision to start a project, a new one or a refurbishment/renovation of an existing one, to the end of the design and the start of the works on site.

The aim of this report is to better understand the information flow during this design phase. Until now, design decisions are taken at different levels, by different professionals based on domain knowledge; effects of design decisions on performance of users, and energy use are taken into account, but often partially, at a (too) late stage.

The first section will highlight the complicated design process of healthcare projects, as well as the importance and the diversity of the involved actors during the stages of the design phase. And above these, the complexity of the functioning of the hospital, with multiple flows, associated with the multiplicity of the departments, and the process equipment will end to prove the needs of collaborative approach for the design, to achieve an efficient project.

The Participatory Design will then be introduced, first with literature definition and application in healthcare projects. This will be followed with a practical example on supervision of Clinical designers, through participatory design. The section will end with the introduction of the methodology of virtual design and construction, linking the product, the actors and the process of design, integrating the computer-based models.

As one the most important issue of the design process during the different stages is to take the best decisions while reaching consensus, the decision making process will be developed, underlining the importance of shared indicators, vocabulary, and typologies between the different stakeholders.

Following this, the last section will highlight the support of the BIM (for the buildings) and the GIS (at the scale of the district) approach to reduce inconstancies and make decisions more fluid.

The conclusion will open the potential improvement with the STREAMER developments.

# 2. Complicated Design Process in complex healthcare

The design of a building project needs to follow a certain way, to be efficient in terms of answering the needs of the end-users, of schedule, of cost, of regulations (fire safety, energy efficiency, structural, health safety). The design involves also plenty of actors, from various horizons such as real estate, public authorities, end-users, operators, designers, engineers, visitors. These different stakeholders have different needs for information at different moments, and so this is one important clue to the difficulty of the process and more particular on the decisions and review phases.

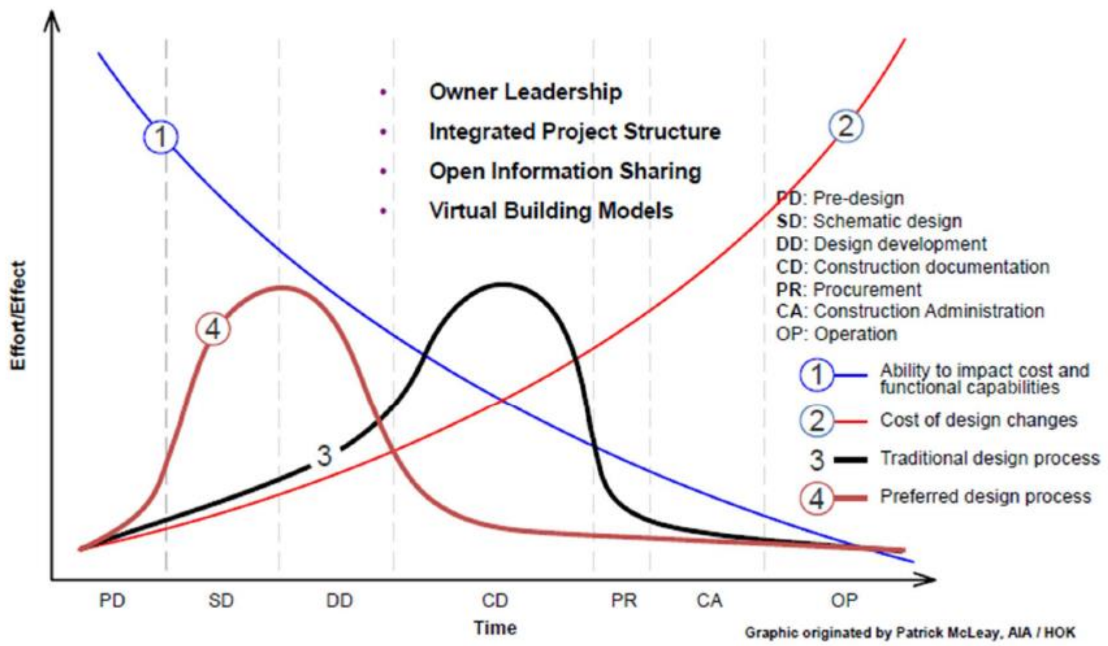



*Figure 1 : Diagram of Effort/Cost related to Stage of Process*

As mentioned in the description of work of the project, the importance of early decisions to reduce cost and effort/time, pushes to develop tools to support and assist early decision making in design, as also indicated in Figure 1. To obtain this, more information is needed at an early phase of the project. But the detail and quality of this information are also a key point, and have to be linked with the level of development of the design. Detailed information, arriving too soon, can have the opposite effect on the design, as well as lack of information.

## 2.1 Design Process Map

The pre-project phase identifies and defines business goals and user needs on a strategic level, and shall be integrated into the programming, pre-design and design phase. This will secure a planning and decision making process that is structured, transparent and holistic where the consequences of alternative options can be calculated and measured against KPI's and evaluation criteria.

Each construction project follows a common route from initiation: In the early stage, client, consultants and specialists come together to define project objectives and requirements, and produce alternative solutions. Client/steering group decides on project realization. If the client decides to continue, the project team produces construction design and production starts. After handover, the project can be evaluated. In order to reach the best possible result, it is essential that the end users and patients are consulted or represented throughout the process.

Design phase includes boundaries, and details the tasks and outputs required at each stage –as from the UK model for the building design and construction process “RIBA Plan of Work 2013” (www.ribaplanofwork.com). The RIBA Plan of Work 2013 is a digital tool allowing users to customize the processes by providing the options to select and define, for example, the procurement route, combine certain work stages, the use of BIM and choose the optimum time to go for planning application. The core objectives of each stage, however, are fixed and cannot be changed.

Using this structure allows the work in STREAMER to map out the information structure to find solutions to better streamline the design work –the supporting information and data and the information exchange using a model-based design approach. The RIBA Plan of Work 2013 consists of eight work stages identified by the numbers 0-7(see Figure 2), following the logics of: Brief – Concept – Developed design.

| | |
|---|---|
| 0 | Strategic definition |
| 1 | Preparation and brief |
| 2 | Concept design |
| 3 | Developed design |
| 4 | Technical design |
| 5 | Construction |
| 6 | Handover and close out |
| 7 | In use |

*Figure 2 : The eight stages of RIBA Plan of Work 2013*

The Design phase comprises stages 0-4 and is strongly connected to the work and responsibilities in the additional stages. Each stage is outlined with clear boundaries, and details the tasks and outputs required according to Core Objectives, Procurement, Programme, (Town) Planning, Suggested Key Support Tasks, Sustainability Check-points, and Information Exchanges (at stage completion).

In complex projects, it is important to use time when time is considered cheap (when design is not too developed, so that changes are not too expensive) and keep the window for optimizing the project open before detailed design starts, thus avoiding expensive changes and need for redesign late in the process.

The strategic definition identifies and defines business goals and user needs on a strategic level, and shall be integrated into the programming, pre design and design phase. This will secure a planning and decision making process that is transparent and holistic where the consequences of alternative options can be calculated and measured against KPI's and evaluation criteria's. As in the integrated project delivery (IPD) processes, defined by the AIA organisation, and described in the T4.3 internal report (Integrated project delivery), the decisions are based on defined criteria and evaluation of alternative solutions against the criteria. After a systematized quality assurance process the Concept Phase ends with a business plan presenting the best option for realizing the project.

The same approach can be described by the work of Alastair Blyth and John Worthington showing the transition from "business language" in pre-project stage to an "Architectural language" in the project stage. This translation is crucial when converting the market (users) and business need to an architectural and technical solution expressed by the buildings, the infrastructure and dependencies between these on a district level.

We focus on the design phases after the strategic decision of starting a project, phases 1-4 of the RIBA Plan of Work 2013. The design itself is here split into three major phases Concept Design-Developed Design and Technical Design.

The first stage translates the needs from phase 1 (goals and objectives, organisational model), in order to establish a functional program associated to technical requirements, and so determine a list of detailed areas (room by room), including the links and flows between them. The outcome of this is the Programme of Needs (and later Requirements).

The second stage transforms the validated program into a volumetric architectural design, integrating the site constraints, the exterior design, and the technical general requirements, generating a complete concept of the building.

The third stage develops the design from the concept building into a complete detailed and technical design, ready for construction. It includes the detailed calculations and simulations in all engineering parts.

The design process diagram (Appendix 1) was created to illustrate the information flow between actors in a design process following the envisioned STREAMER workflow, a fragment is shown in Figure 3. The diagram is quite general, without being specific about country- or project-specific processes. Also, the diagram could be applied for both retrofit and new build design processes.

The diagram is of the so-called “swimming lane” type. The swim lanes (or pools) represent actors or roles that correspond, generically, to the organization deployed in the design phase in constructing or renovating a hospital. Within the lanes (or pools) the information is always displayed in a logical and chronological order. The design phases are as defined by the RIBA.

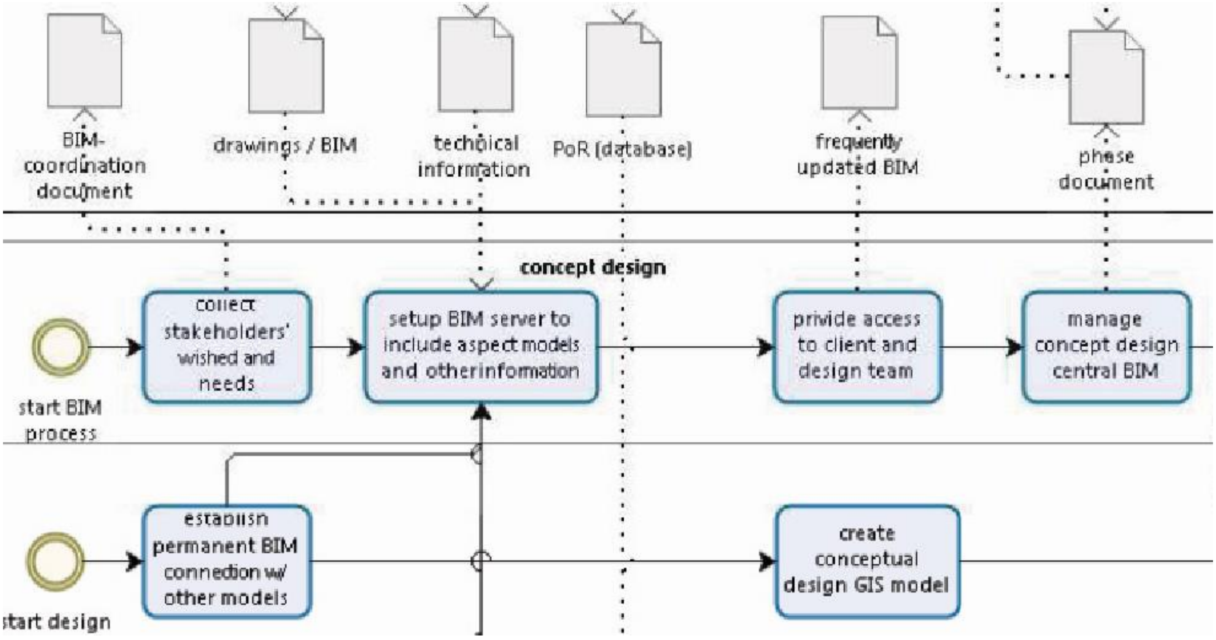



*Figure 3 : Fragment of the process diagram*

The design process diagram is included in STREAMER deliverable 5.1, where it is described in more detail. A detailed formalization of the information flow, as shown in the diagram, is intended to take place in T5.2.

Some of the actions and documents are typical for the STREAMER process and are likely to be further researched in the STREAMER project. In Appendix 1, the mapping of STREAMER deliverables has been made on a detailed process map, linking all documents of a project, with the necessary actors during the different stages of the project. It highlights the benefit of the BIM database as a crucial vector of the information flow during the life of the project to avoid losses and discrepancies.

The map, briefly described above, represents the most general design process, thus, the flowchart should be taken as a reference model. In real cases, the design process could be developed according to a number of variables that makes the process deviated from the ideal flowchart established.
First of all, the real process will reflect the differences and specificities of each country and their bureaucratic and legislative systems. According to that, the phases and the content of each design phase could be slightly different from the one above shown.
Of course, most of the rules and procedures of design processes are based on European Union directives, thus, they are defined starting from the same basis regardless of the differences that occur in the different countries' legislations.
Therefore, factors that could intervene in the development of the process are due to the typology of intervention, the type of procurement procedures, the type of contracts, and the levels of design required.

These concerns require an example able to show the complication of the design process and its glossary: in Appendix 2 the Italian scenarios has been deeply described. The document contains the list, and its instruction - in terms of levels of design, types of contract, procurements procedures and main design actors involved - of the scenarios in the design and construction process from the architect point of view and the hospital owner as well. The document also shows the differentiations between the “real” procedure and the phases defined in the process map above in terms of name, often contents and outcomes to be delivered

To sum up the process of a construction project, the figure below represents the different stages of the process (according to RIBA phases), associated with different families of actors, and their roles during the stages or group of stages.

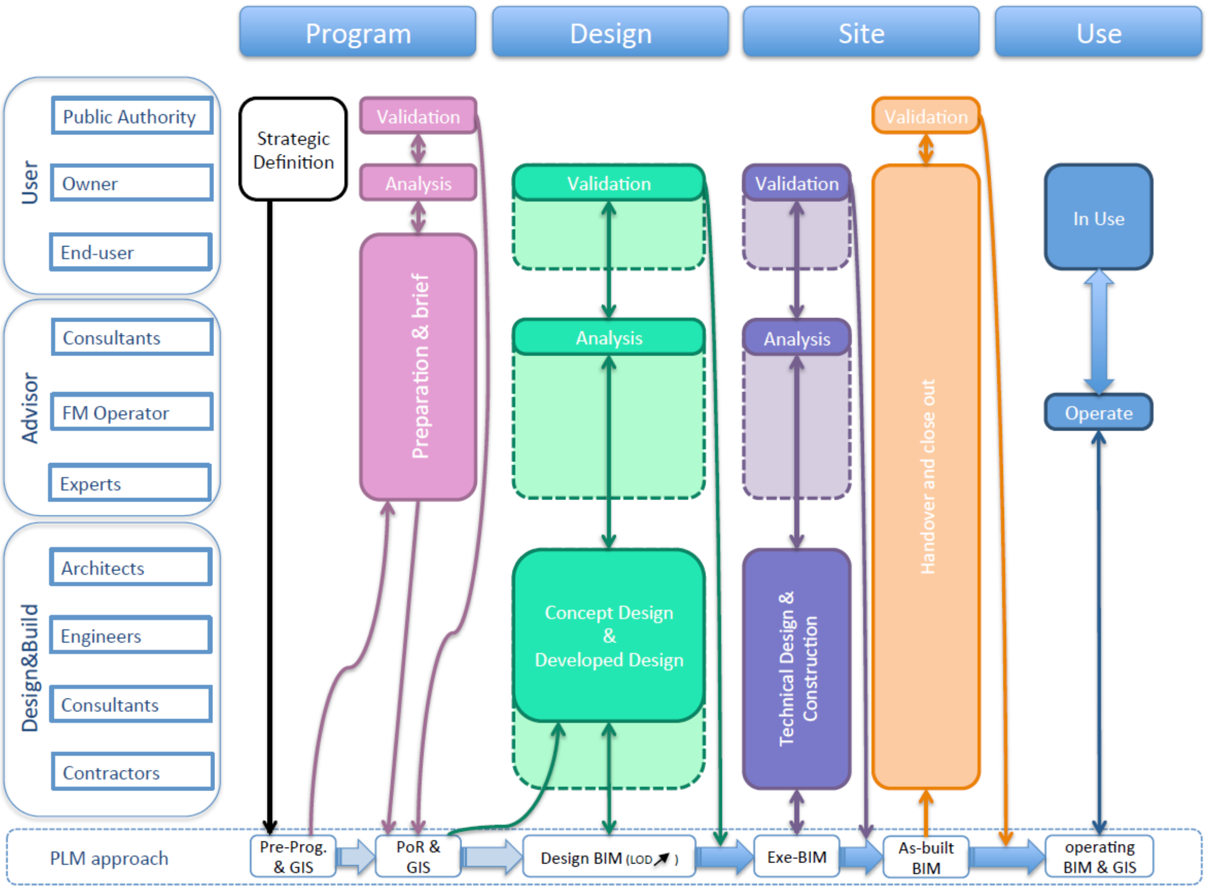



*Figure 4 General Process Map*

## 2.2 Design actors

The number of actors involved is one of the complications of the design process. Indeed, this number could lead to inconsistencies and wastes in terms of time and money during the design phases when the collaboration among professionals is not well structured from the organizational and technical perspective.

For this reason, for complicated projects such as healthcare districts, the application of collaborative and integrated design methods appear to fulfil an attentive development of design activities and a proper information flow among professionals and disciplines.

The goal of this is that key actors (i.e. client, facility managers, designers and engineers) make the right design decisions at the right time, using the right information and informing them about the consequences of design decisions. We do this by aligning all stakeholders through a joint design tool developed in STREAMER (e.g. the dashboard for comparing KPIs of design alternatives), collectively used and understood by all actors, that contains one set of interlinking goals (criteria with key performance indicators) that is updated when planning is progressing and more design information is known.

In traditional design processes, with limited support of the tool, collaborative and integrated design methods are based on the parallel development of design activities according to the dependencies of information flow required between two activities to be developed.
However, in virtual design processes, the aim of the STREAMER research project, the difficulties due to the high number of actors involved could be tackled and solved through the use of the tools, which accomplish the possibility to highlight the inconsistences and to avoid wrong information flow between different actors. This should prevent errors in the design process due to the misunderstandings in sharing the knowledge between the design experts and the non-experts.

An added complication is that not all stakeholders require the same type of information, detail or should be involved in all phases of the design process. Secondly decision taken early on in the design process may impact the room for alternative design solutions at later stages. Design in itself can be a reiterative process, however, too many iterations may proof to be time or cost consuming. This implies that we must be careful in distinguishing which stakeholders should be involved and be able to demarcate when, how and where their contributions are required. Secondly a framework should be in place that prevents sub-optimization of design efforts; a design solution that looks good on a very detailed level, might proof not to be that good if you look from the perspective of a neighbourhood. Clear information that is used in the design process plays a key aspect in all these layers and makes it complicated.

Hereafter, Table 1 contains typical description of the possible actors that play essential roles during the design phase of the project in collaborative and integrated design process. Nevertheless, it is important to emphasize that each country and each typology of project involves a specific number of actors required to develop a design process. The Appendix 2 introduces the key actors and roles participating in the development of a healthcare project in Italy according to the national law.

*Table 1: Table of Involved Actors with their Role in the Project*

| SCOPE | Actor | Role |
|---|---|---|

| SCOPE | Actor | Role |
|---|---|---|
| END-USERS | End-users | Express their vision, goals and needs, and participate with the professionals in decision making process. |
| | End-users representative | Possibly speaks for the end-users |
| ARCHITECT | Architect | In addition to being the technical interface between the end-users and the professionals, the architect coordinates the design activities and solution(s) and the definition of project requirements |
| CLIENT | CLIENT | Takes ultimate decisions on all strategy issues |
| FACILITATOR | Facilitator/project manager for the client | Works as the non- technical interface between the end-users and the professionals, facilitating the participation (on behalf of the Client or consortium), has deep inside knowledge of medical processes |
| | Strategic consultant | Define programme of Needs for the client, incl. organisational strategy/strategic direction of hospital organisation (external oriented) |
| | Finance Consultant | Organises (external) funds for investments, long term investment plan and relations, debt financing and prescribes financial boundaries of the project, |
| OTHER DESIGN EXPERTS | Landscape architect | Analyses site opportunities in terms of habitat preservation or restoration, planting, etc. to be integrated within the building(s) design |
| | Interior Designer | Designs the interior spaces of the dwelling, ensuring that the spatial performance meets the program of requirements |
| TECHNOLOGY EXPERTS | Structural Engineer | Elaborates and evaluates the building system components, taking into consideration their impacts and the construction methods to be adopted |
| | Civil Engineer | Analyses and defines the infrastructures system related to the urban, structural, geotechnical, hydraulic scope |
| | Geotechnical Engineer | Analyses and designs the systems interacting with the soils |
| | Logistical Engineer | Analyses flows of goods, patients, routes, elevators to allow smooth logistical flows inside and outside the hospital organization |
| | ICT engineer | Analyses flows of information of hospital organisations, medical processes and within healthcare systems |

| SCOPE | Actor | Role |
|---|---|---|
| | Medical Technology | Analyses impact of medical technology on hospital organisation and the built environment |
| | Materials expert | Evaluates the material selection and their impacts on quality, comfort and durability |
| ENERGY/SYSTEMS EXPERTS | Mechanical Engineer | Provides his knowledge in energy analysis and simulation to define building components calculation and evaluate the impact of them into the mechanical systems and performances |
| | Electrical Engineer | Provides his knowledge to define electrical components, and feedback on impacts of design choices on the electrical and lighting system sand performances |
| ENVIRONMENTAL EXPERTS | Green Design Specialist | Provides the professionals with knowledge of green strategies identified for the project |
| | Ecologist | Analyses natural resources which could provide design opportunities and features |
| | Thermal comfort expert | Evaluates the impacts of design choices from the thermal comfort perspective |
| | Lighting Specialist | Evaluates the impacts of design choices from the daylight and lighting perspective |
| | Acoustician | Evaluates the impact of design choices from the noise pollution and acoustic insulation perspective |
| ECONOMIC/ FINANCIAL EXPERTS | Cost Consultant | Assists the team in setting and evaluating the budget, calibrating the design choices with the clients requirements |
| | Marketing Expert | Provides information related to the local market conditions, evaluates economic advantages and disadvantages of the project and the whole intervention |
| | Appraisal Professional | Helps for the understanding of the value of the design features defined |
| ADMINISTRATIVE/ PROCEDURAL EXPERTS | Project Manager | Coordinates the whole design process, ensuring effective communication between the parties and monitoring timing and budget |
| | Local Planning Authority | States and verifies the constraints of the project, gives inputs for planning opportunities or synergies |
| | Regulatory/Legal Agency | Legally reviews the project and approves it |

| SCOPE | Actor | Role |
|---|---|---|
| | Surveyor | Provides inputs for site, systems and technology opportunities and possible impacts |
| CONTRACTOR | Contractor | Depending on the procurement procedures, provides his perspective during the design process according to his expertise |

These actors have been described more generally in STREAMER deliverable 5.1. Also, an overview of the roles of the actors in the first design phase (strategic definition and preparation of the brief) has been documented in STREAMER deliverable D4.3.

From the oversight created in the Table 1 above, it is clear that we could distinguish groups of stakeholders that have similar interest in the same phase of the design process, and that they demand information that was created as a result of earlier design decisions that were agreed on by a different group of stakeholders. In the next paragraph we will describe this in more detail and illustrate some specific challenges that deal with complicated decision making and complexity.

## 2.3 Healthcare Design Process

To address the difficulties in complicated design decision making we could try to group the earlier mentioned stakeholders according to their interest/stakes and to their involvement in the design process. This insight helps us to distinguish between the groups of stakeholders, links them to different phases and allows us to make a first initial assessment of which information they need at what time to produce the right design recommendation.

With practical examples we will illustrate how early design decisions have effect on later design decisions and how we can maximize the impact of early design decisions. In essence we can distinguish three typical groups of stakeholders that deal with design decision on different levels;

1. Strategy decisions
2. Tactical decisions
3. Operational decisions

Design considerations of a strategic nature – aiming to identify a strategy in order to solve issues at the level of the whole district in terms of operational efficiency and energy performance.

Design considerations of tactical nature – aiming to solve issues relating to the layout of buildings in terms of distribution, accessibility, circulation, quality and use of spaces.

Design considerations to be made from the operational perspective – relating for instance to energy efficiency and the requirements that guarantee the comfort conditions of spaces (heating / cooling, noise levels, lighting).

The linking pin between these three scale levels is that decisions at higher levels, for instance at strategic level have the largest impact on outcomes and precede lower level decision making. On the same hand the information needed to make such decision is often more complicated as there are more trade-offs between options to consider. The level of detail at higher level is less important, but enough insurance is needed that reinforces decision makers that details can be worked out at lower scale levels. The binding element between the three levels of decision making is that the goal of the project is shared between all stakeholders at all levels. The same set of values should apply throughout and be known to all stakeholders and this could act as a criterion for decision making.

The next set of examples from the hospital side will point out the necessity of implementation of reference semantic models developed in WP1 and the two interlinking design methods (inside-out and outside-in) to ensure that information can flow between the different levels.

### 2.3.1 Example: Flows inside an hospital

The flow of people inside a hospital is a complicated problem that reveals how decision making transfers from strategy to operations. The case for illustration is how a strategy decision about the layout, building mass and volume create the potential and trade-offs between several features such as travel time, distance and operational consequences such as maintenance costs for elevators.

Depending upon the design and layout of the premises, the healthcare building could be deemed to have horizontal or vertical movements. If the building is only a few storeys high but extends over a large area of land, deep plan, it can be said to incorporate horizontal movement. Rotherham hospital is such a building, whereas a building that consists of many floors but does not cover the same ground, narrow plan, could be said to have vertical movement.

Each type of building presents the designer with differing challenges. A low level building may have its circulation areas, such as underground corridors / tunnels, and spiral ramps for logistical movements to access each level in order to facilitate movement of meals, linen, waste, clinical stores and equipment, patient records etc. Fewer lifts would be necessary in a building of this type but there would still be a requirement for dedicated lifts for bed patients, Theatre movements, wheelchair users and those with limited mobility, whilst visitors and staff would be encouraged to utilise the stairs where possible, due to the minimal amount of floor levels.

A high rise building would require more lifts due to the fact that the amount of patient traffic, equipment, stores and meal movements would increase greatly. With the increase in floors many visitors and staff may be discouraged from stair use and this would increase lift usage. There would probably also be dedicated service lifts for the transportation of linen, waste, stores, etc. and the increase in the number of lifts would impact greatly upon the energy use. These are considerations to be incorporated into the design process. The table below details the relevant actors and how they operate and flow through a hospital environment.

| Actors | Horizontal | Vertical | Commentary |
|---|---|---|---|
| In-Patients | Yes | Yes if movement is to another level | These will be transported between departments for various treatments, scans or procedures, they are likely to be dressed in minimal clothing and the temperature of the environments they travel through, or could be waiting in, needs to take this into consideration. Their movement will be either horizontal or vertical and will usually be transported using a bed, trolley or wheelchair and vertical movement will be by use of a lift. |
| Out-Patients | Yes | Likely if movement is to another level | These will often be mobile, but may have limitations to the distances they walk and some will be transported by use of a wheelchair. Vertical movement will be a mixture of use of a lift or stairs. These patients are likely to be wearing outdoor clothing so the environments temperature can be cooler and hot waiting areas may be undesirable and require cooling during summer months. Some of these patients are likely to have visual disabilities and the lighting needs to be designed and positioned to take consideration of this and may require more illumination than a comparable circulation space in a non-hospital environment. |
| Visitors | Yes | Perhaps if movement is to another level | These in many cases will be similar to outpatients, but it there are likely to be a larger percentage that may be able to use stairs and not require lifts. |
| Clinical Staff | Yes | Perhaps if movement is to another level and Yes if transporting equipment | Whilst the majority of clinical staff work in specific areas there will be quite a number who are mobile, their movement will be both vertical and horizontal, more so in a narrow plan configuration as they move from patient to patient. |

| Actors | Horizontal | Vertical | Commentary |
|---|---|---|---|
| Portering Staff | Yes | Yes | These actors are probably the most mobile of all staff groups within a hospital environment as they will be transporting, patients, equipment, supplies, waste, linen and food across wards and departments at all times of day and night, some of their work will be external as they service out buildings and therefore they will have a range of clothing to suit each particular environment. Their movement will be both vertical and horizontal utilising lifts for patient transport and spiral ramp to undertake the logistical tasks. |
| Cleaning Staff | Yes | Yes | Majority are ward or departmental based but there is a small cohort that will be designated to circulation spaces, in most cases their movement will be primarily horizontal. |
| Maintenance Staff | Yes | Perhaps if movement is to another level and Yes if transporting equipment | These actors will work across a more complex of environments from wards, departments, plant rooms, substations and workshops and therefore will have a range of clothing to suit each particular environment |

### 2.3.2 Example: Departmental decision making-complicated interest

The design of a new hospital presents many problematic that will affect a variety of personnel either utilising or visiting the building. When an architect sits down to design a building it is essential that input is canvassed from all those who will be “Actors” within the structure. It may be much more involved than the designer has envisaged and bear little resemblance to a paper plan or 3D image on a computer screen.

Although STREAMER is primarily concerned with energy efficient construction and refurbishment, energy is just a small piece of the jigsaw when designing a modern hospital and rather than be influenced by the architect’s views all the major actors should have an influence upon the final outcome. Evidently, there is a major problem to overcome in satisfying the majority of needs and addressing complex design issues. For instance, the comfort of staff and patients would involve in depth investigation into lighting levels (including optimisation of natural daylight leading to orientation preferences), thermal comfort and accessibility. For example, although circulation / waiting areas require a temperature of 14-16$^{o}$C, in practice it may be desirable to maintain a temperature of 18-19$^{o}$C due to the fact that sick patients are being transferred when wearing very little clothing.

In WP1 the introduction of STREAMER labels is an answer to isolate the complicated and intermixed design considerations that can arise from multiple stakeholders’ points of view. As all rooms have been “labelled” with semantic labels, that carry a set of information related to the function of the room or necessary conditions for the room to function in, it could reveal, by allowing different views on a higher level (floor, building or district), to compare and contrast the different design alternatives and decide at the correct way to continue. This could mean that STREAMER labels will be adapted as a result of decision making.

BIM can greatly support and capture this decision making and is now being used more and more in the design of healthcare premises and it is now common practice to incorporate departmental needs and requirements into the design process in order to optimise the layout of services and departments. For instance, it may be desirable to place the Intensive Care Unit (ICU), high dependency units, and Orthopaedic wards adjacent to the main operating theatres as well as being in close proximity to Radiology services, or the Delivery Suite, Antenatal ward adjacent to the Special Care Baby Unit (SCBU) in case of emergencies and general access for patients. By using the semantic labels first of all we could see the conflicts of interest based on the different types of information that is contained in the labels. Conflicts could arise based on the labels that have for instance different hygienic classes, accessibility or opening times. When a design is constructed and rooms are positioned in the design, conflicts could be detected based on the labels contained in the room specifications. These conflicts could relate to access or opening times. An example of this is when an ICU has some rooms with functions for Radiology. Rooms that are part of the ICU (strict hygienic conditions) cannot be mixed in with rooms from a radiology services (lower hygienic restrictions). The detection of conflicts may result in a new layout or possibly an adjustment to the hygienic requirement for the rooms with a function from the radiology department. As each configuration is likely to have different consequences the trade-offs between the different solutions could be considered by a group of stakeholders. Ideally and within the ambition level of STREAMER, is to compose a KPI methodology that would be able to represent the consequences of design decisions on important KPI's. In this way the stakeholders would be able to see the effects of proposed design decisions on KPI dashboard.

### 2.3.3 Example: Medical process & equipment interfaces

In general the MEP system design starts later when building shape and space function is already proposed. However cooperation between architect and technology experts is very important at the first stage of design. Information exchange and relation awareness as well as possibility of use of new, energy efficient technologies are crucial during the design.

Nowadays MEP systems which are respected as medical equipment are on high level of development. Medical processes as those present on surgery block should be planned by experienced designers specialized in pure environment technologies. Energy saving is not the priority in this part of hospital but if function of spaces is well planned energy can be saved. That is why every technological aspect should be taken into account.
It is not easy to look for energy savings in medical equipment as these technologies are made with lifesaving priority but it should not be forgotten to have a deeper view on supporting processes which can be easily optimized. There are a lot of supporting spaces in hospital environment such as Kitchens and Laundries where energy savings can be done. Studies made for Deliverable D2.1 showed that there are many possibilities for energy generation, distribution and supply realization and energy from many processes can be recovered and reused.

That is why deliberated design and knowledge about energy flows and specific environmental requirements in healthcare facility as well as wise use of available on the market, high efficient technologies is required. For technology experts it is very important to have information about space function and building geometry so that they can make a concept of MEP systems within the building. Moreover a library with space requirements and medical equipment to be installed in the room should be available

Again the relation between the demand from the end users (programme of requirements) and the different phases in the design, are complicated. The STREAMER labels could help to capture specific boundary conditions (nr of sockets, outputs in terms of ventilation, etc.) and carry this information (based on the insights from engineers) from the early design phases to the detailed design and these could be checked for consistencies in the final design.

#### 2.3.4 Summing up

The complicated nature of the design process, the involved stakeholders and the conflicting goals of achieving many desirable outcomes could involve certain compromises within the design process, and possibly result in constraints as it may not be possible to achieve all of the scenarios related to the adjacency of departments / services. What seems needed is a framework in which we can capture the interest of all stakeholders, the goals of the project and a process through which information flows that is ready for decision making, supported by our BIM/GIS models. This could greatly enhance the ability to make better design decision early on in the process, where changes are relatively cheap. The use of semantic labels (two directional; inside out and outside in) and the KPI-methodology to align interest seem an appropriate way forward here. This chapter has introduced the need for a KPI-framework that could be used in three phase of the design by different sets of stakeholders to asses designs on strategy, tactical and operational merits. The value of a similar KPI framework for each of the phases is, that it prevents sub optimization in each design phase.

# 3. Introduction of Participatory Design

Now that we have established that different sets of stakeholders need to work together, the key question remains to answer how then the people within this group need to work together and how the interaction between the different groups is aligned. The question to solve is: How do we go from today's "over-the-wall design" to a more collaborative way?

## 3.1 Participatory Design

A definition of participatory design will be the starting point of this paragraph, which will focus on the potential improvement of more collaboration between the involved actors. Then a practical example will clearly highlight the advantages of the methodology.

### 3.1.1 Participatory Design Definition

Participatory design reflects a process in which envisioned users of the end result are being actively involved in designing. In case of Health Care districts, the end users are not easily listed and not a mono disciplinary group of people. Nevertheless, the active involvement of end users in the design process means careful organization and preparation of the involvement of various end users groups or representatives.
In the section below we first present a literature scan on defining what Participatory Design is actually. Afterwards, the discussion will focus on the premise of having participatory design incorporated in contemporary design processes of healthcare districts. The crucial questions are: Who are the end users, what level of involvement is being pursued, what information is crucial in the design process? It holds the premise of resulting in more robust, sustainable and cooperative way of designing, taking into account the expectations of particular users that involve in care and cure operations logistics, maintenance etc. (i.e. patients, staff, visitors, facility managers etc.).

*Literature:*

Participatory Design (PD) is an end user oriented design method. Sanoff (2008) defines PD as an approach to assess, design, and develop technological and organizational systems that places a premium on the active involvement of end-users in design and decision making. Kensing (1983) explores three main aspects PD deals with, 1) the politics of design, 2) the nature of participation, and 3) the methods, tools and techniques used for PD. A further elaboration per main aspect leads PD 1) embraced a different design approach that includes the participation in the design process, and formulating new rules for actors who and how to participate, 2) is about the form and degree of participation, and 3) requires instruments that facilitate participation in the design process. This way PD creates new concepts and knowledge through parallel development of requirements and sustainable solutions.
Kensing and Bloimberg (1998) address participation of intended end users in technology design. The claim is that PD is one of the pre-conditions for good design and increases the likelihood that buildings will be designed and built useful and well integrated in the daily practice of residents. As a result, buildings realized by means of PD would idealistically last longer and fit better the individual demands of occupants (ibid). Buildings with PD benefit from the early integration of both the expectation of users and the knowledge of designers in the design process.

PD comes with a few basic requirements to, according to Kensing (1983):

- Access to relevant information
- Possibility for taking an independent position on the problem
- Participation in the decision making
- Availability of appropriate participatory development tools
- Room for alternative technical and or organizational arrangements.

*Participatory Design in Health Care districts:*

In the context of relative complex design processes like healthcare districts, there are additional challenges that come forward. As identified in the Chapter 2, in the healthcare domain, many different design disciplines are involved (design professionals, facility managers, advisors etc.), but one of the crucial actors is the end user group. This group consists of various different disciplines such as professionals in their service domain (doctors, nurses, biologists, academic researchers, lecturers, maintenance operators etc.), non-professionals (patients, visitors etc.). They have their own perspectives to look at the healthcare buildings and expectations due to their various uses. These varieties are to be represented to the clients who take the expectations into account of program of requirements.

Precisely where it comes to the requirements formulated earlier, the access of relevant information for instance requires a very specific type of funnel, to allow the patients to be involved in the lay-out of patient rooms and facilities related, but have no access to the design of operational rooms for instance, and vice versa. Professional users, like doctors and nursing personal, need to access more detailed, or specified type of information with the designing; while the exploiter of any shopping space in the health care building is interested just in orientation, logistics and routing of day to day visitors on the premise.

Applying the requirements for PD in the further context of STREAMER, and in relation with the matter of information flow in the design process, the three most important measures to deal with in this light might be summarized as:

a) Agree upon the extent of participation and their rules between various actors (designers and end-users),
b) Agree on the way of participation and up to what level (how far does participation go?)
c) Selection of tools to be used in the participatory design.

PD of any health care project is ultimately a tailored process, depending on the requests of the demand (client) side, and a certain pre-fixing of solutions and design freedom from the supply side.

In some situations, the client wishes to have little interference with the actual designing, and just requires some moments of decision making (choose between alternative solutions for instance), versus the situation where both the design disciplines and client manage to work on a more equal basis of input and involvement in the designing of the building. It remains an interplay between the partners in demand and supply, as well as depending on the level of know-how and expertise from the client to act as an actual member in the design team.

### 3.1.2 Practical implementation: "From the Idea to the Reality"

***Working in a Participatory Design project via supervision of Clinical designer's.***

***This case study describes how the participatory design is used and affected in the context of a Locum Refurbishment.***

***Introduction***

This section describes how the Swedish healthcare management company Locum works to meet the premises' needs of care providers.

To understand the roles in a Participatory Design project organization, the reader has to take into account the fact that after a political decision Stockholm County Council has formed a separate management company, Locum AB for the entire County Council's property portfolio in order to free resources from health care personnel and streamline the use of the premises by a rent clause between hospital activities and Locum AB.

A refurbishment project is always involving many different actors. The main groups are:

- Care of actors (representing/operating the business premises adapted for the landlord i.e. Locum who is a managing organization of health care facilities).
- Customer manager supported by the Facility manager ( both responsible for the finances)
- Architects
- Various consultants
- Contractors
- Various equipment suppliers

Rebuilding in the hospital is often complicated. The hospitals are installation intensive with gas pipes, special types of ventilation, heating and cooling systems etc. This affects the ability to change the premises. All technical aspects must be investigated before construction can take place, both in large and small rebuilding projects.

To achieve the best possible results, it is important that the tenant is involved in the entire project, particularly at the project's early stages.

Locum has formed a **specialist unit**, clinical designers that holds together the participatory design premises development and is the hub of all the work in the early stages of the development of programs to handover and follow-up of the mission. These people have long experience of working in health care as nurses and can more easily communicate the requirements stipulated in the project. Their opinions regarding work surfaces, equipment design and aspects in medicine hygiene are strongly influenced by the hospital hygienist.

Every participatory design project is subordinated to a steering group which is a decision-making body where the participants have the mandate to make decisions. The steering committee has responsibility for project's overall direction, objectives and circumstances. The group includes representatives of a tenant and Locum. The latter is the chairman as the property owner's representative.

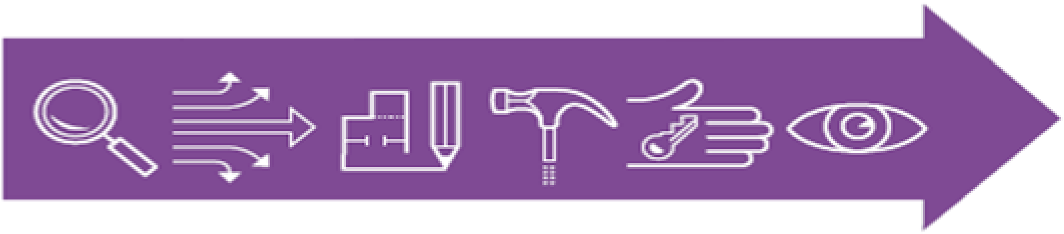
The project team works through collaboration to develop alternative solutions and a basis for decisions together with consultants. The project group's composition differs by various project stages and is adapted to reflect the

**refurbishment project** scope and complexity. The project team includes staff from Locum and tenants as well as specialists, architects and contractors.

Working in a Participatory Design Project group is an exciting way of working where good ideas and knowledge can become a reality. Each person has a responsibility for the end result, contributing expertise in the different project phases. During the Participatory Design Project a large number of various people are involved in creating and implementing a common vision.

### *Forms of work*

A Participatory Design Project group is implemented in several phases, from requirements analysis to handover and evaluation of the finished room. On three occasions it is decided to continue the Participatory Design Project to the next phase or to cancel it. It takes place after the **needs analysis**, **feasibility study and program stage**. On these occasions is also written, an agreement for the Participatory Design Project group to continue its work.



When the decision is made to continue, the project continues to **implementation, handover and evaluation** stage.

These phases are easily linked with the eight stages of RIBA Plan of Work introduced in the Design Process Map chapter before. Needs analysis belongs to strategic definition (stage 0), feasibility study to preparation and brief (stge1), and program stage to concept design (stage 2). Implementation, which is divided in two parts, design and production belongs to stages 3 to 5, developed & technical design and construction, while handover is stage 6. At the end, evaluation is the first period of the in-use stage (stage 7).

To achieve the best possible results, it is important that the tenants are involved in the entire Participatory Design Project, particularly in the project's early stages. Those who represent the clinics concerned have a mandate to conduct operations proceedings and to anchor the emerging issues and choices in their own organization. If possible, the same people are involved in group work meetings. Continuity and time set aside for the task are factors that are important for the Participatory Design project's success.

Responsibility for the implementation of Participatory Design projects lies by Locum. It is also Locum who procures consultants and contractors. It takes place under the Law on Public Procurement Act.

The ability to influence and change is greatest at the beginning of a project. In order to describe the needs and conditions contained the following questions must be answered at the start of each Participatory Design project:

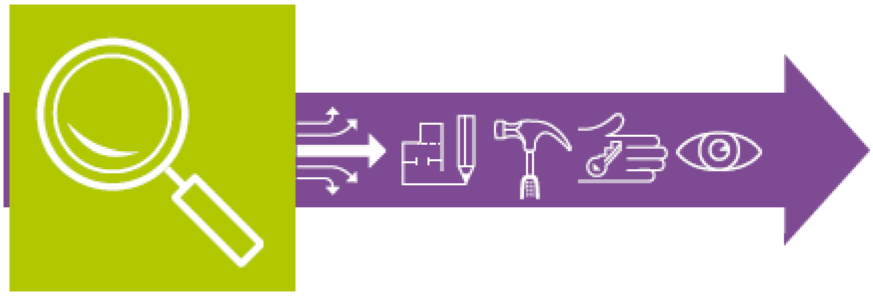
- What are the overall objectives guiding the activities?
- Why would like a clinic to make changes?
- Is it necessary to modify or expand the premises?

- How will the premises work?
- What technology is needed?
- How do the changes affect the operation's budget?
- How will the project be organized and financed?

As soon these questions been answered, is easier to save money for the project while achieving the goals set. Changes made in the late stages will create unnecessary cost increases

Critical factors that can affect the success of the project should be discussed and analysed early. These may be a matter of time, technology and economics.

***Needs analysis***



The purpose of a needs analysis is:

- clarify why a change is needed
- describe the need for different functions
- formulate goals and strategies as a basis for future decisions.

The needs analysis provides answers to three questions:

- What will be achieved?
- Which are the limitations and risks?
- What should be prioritized?

Remember:

- Focus on the causes of the need
- Overall context and external factors influence
- Needs analysis will identify needs and problems - not solve them.

***Division of labour***

The tenant presents the need for localization for Locum's account manager.

Locum assists the tenants to develop a needs analysis.

### *Results*

The result of this work is a needs analysis report presenting needs and goals, as well the particular requirements.

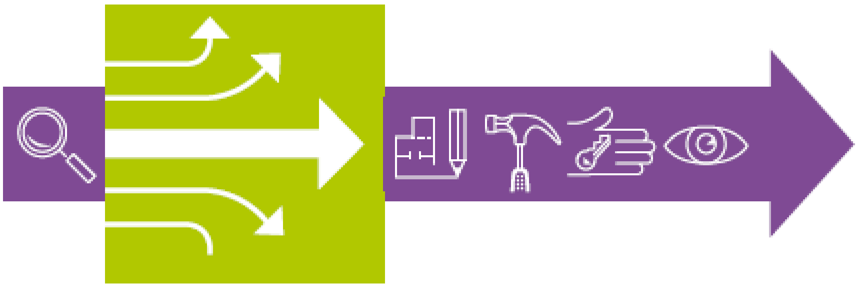
### *Decision*

If the steering committee decides that a local project should continue, he will sign a feasibility study contract and a feasibility study begins.

<u>Clinical designer's role in the needs analysis stage</u>

- Customer Manager is stage manager
- Clinical designers are administrators in stage
- The tenant is responsible for needs analysis and business description
- Clinical designers analyses the tenant's needs inventory
- Clinical designers do impact statement (Ex. Assess the suitability/unsuitability of a particular locale for thinking activities)
- Clinical designers advises/supports the Account Manager in the health/functional issues
- Clinical designers are involved and support a tenant at the first meeting and actively listens to the tenant's descriptions with the support of the issues described in the brochure "From concept to reality"
- Clinical designers contribute with external knowledge

***Feasibility study***



The purpose of a preliminary study is to:

- specify the conditions and requirements based on needs analysis and to develop alternative solutions
- analyse and evaluate options based on selected criteria such as goal-setting, conditions and requirements
- choose the option that best corresponds to the local project needs and goals.

### *Division of labour*

The Account manager in Locum is responsible for developing the feasibility study together with the tenant. The task can be delegated to the project manager and/or Functional planner.
In the feasibility study phase, the organization is expanded to a project by involving steering committee and project team. In larger refurbishment projects a consultancy group, peer group or

other working groups can be contemplated. It's important that all relevant perspectives are illuminated. The tenant occupies a central role in this stage of the local project.

### *Results*

The result of this work is a preliminary study report presenting one or more alternative solutions to the needs identified. Suggested solutions evaluated for example, function and connection requirements, flexibility, safety aspects, environmental, and energy aspects, local efficiency, investment and estimated time for implementation. An analysis of the risks that exist for refurbishment project is also included in the report. After evaluation the proposal that best meets the objectives will be selected.

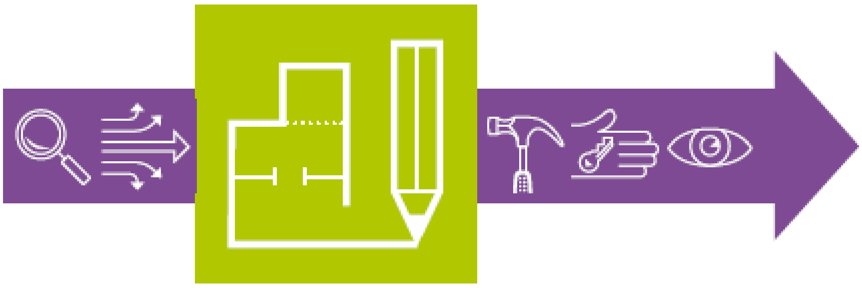
### *Decision*

If the steering committee decides that a refurbishment project should continue, an agreement is signed by all partners.

Clinical designer's role in the feasibility study

- Customer Manager is stage manager
- Clinical designers collect information from Business representatives in order to create Room Requirements List and decision support
- Clinical designers manage workgroup meetings with the tenant and architect
- Clinical designers are co-opted in the steering committee as an expert in the health / functional issues
- Clinical designers contribute with external knowledge

## *Program*



The purpose of the program work is to:

- describe in detail the tenant's premises requirements
- provide a basis for decisions and signing of contracts

### *Division of labour*

In the application phase Locum manage all project work in consultation with the tenant and with the help of hired consultants.

For it to be right from the start, it is important that the tenant even in this phase of the local project takes an active role. It requires time, dedication and mandates.
The tenant ensures its internal communication with those businesses and experts that are important for the participatory design project. There may be medicine technical department, the medicine hygienist, the IT department, security officers, ergonomists and others.
Locum establish a demarcation list in order to clarify who does what in the next phase, as well as what should be included in the rent, and what the tenant owns and / or acquire.

***Results***

The amount includes the local list, Room Appliance Program (RAP) based on Program for technical Standard (PTS) and drawings, tenant and Locum drawing together. A RAP is a specification of the premises characteristics (such as light, sound, water, air, cooling, warming etc. ) as well as furnishings and equipment. RAP and drawings are describing together the layout of rooms and relationships. During the programming phase the technical programs are ready and specify the technology and media supply which is required.

***Decision***

If the result of the program work shows that project should continue, the steering committee signs an agreement, and implementation begins. This may be the project agreement or lease.

Clinical designer's role in the program work

- Project is stage manager
- Functional planners collect information from Business representatives in order to create the RAP (Room Appliance Program)
- Clinical designers take based on the contents of the Room Functional Program provide a basis for discussion, distinction between Client manager, project manager and tenant
- Functional planners lead working with tenant and architect
- Clinical designers participate program meetings, consultant meetings, etc.
- Clinical designers are co-opted in the steering committee as an expert in the health / functional issues
- Clinical designers contribute with external knowledge

***Implementation***

During the implementation the Participatory Design Project goes through two different stages

1) Design and 2) production, which are described below.

The purpose of implementation is to:

- describe in detail the layout of rooms
- create a specification before production
- implement remodelling or new construction

### *Division of labour*

In the implementation stage Locum manage all project work with help of hired consultants and contractors.

The project design drawings and documents. These documents describe together the layout of rooms in detail. They then form the basis for the planned renovation or new construction. Locum is responsible for the work and hiring consultants to design the above mentioned documents. Tenant participate by continuing specify the furnishings and the needed equipment. The tenant is also responsible for ordering these. Cost of furnishings and equipment are not included in the project cost. For the production, Locum employs contractors for the implementation of renovations or new construction.

### *Results*

Planning will result in a contract document that forms the basis for the procurement of the contractor who will carry out renovations or new construction.

The result of the production is finished rebuilding or newly built premises.

Clinical designer's role in implementation

- Project manager is stage manager
- Functional planners role is to monitor and pursuing programs of action "soft parameters" and intentions into the project's production phase
- Clinical designers are expert in health / function issues
- Clinical designers answer questions in the health / functional issues
- Clinical designers can lead investigative teams in certain special issues
- Clinical designers participating in planning meetings where function and related issues are discussed
- Clinical designers shall provide the audit opinion on the A-drawings in accordance with the Room Appliance Specification and they decided changes / additions to eat - that have come up during the planning meetings

Clinical designer's role during production

- Project is stage manager
- Clinical designers are expert in health / function issues
- Clinical designers will be consulted if deviations occur during construction that may affect the functions and the associated

* Clinical designers otherwise can answer questions in health / function issues
* Clinical designers can combine with tenant / activity-representative organize information meeting for entrepreneurs about business content on the device to be rebuilt.
* Clinical designers are not usually participating in the construction meetings but has the opportunity to follow the construction and get Build Minutes

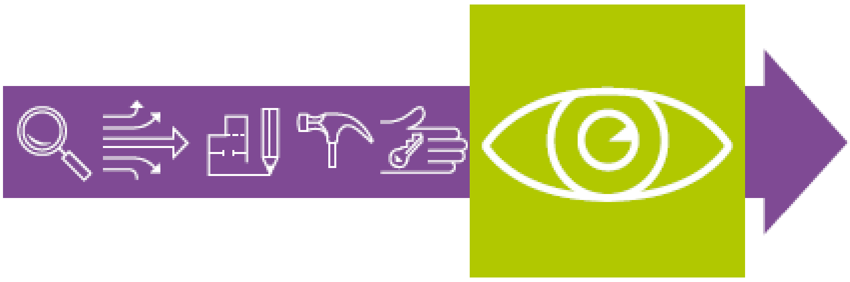
### *Handover*

When the Participatory Design Project is completed the premises are handed over to the tenant. As is normally an occupancy inspection and a review of the premises with the tenant. For larger or more complex projects, it may be useful early on in the Participatory Design Project to plan how the handover should be done, sometimes it must be done in several stages.

Clinical designer's role in handover

* Clinical designers follow along with the project manager, account manager and tenant the RAP changes of program documentation in connection with immigrations / handover in a first operational check.

### *Evaluation*



Major refurbishment projects are evaluated throughout the project concerning the conduct and outcome. A project measurement and a local measurement is normally done by interviewing a time after the premises is in use. Those who have participated in or are directly affected by the localization answer questions about the local implementation of the project and how the new / rebuilt premises work.

An evaluation of a project is also an experience feedback for the next Participatory Design Projects.

<u>Clinical designer's role in the evaluation</u>

- A follow-up functional review takes 3-4 months after the surrender along with the project manager, account manager and tenant
- Clinical designers are responsible for local measurement that takes 3-4 months after the surrender. Important to all points in the final inspection is rectified so this does not affect the overall assessment.

***Conclusions***

The Stockholm County Council and Locum have found that working with participatory design processes by an own specialist unit so called clinical designers, has been able to bridge the knowledge of hospital activities, the real estate management organization as well as other actors who designs or upgrade hospitals.
This way to bridge the gaps have been found more cost effective, create more efficient architecture throughout the health care system in Stockholm which supports the care process and with new logistics solutions, improves patient safety and privacy as well as shortens treatment time, improves staff's working environment, has high architectural values, and convey a human environment.

These clinical designers have together developed given concept applications for new construction and renovation within the Stockholm County Council.
This is a new unique thinking which it is hoped that more County Councils in Sweden will accept to follow and take note of.

## 3.2 Virtual Design and Construction

With the development of the computer-based models in the design process of construction, associated to the participatory design, the need of revised process has emerged. Virtual design and construction developed an integrated approach linking the three main aspects, the product (the building and its own constraints), the organisation (the involved actors and their role), and the process (the design process), to create collaboration and exchanges in the design of construction projects. The main principles of virtual design and construction are developed hereafter.
The works provided by John Kunz and Martin Fischer within the CIFE (Center for Integrated Facility Engineering) on Virtual Design and Construction (VDC) has developed a renewal of the approach of design process in construction projects, focusing on the aspects of People, Organisation and Process.
Virtual Design and Construction is the use of integrated multi-disciplinary performance models to support explicit and public business objectives. The approach is dealing with virtual models, with the increasing use of computer-based systems. The innovation is to integrate the different parts of the design process in the concept, i.e. the product (a building or a district in Streamer's case), the organization (people) that will define, design, construct and operate it, and the process that the organization will follow. To minimize latency and inconstancies, the use of shared data, with access for the stakeholders is a key success factor. With all the involved actors, from the owner to the end-user, including architect, engineering, contractor and operator, the virtual models have to be multi-disciplinary, and performance predictive to follow the overall objective.

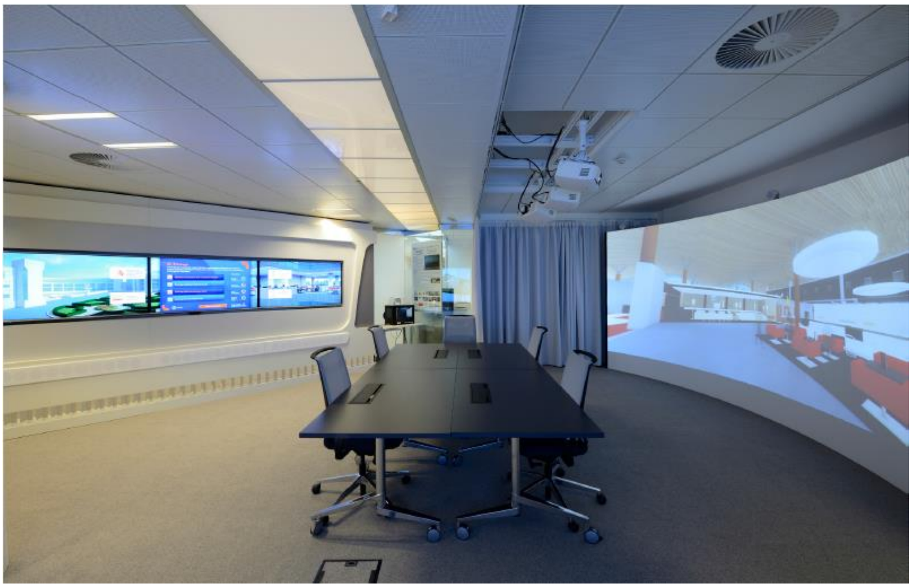


*Figure 5 : Virtual Design Room in Bouygues Construction head office*

### 3.2.1 Methodological recommendations for VDC process

First of all, all important stakeholders have to be around the table from the kick-off meeting to the end of the process. It is important to start to define the project structure, for the product in itself (design and/or construction), but for the organization and the process. Here the idea is to have a shared understanding between the involved actors, through common vocabulary, KPI and metrics. In VDC process, the POP model, defined as the Product, the Organization and the Process develops its structure according to these elements.

As projects are of a large scale, POP models are divided in different level of detail, with a factor of ten between them.

The first level (so to say Level-A) represents the product, organization and process as a single element, e.g. the building, design-construction team and design-construction process. This level is useful as reference, too abstract to have managerial interest. Level-B POP Model represents product, organization and process elements that each incurs about 10% of the project cost, or design-construction effort or schedule duration. Then Level-C POP model represents POP elements with about 1% of the cost, effort or duration… and so one with Level-D or greater level of detail. For example, for a healthcare district project, the Level-A refers to the district in itself, the Level-B represents the different buildings, the Level-C the departments, and Level-D the rooms.

The Product, Organization and Process model are defined within breakdown structures, one for each part.

The Product Breakdown Structure (PBS) represents the components that together represents the facility being built, and can be based on the IFC specification. LOD are introduced here to detail the different levels of the product from the overall project (level 3) to the parts (level 5), going through buildings, systems and components in between.

The Organization Breakdown Structure (OBS) represents the teams that do the work of the process to create the building of the project. Here again, LOD are introduced from the project developer (level 1) to the workers as design engineers (level 5), with intermediate levels, such as Design manager, discipline design manager and design group leader in the case of the design.

The Process (Works) Breakdown Structure (WBS) represents the work design, the activities that the organization performs to design, build and manage the project. LOD are also significant in this part.

The interest of VDC is that the POP models show physical and abstract elements of a design. BIM is part of the VDC with the notion of object oriented, but VDC approach adds the relationships between the organization (actors), the process (works) and the product (objects). One advantage of the BIM use, is the possibility to add the 4D models to link the object and the Gant chart associated to the process of construction.

### 3.2.2 Interest of VDC approach

Now we need to answer to the question: why should we use the virtual design and construction methodology? The use of shared data, and common language, understood by the whole panel of actors, will allows a drastic reduce of the latency, by making the requirements for coordination and the objectives on timeliness both explicit. This can be achieved with clear organization models, so all stakeholders understand it. It will also mitigate predicted organization backlogs, coordination, time and cost risks, while assuming the volume and distribution of both direct and hidden work.

The VDC objectives can be foreseen in three levels: the project controllable factors for the day by day management and monitoring, the project process objectives with several progress indicators, linked with the previous factors, but reviewed in shared weekly or by-weekly meetings, and the project outcome objectives, which can only be measured at the end of the project to be compared with the original objectives.

These objectives, made public, specific and aggressive yet realistic will allow a fine tuned management of the project, on one hand, and help decision making on the other hand, to improve the time, cost, energy and effort efficiency of the complete POP process.

As a conclusion, participatory design is the generic and conceptual approach of collaborative process in design, where virtual design and construction is the practical implementation of the process with the addition of the newly improvements of the computer–based BIM.

Another interesting conclusion about VDC is the potential use of the methodology even in the early design phase, while preparing the PoR, program of requirements. At this stage, where nowadays oral knowledge is the most often used, the introduction of processes defining the roles of all actors, shared KPIs as developed in WP3, labelled and defined spaces in a logical matrix as defined in WP1, will improve significantly the efficiency of the characterisation of the project.

### 3.2.3 Digital Plan of Work

One way of looking at the process, actors and flow of the design process is to look at the so called Digital Plan of Work (dPoW)

The client may also specify his information requirements (in the UK referred to as the EIR, Employer's Information Requirements). Whilst primarily focused at efficient and complete handover information, earlier information deliverables are also anticipated for example for functional and cost review. Aspects of these requirements may cascade and be amplified down through the design chain and the supply chain. A key aspect of the EIR is the adoption of a digital 'Plan of Work' (dPoW), detailing information expectations:

- **Context** – the scope or mandate of the dPoW
- **Stage and Purpose** (for example stages 0-7 and any sub-purposes within the stages)
- **Actor** – client, design or construction experts
- **Role** – responsible for, accountable for, consulted on, informed of
- **Object** – the system, zone, product or space
- **Attribute** – property, representation or measurement

The abovementioned framework could be used to carry semantic information throughout the design process.

The dPoW is intended to replace course Level of Detail (LoD) grades (such as the LoD100-500) with verifiable requirements. It is important to differentiate the PoR as stating the required values (provide 5 office rooms each with a net area of 20m²) from the information requirement (architect shall provide the information about room type and net room area for each room object in its BIM deliverable).

# 4. Decisions & Consensus during Design

Decision-making lies at the heart of many human accomplishments, including designing and constructing. Design teams use decision-making skills for designing products and processes, for developing alternative building systems along the way, and finally shaping construction projects, thereby causing environmental, social, and economic impacts. This chapter will discuss the decision making process as well as suggesting a possible method for making structured and transparent decisions.

## 4.1 Decision making Process

As shown earlier in this report, healthcare design projects are very complex and involve a number of different stakeholders. In a situation where multiple criteria problems are present, confusion can arise if a logical well-structured decision-making process is not followed. Furthermore, the traditional ad hoc decision procedures can exacerbate wrong decisions because there is no “track record” to help explain the rational or logic behind the decisions.

Multi-Criteria Decision Analysis (MCDA), or Multi Criteria Decision Making (MCDM), is a discipline aimed at supporting decision makers who are faced with making complex, numerous and conflicting evaluations. MCDA aims at highlighting these conflicts and deriving a way to come to a compromise in a transparent process. MCDA methods have been developed to improve the quality of decisions involving multiple criteria by making choices more explicit, rational and efficient. The goal is to create a structured process to identify objectives, create alternatives and compare them from different perspectives. In simple circumstances, the process of identifying objectives and criteria may alone provide enough information for decision-makers. However, when the level of detail increases, MCDA offers a number of ways of aggregating the data on individual criterion providing indicators of the overall performance of options. There are many textbooks and articles about this topic (Bana E Costa et al (2000), Goodwin and Wright (1998) and Department for Communities and Local Government (2009) to mention a few). Thus, this chapter will merely give the basics about the methodology and how it can be used for healthcare design decision making.

A Multi-criteria Decision Analysis (MCDA) establishes preferences between options by reference to an explicit set of objectives that the decision making body has identified, and for which it has established measurable criteria to assess the extent to which the objectives have been achieved. A key feature of MCDA is its emphasis on the judgement of the decision making team, in establishing objectives and criteria, estimating relative importance weights and, to some extent, in judging the contribution of each option to each performance criterion. Its foundation, in principle, is the decision makers’ own choices of objectives, criteria, weights and assessments of achieving the objectives, although ‘objective’ data such as observed prices can also be included. MCDA, however, can bring a degree of structure, analysis and openness to classes of decision that lie beyond the practical reach of traditional cost-benefit analysis.

MCDA is a way of looking at complex problems that are characterised by any mixture of monetary and non-monetary objectives, of breaking the problem into more manageable pieces to allow data and judgements to be brought to bear on the pieces, and then of reassembling the pieces to present a coherent overall picture to decision makers. The purpose is to serve as an aid to thinking and decision making, but not to take the decision. As a set of techniques, MCDA provides different ways of disaggregating a complex problem, of measuring the extent to which options achieve objectives, of weighting the objectives, and of reassembling the pieces. They built on decision theory, which for most people is associated with decision trees, modelling of uncertainty and the expected utility rule. By extending decision theory to accommodate multi-attributed consequences, Keeney and Raiffa (1993) provided a theoretically sound integration of the uncertainty associated with future consequences and the multiple objectives those consequences realise.

The main assumption embodied in decision theory is that decision makers wish to be coherent in taking decisions. That is, decision makers would not deliberately set out to take decisions that contradict each other. The theory expands on this notion of coherence, or consistency of preference, and proposes some simple principles of coherent preference, such as the principle of transitivity: if A is preferred to B, and B to C, then A should be preferred to C, which is a requirement if preference is to be expressed numerically. By treating these rather obvious principles as axioms it is possible to prove non-obvious theorems that are useful guides to decision making.

The first two theorems establish a logical equivalence between coherent preference and number systems. If preferences are coherent, then two sorts of measures follow logically: probability and utility, both associated with the consequences of decisions. The first theorem establishes the existence of probabilities: numbers which capture the likelihood that consequences will occur. The second theorem shows the existence of utilities: numbers which express the subjective value of the consequence and the decision maker's risk attitude.

The third theorem provides a guide to taking decisions: choose the course of action associated with the greatest sum of probability-weighted utilities. That is the expected utility rule, which has existed in various guises for over 200 years. To apply the expected utility rule, assess a probability and utility for each possible consequence of a course of action, multiply those two numbers together for each consequence, and add those products to give the expected utility for that course of action. That description sounds rather dry and impractical, but decision theory gave birth to the applied discipline of decision analysis.

Keeney and Raiffa (1993) extended the set of axioms so that decisions with multiple objectives could be analysed. In practice, MCDA is applied to help decision makers develop coherent preferences. In other words, coherent preferences are not assumed to start with, but the approach helps individuals and groups to achieve reasonably coherent preferences within the frame of the problem at hand. Once coherent preferences are established, decisions can be taken with more confidence.

Figure 6 below illustrates a possible process.

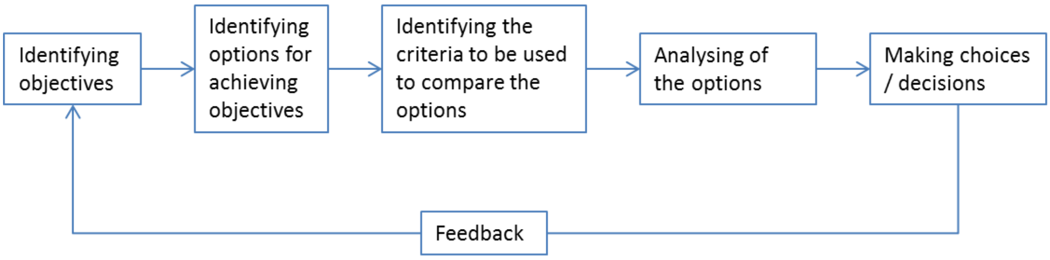



*Figure 6 : Process that may be used for the development of a project decision*

Any social decision problem, and building or refurbishing a healthcare facility in urban areas certainly being such problem, is characterised by conflicts between competing values and interests and different groups and communities that represents them. Multi-criteria evaluation techniques cannot by all means solve all conflicts, but they can help to provide more insight into the nature of conflicts and into ways to arrive at compromises in case of divergent preferences so increasing the transparencies of the social decision process.

A schematic figure of an example of information links in a MCDA is shown in the following figure. This provides the decision framework for STREAMER, and shows where and how the Key Indicators (in MCDA called Criteria) of WP3 (D3.1) can be introduced and used. Of course, depending on the stage of design and the decision to be taken, all indicators will not be relevant. The outcome of the analysis will generate a transparent and structured decision support material in order to be able to, for example, select which solution (in the example illustrated in Figure 7, Solutions A-C) will be most suitable for this particular project and situation.

There are different methods within MCDA to choose between, the representation shown here is a quite common way to show the structure. The STREAMER specificity of this Figure 7 is that specific KPIs have been introduced. This is to show the connection to WP3. Of course, other KPIs could (and should) be introduced as well in a real situation. Within the MCDA methods, there are multiple techniques that can be used. Recent attention, from the Lean construction perspective, has been given to one called CBA, choosing by advantages, which could be interesting to further explore (Rybkowski et al, 2012; Arroyo et al, 2012). In relation to Evidence Based Design (see D4.3 for further details), the fuzzy neural knowledge model structure has been explored and exhibit interesting features especially for the very early design stage (Durmisevic and Ciftcioglu, 2010). The message we want to send is that we need to leave the ad hoc decision taking we usually use today and introduce a more structured and transparent way that is also compatible with using BIM.

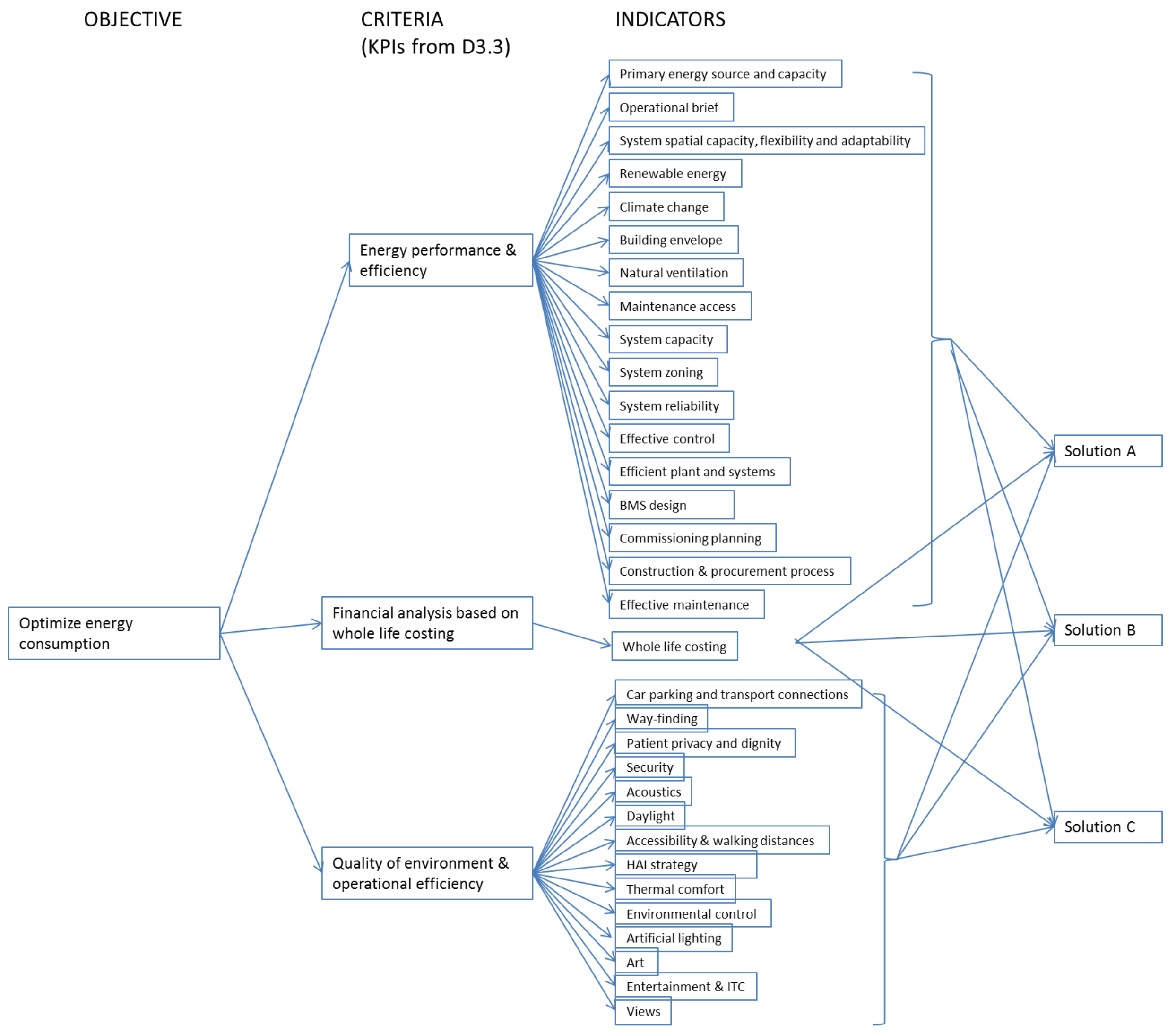



*Figure 7 : Schematic illustration of information flow links in MCDA hierarchy – here only the optimize energy consumption goal is illustrated but other objectives and KPIs can be added*

## 4.2 Weighting the criteria

One of the most difficult parts in carrying out a MCDA is assigning weights to the criteria. While this may a challenging task for one person to carry out, reaching a general consensus in a multidisciplinary team can be very difficult to achieve. By using MCDA the members don't have to agree on the relative importance of the Criteria or the rankings of the alternatives. Each member enters his or her own judgements, and makes a distinct, identifiable contribution to a jointly reached conclusion.

While varying slightly depending on the specific phase of the project (early go/no go phase, early design, detailed design, construction or operation and use), it is clear there is a need to involve more stakeholders than was customary some decades ago. Depending on the phase of the project, different stakeholders will be more or less active. Thus, it is important to include this group or these groups throughout the decision making process. Many different approaches have been undertaken; see Macharis et al (2012) for a review. For example, Chen et al. (2008) combined GIS with AHP (a specific solution technique) to select the optimal route for nuclear waste transport in Taiwan. Five different stakeholder groups were included in this study: the Institute for Nuclear Energy Research (INER), the police department, a medical expert, a group of transporters and a professor in nuclear energy who has to embody the interests of the community. Each of the groups separately defined the weight of the three predefined criteria through the pairwise comparisons of the AHP technique. Afterwards, the computed weights were averaged to a global weight per criterion. Based on the evaluation of the different alternatives for these weighted criteria, an optimal route was calculated by the GIS application for each criterion separately and for the combination of the three criteria.

Farkas (2011) showed how GIS with the value-focused approach of MCDM can support decision makers in the design, evaluation and implementation of spatial decision making processes. The analytical capabilities and the computational functionality of GIS promote to produce policy relevant information to decision makers. Farkas noted that although different stakeholders usually have different priorities to highest level objectives, the proposed approach provides a considerable help in reaching a satisfactory compromise ranking of the objectives for the conflicting interests. This was illustrated by means of an example aiming to finding a suitable location of a metro-rail system network where different stakeholders represented different, and sometimes conflicting, views: five transportation engineers, three mechanical engineers and two economists.

Design decisions made early in the process have the greatest ability to affect functional capabilities, time and cost. These decisions must be based on tacit and explicit knowledge but be made in a structured, documented and transparent way. The techniques discussed in this chapter may be one way forward in fulfilling this aim and also show how the work carried out in the other WPs could be used and linked in the decision making process.

## 4.3 Introduction of LOD

When we started the works to elaborate the deliverable 4.1, we have rapidly noticed the evolution of the relation between level of detail and stage of design. Actually, in the traditional design development, the level of detail is most often linked with the scale of the drawing, 1/200 for the schematic design, 1/100 for the detailed design and 1/50 for the technical design. With the implementation of the computer based design, the importance of the drawing’s scale is reducing during the design, although it remains important for the effort to place in the different stages of the design. The notion of level of development (LOD), developed by the AIA appeared to fill this gap, but there are still some inconstancies between the different notion of level of development, level of detail, level of information and level of scale. We started to elaborate a clear definition of the LOD to be used in STREAMER, but this work is still in progress and will be finalised in the second term of the project with the second deliverable of task 4.1.

Nevertheless, we present below the current definitions of the LOD.

***LOD Definition***

In 2008, the AIA developed its first set of Level of Development definitions in AIA Document E202™-2008 Building Information Modeling Protocol. Due to the rapidly evolving nature of the use of BIM, the AIA evaluated the AIA E202–2008, including the LOD definitions.

The result is the updated and reconfigured Digital Practice documents, AIA E203™–2013, Building Information Modeling and Digital Data Exhibit, AIA G201™–2013, Project Digital Data Protocol Form, and AIA G202™–2013, Project Building Information Modeling Protocol Form, which are accompanied by a detailed guide document entitled Guide and Instructions to the AIA Digital PracticeDocuments. The AIA's updated Digital Practice documents include revised LOD definitions.

The Level of Development (LOD) framework addresses several issues that arise when a BIM is used as a communication or collaboration tool, i.e., when someone other than the author extracts information from it:

- During the design process, building systems and components progress from a vague conceptual idea to a precise description. In the past there has been no simple way to designate where a model element is along this path. The author knows, but others often don't.
- It's easy to misinterpret the precision at which an element is modeled. Hand drawings range from pen strokes on a napkin to hard lines with dimensions called out, and it's easy to infer the precision of the drawing from its appearance. In a model though, a generic component placed approximately can look exactly the same as a specific component located precisely, so we need something besides appearance to tell the difference.
- It is possible to infer information from a BIM that the author doesn't intend – unstated dimensions can be measured with precision, assembly information often exists before it's been finalized, etc. In the past, this issue has been sidestepped with all-encompassing disclaimers that basically say, "Since some of the information in the model is unreliable, you may not rely on any of it." The LOD framework allows model authors to clearly state the reliability of given model elements, so the concept becomes "Since some of the information in the model is unreliable, you may only rely on it for what I specifically say you can."
- In a collaborative environment, where people other than the model author are depending on information from the model in order to move their own work forward, the design work plan takes on high importance – it is necessary for the model users to know when information will be available in order to plan their work. The LOD framework facilitates this.

The LOD Framework addresses these issues by providing an industry-developed standard to describe the state of development of various systems within a BIM. This standard enables consistency in communication and execution by facilitating the detailed definition of BIM milestones and deliverables.

But LOD is also interpreted as Level of Detail. Level of Detail is essentially how much graphical detail is included in the model element. Level of Development is the degree to which the element's geometry and attached information has been thought through – the degree to which project team members may rely on the information when using the model. In essence, Level of Detail can be thought of as input to the element, while Level of Development is reliable output.

# 5. Support from BIM / GIS approach

One important aim of STREAMER is to develop the BIM & GIS, and this section elaborates how they can help to achieve decision consensus and assist in the decisions-making process, all of them included in the participatory design.

Within STREAMER project, BIM and GIS are developed from a technical perspective (LCA, EeB, WLC/LCC, PLM). But the interest of BIM and GIS innovative approach is also from a management perspective of the design process.

## 5.1 Support from BIM approach

The structuring aspect of the BIM approach:

There are different levels to be taken into account when talking about a BIM based approach.

It is obvious that the BIM plays the role of a central structure or repository of information that is thus facilitating by this means the process leading to a consensus or to making a decision. The interoperability need leads to the adoption of common, shared, agreed solutions. To play the role of a reference, available and usable for all, these solutions have to be maintained by neutral bodies. When talking about BIM, this aspect is ensured by the association BuildingSmart, which is managing to development of interoperable and complementary solutions for the BIM.

Generally speaking, when exchanging information in the frame of a virtual enterprise (different actors from different organisations working together on the same project and exchanging digital information), there is a strong need to rely on three pillars that will guarantee and support an efficient exchange of information. These pillars are: 1) A common exchange information format that must be shared and unique among parties, 2) A common understanding on the information exchanged, and 3) An explicit and synchronised orchestration of the exchanges.[Ref. BuildingSmart].

These general requirements have been translated by BuildingSmart around the concept of BIM like the following:

- The IFC (Industry Foundation Classes) as a common exchange language;
- The IFD (International Framework for Dictionary) as a formalised way for expressing the semantic of a chosen vocabulary;
- The IDM (Information Delivery Manual) as a formalised way to express and represent processes and data exchanges;

These solutions are now ISO standards. They come along with other technical proposal like MVD (Model View Definition) or BCF (BIM Collaboration Format) that are complementary approaches to what has been mentioned above with always the idea of facilitating the exchanges among actors. These points are already well described in the deliverable D5.1.

The BIM is a mean that is well adopted now by the building sector and that is surrounded (and supported) by several tools (more than 150 softwares are certified as IFC compatible). It is then obvious to stress the help

provided by such tools to facilitate different parties to reach an agreement or to share a common view on a specific design aspect.
While above mentioned standards provide the basis to manage BIM data a main challenge remains; which basically is about how to translate specific requirements like for instance as needed for hospital design as briefly discussed in chapters 2 and 3 to:

- IFC: for Model View based data exchange – mainly to support and control machine to machine communication,
- IDM: for design process management – to specify who is responsible for what kind of data, and
- IFD: for interpretation of the building data by domain experts – to enable machine to human communication.

There are many definitions that can and shall be reused from one project to another due to its generic character, but there are also definitions that need to be adjusted in order to reflect specific agreements of the Virtual Design and Construction process. Such requirements are typically managed with spreadsheets and tools like Excel, which are simply to use but restricted to a textural description of requirements. Also, there is only limited support for using, maintaining and adjusting such definitions leading to a high maintenance effort in the long run.

A new web-based solution developed by AEC3, and being extended in WP5, is aiming at a new kind of tools that support Building Information *Management*. Based on process definitions, more specifically on identified stages and processes (see 2.1), design actors (see 2.2) and its process dependencies (see process maps), the required data can be:

- specified as defined by domain experts (e.g. using a vocabular based on the buildingSMART Data Dictionary)
- assigned to actors and processes in order to identify which data has to be delivered by whom and for what (and when), and
- mapped to data structures like IFC, linked to a classification system like Omniclass and even other languages.

Once all project requirements have been configured in the system they can be filtered using different criteria and then exported to:

- project reports – for example to be used as user guideline or annex of the project contract,
- spreadsheets – to be used offline, and
- checkable Model View definitions for the IFC data format.

Especially the later will enable a new level of project management. A Model View definition is exported in the mvdXML format[1], which for instance enables to check if all required data is contained in an IFC file or if some information that is needed by another process is missing. This enables to partially automate data quality control by sorting out many low-level issues. On the other hand, by generating user specific reports it is expected that all project participants will get better support to deliver required information in the expected data format.

The system is designed to provide a set of reusable object and property definitions that can be configured to project requirements. New properties, if needed, can be added to the system and assigned to objects to reflect

[1] mvdXML is another standard developed by buildingSMART. It is used to for generating the IFC documentation and to specify model subsets.

specific data exchange requirements. If new properties have been added by the project manager they have to be mapped to the IFC data structure before being able to generate mvdXML specifications. This mapping configuration is done by an IFC expert who knows which attribute in the IFC data structure is used to store that information. Once all requirements have been defined, assigned to processes and actor roles and all mapping definitions are specified the requirements can be exported as described above. For instance it would be possible to export a user guideline for a specific actor role and process only.

The principle steps for defining requirements are shown in the following figures. The typical starting point is to check available components, namely objects, properties (see Figure 8), actor roles, design stages & processes as well as available mapping definitions. Most of those components can be reused from previous projects so that a next step would be to check the requirements setup. If a similar project has been used in the past or if a suitable example is available the requirements setup can be reused as well and may have to be adjusted (see Figure 9).

The next and final step for the project manager is to configure (or adjust) ownership and requirements settings, i.e. if some information is mandatory, optional or may even not allowed. Figure 10 shows an example configuration for the architect, who is responsible to provide gross and net planned area and other information for the shown processes S00-P01 to S02-P01. Once the project management receives an IFC file from the architect it can be checked based on the generated mvdXML file. For this, other tools with mvdXML support like XBIM explorer must be used in order to highlight spaces with missing information.

More information about this requirements management system and possible extensions are discussed in the deliverable D5.1.

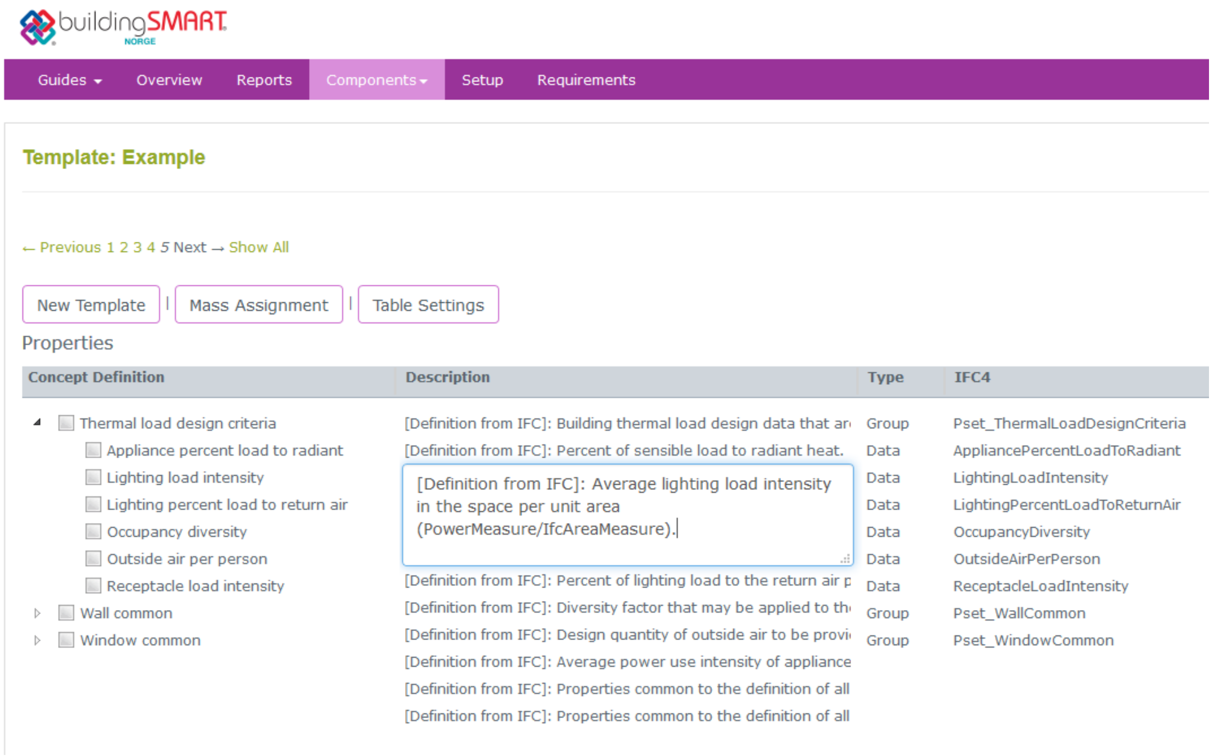



*Figure 8 : Definition of reusable components to be later used for the configuration of requirements. (Screenshot shows properties that have been imported from IFC property definitions)*

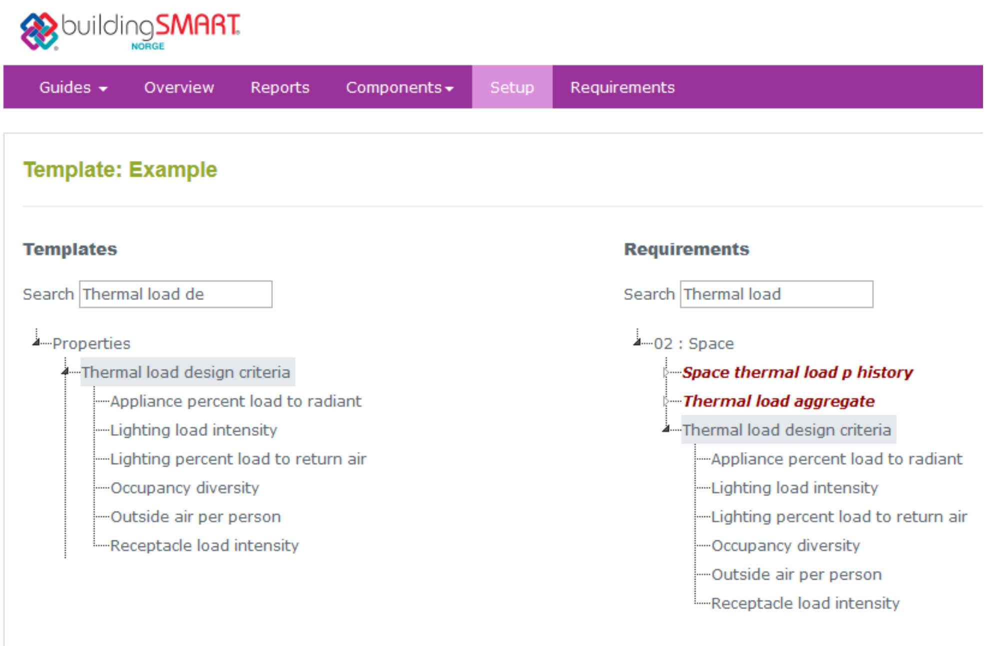
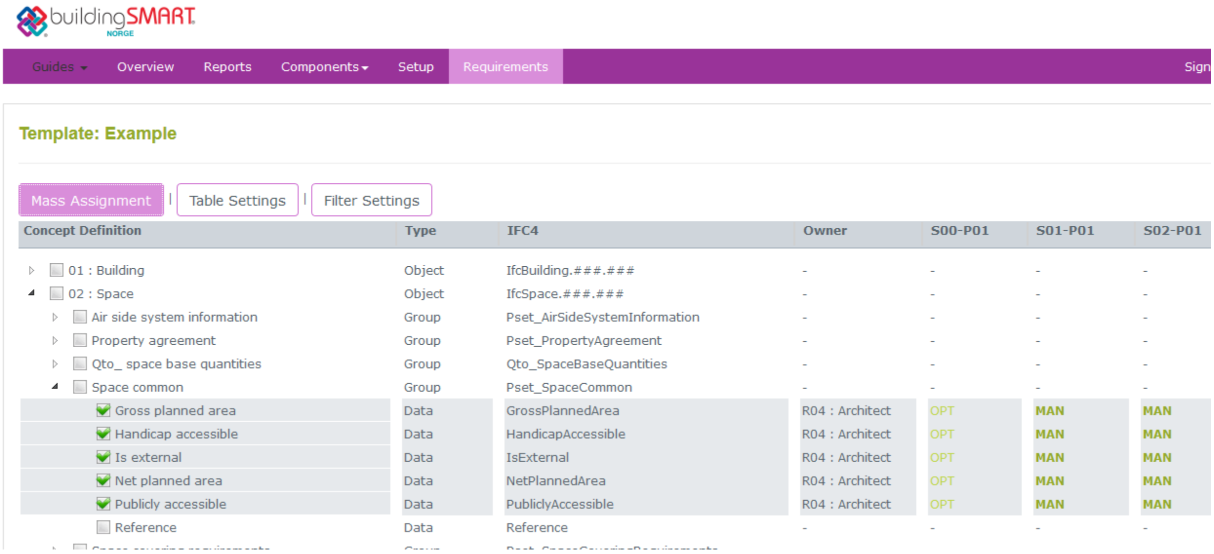



*Figure 9 : Use of components to configure requirements*




| Concept Definition | Type | IFC4 | Owner | S00-P01 | S01-P01 | S02-P01 |
|---|---|---|---|---|---|---|
| 01 : Building | Object | IfcBuilding.###.### | - | - | - | - |
| 02 : Space | Object | IfcSpace.###.### | - | - | - | - |
| Air side system information | Group | Pset_AirSideSystemInformation | - | - | - | - |
| Property agreement | Group | Pset_PropertyAgreement | - | - | - | - |
| Qto_ space base quantities | Group | Qto_SpaceBaseQuantities | - | - | - | - |
| Space common | Group | Pset_SpaceCommon | - | - | - | - |
| Gross planned area | Data | GrossPlannedArea | R04 : Architect | OPT | MAN | MAN |
| Handicap accessible | Data | HandicapAccessible | R04 : Architect | OPT | MAN | MAN |
| Is external | Data | IsExternal | R04 : Architect | OPT | MAN | MAN |
| Net planned area | Data | NetPlannedArea | R04 : Architect | OPT | MAN | MAN |
| Publicly accessible | Data | PubliclyAccessible | R04 : Architect | OPT | MAN | MAN |
| Reference | Data | Reference | - | - | - | - |

*Figure 10 : Requirement settings and assignment of data owners in the requirements table view.*

## 5.2 Support from GIS approach

In the design processes regarded in the STREAMER project, BIM and GIS data play different roles. It is a central paradigm in STREAMER that the design of the new or majorly retrofitted hospital building is represented in BIM ("design model"), and that this design-model continuously grows and gets more detailed over the different stages of the design process. In contrast to this dynamic BIM model, the used GIS models will be static. They contain spatially related information on the neighbourhood of the planned building, comprising, e. g., existing hospital buildings, technical or social infrastructure, the natural environment and the relief structure. This kind of information principally can be used in all stages of the design process for supporting decision making. Which kind of support effectively can be realized mainly depends on quality and information content of the available GIS data. STREAMER deliverable D 6.5 gives an overview on usable GIS data formats.

In STREAMER, the two use-cases "construction of a new building" and "renovation of an existing building" are considered. The planning phase for a new building always starts with specifying its location on the site. For this initial planning step, spatially related information on the built-up and natural environment is essential. The easiest way to verify the suitability of a certain location is a superposition of BIM and GIS model data in a virtual scene. In deliverable 4.3 such a planning tool for the very early design stage is described, which realizes a two-dimensional (2D) superposition of the planned building's footprint with OpenStreetMap (OSM) data of the environment.

A common visualization of the BIM based design model and GIS data of then neighbourhood can also support later stages of the design process. The design team needs to evaluate how the planned building optically fits into the existing environment, and how it is spatially related with the existing hospital infrastructure like central (medical, technical or logistical) facilities, roads or parking areas. In this case, for generating a visual impression of the planned building in the existing environment being as realistic as possible, the GIS model should contain three-dimensional (3D) geometry and corresponding photo-realistic textures.

If in addition to the 2D or 3D geometry the GIS model also contains semantic and attributive information of the neighbourhood objects, the potential of the GIS approach for supporting participatory design grows. One central approach of STREAMER is to compare and assess different design alternatives of base of Key Performance Indicators (KPIs, see chapter 4.1). Many of these KPI can only be determined reliably by taking into account the neighbourhood. In these cases, a GIS model may provide the information needed for objectively calculating performance indicators. In the following, for the three groups of KPIs (energy efficiency, cost efficiency and operational efficiency) corresponding examples are outlined.

The energetic situation of a building is influenced by the environment in different ways. So, shading caused by existing buildings/facilities, large vegetation objects or the relief has strong impact on the heating or cooling demand, and has to be taken into account in energy simulations. Furthermore, every building location has a specific potential for the usage of renewable energy (solar energy, wind energy, geothermal energy), which should be considered in the planning and decision making process.

Already in early stages of the design process it has to be decided, to which extent the planned building can use the existing energetic infrastructure (electricity, heating and cooling, process steam), and whether the planned building will have own energy production facilities, eventually being able to deliver extra energy to the neighbourhood. Only a detailed geospatial model of the existing facilities and utility networks can deliver the input data for this decision, which has significant influence on the overall lifecycle cost.

The third group of KPIs deals with quality of environment and operational efficiency. Also in this case, some of the factors mentioned in deliverable D 3.1 (e.g. “car parking and transport connections”, “way finding”) are related to the spatial context of the building. The analytical functionality of modern GIS systems principally enables to assess these parameters in an objective manner.

# 6. Proposed Framework for Management of Design

The different WPs in STREAMER have developed tools, methods and ways of looking at the project and goal at hand that need to be integrated in the process flow of a regular design process.

This chapter will first summarize the conclusions of the previous sections, then will highlight the relationships with the other work packages within STREAMER, and will prepare for the next phase of work in task 4.1.

## 6.1 Analysis and conclusion

The importance of having a “shared language” in all the different parts of the design process of healthcare projects, due to the large panel of involved actors, the complication and the diversity of the product, underlines the need of the use of BIM and GIS approaches, associated to collaborative design.

The design process map approach points out the three different stages in the design process, with different levels of details. When we add the fact that the large number of involved actors may have different roles within these stages, we can conclude that there is a huge need of defining the right level of information and roles in the design process. The multiplicity of space areas and departments, needs a formal and comprehensive labelling to allow collaborative design without omitting strategic objectives of the project, whether it be for the medical objectives or for the efficiency of the building design.

In order to avoid today’s “over-the-wall design”, we have to implement the Participatory Design, involving many actors (from the end-user till the contractors and maintenance) from the brief preparation of the PoR until the decisions reviews. To allow a high comprehension of the objectives, clear indicators (more and more detailed within the stages of design, but still complementary such as Russian dolls) are necessary. There, the methodology developed in Virtual Design and Construction, must be adapted to the early design stage, but allows practical approach linking together the levels of the product, the organization and the process.

The objective of those previous sections is to prepare consensus and decision that occurs at each stage of the design. A decision making process, with multi-criteria analysis is therefore essential, and has to be based also on clear and adapted indicators, means of analysis.

The complexity of the healthcare process has a huge need of structured procedures and information flow, in addition to the fact that many changes appear during the design process. The variety and large number of stakeholders is another important factor belonging to healthcare projects. For these reasons, the use of interoperable language is essential to control the process, with a numeric model which is able to be used by all actors, in particular the non-designers. Then BIM and GIS are a complementary key success factor to allow quick, secure and comprehensive design process of healthcare projects.

## 6.2 Relationships with other work packages

Task 4.1 contributes to the global objective of STREAMER by working on the collaborative design process with improvement of information flow to enable better links between the designers and the engineers for the energy efficiency of the projects. Design process needs clear, shared and comprehensive relations to achieve it, and so most of other work packages improvements will benefit to the collaborative design, with different levers.
The clear definition of the typologies of buildings and the matrix of relations between spaces, as developed in WP1 is a first lever. The knowledge of the energy efficient solutions, on MEP as well as on spaces and envelopes, associated to their impact on the energy and CO2 potential reduction, described in WP2 is a second important lever. But on the top of all, key performance indicators, understood by all the involved actors, and established by WP3, are a key success factor to the consensus reaching during the review phases. From WP5 information about the digital Plan of Work is taken.

The client may also specify his information requirements (in the UK referred to as the EIR, Employer's Information Requirements). Whilst primarily focused at efficient and complete handover information, earlier information deliverables are also anticipated for example for functional and cost review. Aspects of these requirements may cascade and be amplified down through the design chain and the supply chain. A key aspect of the EIR is the adoption of a digital 'Plan of Work' (dPoW), detailing information expectations:

- **Context** – the scope or mandate of the dPoW
- **Stage and Purpose** (for example stages 0-7 and any sub-purposes within the stages)
- **Actor** – client, design or construction experts
- **Role** – responsible for, accountable for, consulted on, informed of
- **Object** – the system, zone, product or space
- **Attribute** – property, representation or measurement

This deliverable D4.1 highlights many factors which must be taken into account in the other work packages:

- There is a strong need of experts / specialists who must be involved at the early design phase, such as clinical specialists, operating & maintenance team, end-users, energy efficiency experts, and above all some kind of interpreters who can translate between healthcare language and building design in the two-ways.
- The design process must be transparent and structured, to be comprehensive and accepted by all the stakeholders, especially the user (owner, FM, staff…)
- It belongs to people to make decisions, the aim of STREAMER is to facilitate the decision process with supporting tools.

## 6.3 Further work for Task 4.1 within STREAMER

With these elements, the information flow, in the virtual design and construction, will be the key to introduce the basis of the collaborative process to design EeB healthcare districts. The roadmap to develop will have to be extremely cautious with the different stages of the design, to avoid creating a far too complicated process at the early stages of design. In addition, the roadmap will integrate the revision loop process according to the different phases of the design process, within the approach of participatory design and decision making process.
But, with the cross-assistance of the design configurator tool from WP6, the roadmap of collaborative design process will be built in the next part of STREAMER project, within the deliverable D4.2.

We will use Participatory Design, with the assistance of Experts in the domains of Clinical, FM and EeB, associated to IT tools such as VDC and PLM at BIM and GIS level, to achieve a Collaborative Design Process which will allow to succeed while running together.

# 7. References

Alastair Blyth and John Worthington, Managing the Brief For Better Design (July 2010), 2nd Edition

Arroyo, P., Tommelein, I.D., and Ballard, G. (2012), “Deciding a Sustainable Alternative by Choosing by Advantages' in the AEC industry”, IGLC 20, San Diego, USA, retrieved from http://www.iglc20.sdsu.edu/papers/wp-content/uploads/2012/07/5%20P%20122.pdf (March 12, 2015)

Bana e Costa, C., Nunes da Silva, F., and Vansnick, J.-C. (2000), ”Conflict dissolution in the public sector: a case study”, European Journal of Operational Research, 130:2, pp. 388 – 401

Chen, Y.-W., Wang, C.-H., and Lin S.-J. (2008), “A multi-objective geographic information system for route selection of nuclear waste transport”, International Journal of Management Science 36 (2008) pp. 363–372.

Department for Communities and Local Government (2009), Multi-criteria analysis: a manual, Communities and Local Government Publications, London

Durmisevic, S. and Ciftcioglu, O. (2010), "Knowledge modeling tool for evidence-based design", HERD, vol. 3, no. 3, pp. 101-123

Farkas, A. (2011), “Route/Site Selection of Urban Transportation Facilities: An Integrated GIS/MCDM Approach”, MEB 2009 – 7th International Conference on Management, Enterprise and Benchmarking, June 5-6, Budapest, Hungary, pp. 169-184

Goodwin, P., and Wright, G. (1998), Decision Analysis for Management Judgement, Second edition, John Wiley, Chichester.

IPD Case Studies, (March 2012), AIA Minnesota, School of Architecture – University of Minnesota
Keeney, R. L., and Raiffa, H. (1993), Decisions with multiple objectives: preferences and value tradeoffs, Cambridge Univ. Press, 2nd edition, 569 pp.

Kensing, F. and J. Bloimberg, PD meets CSCW – Issues and Concerns. Computer Supported Cooperative Work, 7, 167–185, 1998

Kensing, Finn, The Trade Unions Influence on Technological Change. In Systems Design For,
Kunz, J., and Fischer, M. (2012), “Virtual Design and Construction : Themes, Case Studies and Implementation Suggestions”, CIFE Working Paper #097 version 14, (January 2012)

Macharis, C., Turcksin, L., and Lebeau, K., (2012), “Multi actor multi criteria analysis (MAMCA) as a tool to support sustainable decisions: State of use”, Decision Support Systems 54 (2012) pp. 610–620

RIBA Plan of Work 2013 Overview, www.ribaplanofwork.com

Rybkowski, Z. K., Shepley, M. M., & Ballard, H. G. (2012), “Target value design: Applications to newborn intensive care units”. Health Environments Research & Design Journal, 5(4), 5–23

Sanoff, Henry, Community Participation Methods in Design and Planning, John Wiley & Sons, 2000

With and By the Users. U. Briefs et al. (eds.), North Holland Publishing Company, New York, 1983

# APPENDIX 1 – Design Process Map

See A3 Design Process Map at the end of the document

APPENDIX 2 – Italian Scenarios

# Task 4.1 Collaborative Design Process

## Italian scenarios

IAA | AOC

5th May 2014

### Scope of this document

The document contains the list, and its instruction, of the Italian scenarios (procurements, level of design and design actors) in the design and construction process from the architect point of view and the hospital owner as well.

## ITALY (*ITALIA*)

**PUBLIC PROCUREMENT** contracts must comply with the rules of the Public Works Code and a document containing the technical specifications for the execution of the works (*capitolato*).

**PRIVATE PROCUREMENT** contracts are governed by:

- Civil Code (Articles 1655 to 1677).
- Relevant applicable legislation (for example, on project finance), as private parties are free to choose their contractual arrangements.

There are no national standard contracts.[2]

The following description regards the public sector

The public construction contracts are regulated by the Legislative Decree no. 163 of April 12, 2006, "Regulation of public procurement regarding works, services and supplies implementing Directives 2004/17/EC and 2004/18/EC" (*Codice dei contratti pubblici relativi a lavori, servizi e forniture in attuazione delle direttive 2004/17/CE e 2004/18/CE*), published in the Official Journal n. 100 of May 2, 2006 - Ord. Suppl. n. 107, and effective from July 1, 2006.

The Decree regulates all awarding procedures for both above threshold and below threshold procurement. "With the Regulation implementing the Public Works Code, the services and supplies are controlled during their implementation cycle, from the programming and planning phase to the execution and testing phase, including the regulation of the instruments for resolution of disputes during the execution phase.

There are three categories of **PUBLIC CONTRACTS**:

- **Contracts of works** (*lavori*): including construction, demolition, recovery, restoration renovation and maintenance activities;
- **Contracts of supplies** (*furniture*): these are public contracts for procurement, financial leasing or leasing by public administrators of all products necessary for the functioning of institutions;
- **Contracts of services** (*servizi*): are public contracts for the provision of services." [3]

[2] http://uk.practicallaw.com/3-520-0016?source=relatedcontent

[3] http://europa.eu/youreurope/business/public-tenders/rules-procedures/index_en.htm#italy_en_benefiting-from-public-contracts

Before introducing the types of contracts of works, the description of **LEVELS OF DESIGN** is necessary:

1. **Triennial plan and annual list of works** (*Programma triennale ed elenco annuale*): list of works to be done during the following three years including an operative tool defining those works to be started during the first year. The plan is only a report: it has to contain the feasibility study (or the preliminary design if the cost is over I billions Euros) of the listed works.

2. **Feasibility study** (*Studio di fattibilità*) made up of the following documents:
   - General descriptive report (*Relazione illustrativa generale*)
     - Analysis of the state of the art: urban, social and economic background
     - Analysis of planning options
     - Analysis of supply and demand
     - Environmental and landscape sustainability
   - Technical report (*Relazione tecnica*)
     - Technical and functional analysis of the project
     - Timing and appraisal
     - Bureaucratic and administrative sustainability
   - Financial report (*Relazione economico-finanziaria*)
     - Financial feasibility (budget)
     - Social feasibility (Cost-benefit analysis)

3. **Preliminary design or Concept design** (*Progetto preliminare*) made up of the following documents:
   - Descriptive report (*Relazione illustrativa*)
     - Description of the project
     - Motivation of the proposal and description of the background
     - Feasibility of the project regarding historical, cultural, artistic, geological, seismic and landscape constraints
     - Availability of the plot or feasibility of its purchase
     - Recommendations for the following level of design
     - Timing of design, construction and technical-administrative testing phases
   - Technical report (*Relazione tecnica*)
   - Preliminary report on the environmental feasibility (*studio di prefattibilità ambientale*)
     - Conformity with possible urban and landscape plan
     - Study on the effects of the project regarding the health of citizens and environment
     - Motivation on the choice of the site
     - Description of environmental actions and related costs if needed

  - List of environmental regulations (and related technical suggestions for their respect) the project has to submit to
- Preliminary geological, hydrogeological and archaeological surveys (*indagini geologiche, idrogeologiche ed archeologiche preliminari*)
- Site plan and graphic schemes (*planimetria generale e schemi grafici*)
- Preliminary recommendations related to the health and safety plan (*prime indicazioni e disposizioni per la stesura dei piani di sicurezza*)
- Assessment of the costs (*calcolo sommario della spesa*)
- Other reports as seismic risk report, etc. if needed (*relazioni e grafici relativi alle indagini necessarie di natura geologica, geotecnica, idrologica, idraulica e sismica*)
- Performance technical report (*uno speciale capitolato prestazionale*)
  - Description of the requirements the project has to satisfy
  - Description of the general and specialized works
  - Table containing the technical elements forming the project

4. **Final design** (*Progetto definitivo*) made up of the following documents:
   - Descriptive report (Relazione generale)
     - Description of the project (framework, MEP, materials, etc.)
     - Description of topography, geology, hydrology, landscape, environment, historical and cultural heritage related to the project site
     - Data relevant to quarries and dumps
     - Description of solutions for accessibility
     - Interferences and connection with neighborhood grids
     - Description of artistic and architectonical improvements
     - Updating of the timing of design, construction and technical-administrative testing phases
   - Technical and specialized reports (relazioni tecniche e relazioni specialistiche)
     - Geological report
     - Hydrogeological report
     - Other reports if needed
   - Land and elevation profile surveys and detailed plan for the urban integration (*rilievi plano-altimetrici e studio dettagliato di inserimento urbanistico*)
   - Drawings (*elaborati grafici*)
     - Urban plan containing the position of the project
     - Site plan and elevations (included volumes and surfaces)
     - Floor plans (included destinations and framework)
     - Cross sections (included framework)
     - Elevations
     - Schemes of the structural framework (especially foundations)

- Functional schemes and approximate sizing of MEP systems
- Study of the environmental impact if needed (*studio di impatto ambientale*)
  - Description of the project related to the urban plans
  - Timing of the construction phase
  - Description of the modernity of the project
  - Description of offered services and goods
  - Description of the manufacturing and the technical characteristics of the project
  - Motivation of the choice of location
  - List of the constraints the project has to be submitted (urban plans and legislations)
  - Measures to be adopted to soothe the impact during the execution phase and the life cycle of the project
  - Description of the existing environmental system and contingent decay situations
  - Quality and quantity evaluation of the environmental impact of the project
  - Description of the foreseeable changes of the environment after the realization of the project
  - List of tools and parameters to control and monitor the environment
  - Description of actions in case of emergency
- Preliminary calculation of structural framework and MEP systems (*calcoli preliminari delle strutture e degli impianti*)
- Performance and technical specifications of technical elements (*disciplinare descrittivo e prestazionale degli elementi tecnici*)
- Survey and solution of interferences (*censimento e progetto di risoluzione delle interferenze*)
- Compulsory purchase plan if needed (*piano particellare di esproprio*)
- List of unit pricing (*elenco dei prezzi unitari ed eventuali analisi*)
- Bill of quantities (*computo metrico estimativo*)
- Updating of the preliminary recommendations related to the health and safety plan (*aggiornamento del documento contenente le prime indicazioni e disposizioni per la stesura dei piani di sicurezza*)
- Financial chart containing the costs for the safety of workers during the construction phase (*quadro economico con l'indicazione dei costi della sicurezza*)
- Technical document aimed at the contract (*capitolato speciale di appalto*) instead of "Performance and technical specifications of technical elements" if the project is used for a tender
- Draft of contract (*schema di contratto*) if the project is used for a tender

5. **Construction design** (*Progetto esecutivo*) made up of the following documents:
   - Descriptive report (*relazione generale*) deepening the one of the Final Design
   - Technical and specialized reports (*relazioni specialistiche*) deepening the ones of the Final Design

- Drawings (*elaborati grafici*) deepening the ones of the Final Design and containing the complete description of works in order to allow the contractor their correct and certain reading
- Structural calculation (*calcoli esecutivi delle strutture*)
  - Drawings (scale 1:50 and 1:10)
  - Calculation report (legislation to follow, quality and mechanical characteristics of materials, analysis of loads, static audits)
- Executive calculation of MEP systems (*calcoli esecutivi degli impianti*)
  - Drawings (scale 1:50 and 1:10)
  - Detailed description of each system included relevant calculation reports
  - Description of quality and functional characteristics of materials, equipment and tools
- Maintenance plan (*piani di manutenzione dell'opera*)
  - Operating instructions
  - Maintenance handbook
  - Maintenance programme
- Security Coordination Plan (*piani di sicurezza e coordinamento*)
- Bill of quantities and financial chart (*computo metrico estimativo definitivo ed il quadro economico*)
- Timing of works (*cronoprogramma dei lavori*)
- List of unit pricing (*elenco dei prezzi unitari ed eventuali analisi*)
- Incidence of workforce for every works (*quadro dell'incidenza di manodopera per le diverse categorie*)
- Technical document aimed at the contract and contract template (*schema di contratto ed un capitolato speciale d'appalto*)

6. **Construction set-up-stage design** (*Progettazione costruttiva*) to be made before the installation of the construction site and during the execution.

7. **As built** to be made after the execution.

There are three types of **CONTRACTS OF WORKS**:

1. **Direct works** (*Lavori in economia*) made with:
   - Direct administration (*Amministrazione diretta*); purchases should be made with own materials or means or specifically purchased or rented and with the general contractors' own personnel, or with personnel specifically hired for the purpose, under the supervision of the person in charge with the procedure.
   - Pieceworks (*Cottimi fiduciari*)
2. **Procurement contract** (*Contratto di appalto*); the object of the contract can be:
   - the only execution,
   - design and build: the construction design and the execution (A) (on the basis of the final design made by the Administration),
   - design and build: the construction design and the execution (B) asking, during the bidding, the final design (on the basis of the preliminary design made by the Administration).
3. **License contract** (*Contratto di concessione*); the object of the contract can be the final design, the construction design, the execution and the economic and functional management (for a certain number of years). It can be promoted by:
   - a public body (*iniziativa pubblica*) on the basis of a preliminary design or final design
   - a private company (*iniziativa privata*) and it is called project financing

The **PROCUREMENT PROCEDURES** (*PROCEDURE DI APPALTO*) (above the thresholds) to be used are described below.

Tenderer identification procedures, which include the natural and necessary step of selecting the best offer based on the lowest price or most economically advantageous (value for money) offer criteria, may be distinguished into:

1. ordinary procedures (open or restricted), which can be used in general at the General Contractor's discretion depending on specific contract requirements:
   - **Open procedure** (or public auction): all companies that wish to participate, may request to do so, provided they satisfy the criteria for the type of work and the price.
   - **Restricted procedure** (or private treaty): all companies invited by the relevant public administration may take part in the tendering procedure.
2. procedures that can be admitted only when compulsorily required:
   - **Negotiated procedure with advertisement**,
   - **Negotiated procedure without advertisement**,
   - **Competitive dialogue**,
   - **Dynamic purchase system**.

The procedure is selected by the authority with determination to award a contract, together with the tender selection criterion, and is disclosed in the tender notice (when the selection of an open or restricted procedure, negotiated procedure with publication or competitive dialogue requires said deed to be published)."[4]

"The 2011 annual report of the Authority for the supervision of public works contracts, and services and supplies (*Autorità per la Vigilanza sui Contratti Pubblici: AVCP*) keeps a statistic record of the total number of times a public procedure was used in that year and the percentage of times that each procedure was used. Of the four EU procurement procedures, the following are prevalent:

- In the awarding of public work contracts there is a prevalence of negotiated procedures (44.6% used the negotiated procedure without publication of a contract notice and 29.4% used the negotiated procedure with prior publication of a contract notice).
- In the awarding of service contracts there is also a prevalence of negotiated procedures (26.5% used the negotiated procedure without publication of a contract notice and 26.6% used the negotiated procedure with prior publication of a contract notice).
- In the award of supply contracts there is a large use of open procedure (19.9% of contracts awarded).

According to the 2011 AVCP annual report, 31% of the public contracts awarded have been public works contracts, 41% have been service contracts and 28% have been supply contracts."[5]

The **PROCEDURES FOR THE PROVISION OF SERVICES**, if the Administration cannot implement them internally, are as follows:

- **Ideas competition**
- **Architectural competition (open o restricted, one or two stages)**
- **Tender**

**THE DESIGN ACTORS FROM THE SIDE OF THE HOSPITAL**

- **Estates Personnel (Architects and Engineers)**
- **Superintendence for Environmental and Architectural Heritage**
- **Fire Officer**
- **Security Adviser**
- **Health & Safety Adviser**
- **Clinicians**
- **Nursing**
- **Infection Control**
- **Healthcare Assistants**
- **Logistics Personnel**

[4] Public Procurement in Italy, Euro Info Centre Promofirenze, October 2006
[5] http://uk.practicallaw.com/9-521-2163?q=&qp=&qo=&qe=

- **Cleaning Services**
- **Waste Management**
- **Pharmacy**
- **Patients**
- **Other Stakeholders**

**THE DESIGN ACTORS FROM THE SIDE OF THE CONSTRUCTION**

- **Conservation Architect**
- **New build Architect**
- **Quantity Surveyor**
- **Landscape designer**
- **Lighting designer**
- **M&E Consultants**
- **Structural engineer**
- **Fire Strategists**
- **Health and safety coordinator**
- **Archaeologist**
- **Geologist**
- **Environmental Impact Analysts**
- **Acoustician**
- **Access consultant**
- **Travel Impact Assessors**
- **Principal Contractors**

"The main parties involved in a construction project are:

**Owner/employer or principal** (*committente*)

This is the person or entity on behalf of which the works are carried out. In the case of public procurement, the principal is the contracting public authority holding decision-making powers and the expenditure authority relating to the management of the construction contract.

**Designer** (*progettista*)

The designer has the specific role of drawing up plans and projects. In addition, the designer must complete a number of preliminary activities. Engineers and architects involved in the design phase of projects must be registered with their relevant professional bodies (*ordini profesionali*).

**Contractor/general contractor** (*appaltatore*)

The contractor is the party performing the project, which can be either a natural or legal entity, an European Economic Interest Grouping (EEIG) or a Consortium.

**Engineer** (*direttore dei lavori*)

The engineer ensures compliance with the construction requirements. He represents the interests of the employer on the building site and carries out the direction and surveillance of the works.

**Construction foreman** (*capo cantiere*)

The construction foreman is the contractor's employee and acts in accordance with the contractor's directions and instructions.

**Subcontractors** (*subappaltatori*)

Subcontracting must be authorised by the contracting authority.

**Project manager** (*direttore tecnico*)

The project manager represents the contractor and is responsible for the administration of the project.

**Health and safety coordinator** (*responsabile per la sicurezza*)

The health and safety coordinator is responsible for supervising health and safety in the workplace as regards the workers involved in the construction works (Legislative Decree no. 81/2008).

Other professionals may be required under public procurement rules. For example, a responsible person entrusted with the surveillance of public works (*responsabile delle procedure di affidamento e di esecuzione dei contratti pubblici*).

Rules on construction/projects also require the involvement of administrative and regulatory authorities. Among others, the Italian authority for the control of public contracts (*Autorità di vigilanza sui contratti pubblici*) has the task of monitoring both the award and the execution of public contracts."[6]

[6] http://uk.practicallaw.com/3-520-0016?source=relatedcontent

**TABLE INSTRUCTION**

Regarding the procurements, the symbol ■ does not mean a “direct action”.

For example, the private architect can be involved in a public procurement in case of successful services tender.

Regarding the actors, the symbol ■ means the involvement and the collaboration as well.

| en | it | IAA architect | AOC hospital |
|---|---|---|---|
| **LEGAL DESIGN AND CONSTRUCTION TYPE OF CONTRACTS** | | | |
| **Types of procurements** | | | |
| Public procurement | *Contratto pubblico* | ■ | ■ |
| Private procurement | *Contratto privato* | ■ | ■ |
| Contract of works | *Contratto di lavori* | ■ | ■ |
| Contract of supplies | *Contratto di forniture* | ■ | ■ |
| Contract of services | *Contratto di servizi* | ■ | ■ |
| **Types of contract of works** | | | |
| **Direct works** | *Lavori in economia* | | |
| Direct administration | *Amministrazione diretta* | | |
| Pieceworks | *Cottimi fiduciari* | | |
| **Procurement contract** | *Contratto di appalto* | | |
| Execution | *Esecuzione* | | ■ |
| Design and build (A) | *Ex-appalto integrato (A)* | ■ | ■ |
| Design and build (B) | *Ex-appalto concorso (B)* | ■ | ■ |
| **License contract** | *Contratto di concessione* | | |
| Public initiative | *Iniziativa pubblica* | ■ | ■ |
| Project financing | *Iniziativa privata* | ■ | ■ |
| **Procurements procedures for the provision of works** | | | |
| **Open procedure** | *Procedura aperta* | | ■ |
| **Restricted procedure** | *Procedura ristretta* | | ■ |
| **Negotiated procedure** | *Procedura negoziata* | | ■ |
| **Competitive dialogue** | *Dialogo competitivo* | | ■ |
| **Dynamic purchase system** | *Sistema dinamico d’acquisizione* | | ■ |
| **Procurements procedures for the provision of services** | | | |
| Ideas competition | *Concorso di idee* | ■ | ■ |
| Architectural competition | *Concorso di progettazione* | ■ | ■ |
| Tender | *Gara di progettazione* | ■ | ■ |
| **LEVELS OF DESIGN** | | | |
| Triennial plan | *Programma triennale* | | ■ |
| Feasibility study | *Studio di fattibilità* | ■ | ■ |
| Preliminary design | *Progetto preliminare* | ■ | ■ |
| Final design | *Progetto definitivo* | ■ | ■ |
| Construction design | *Progetto esecutivo* | ■ | ■ |
| Construction set-up-stage design | *Progettazione costruttiva* | ■ | ■ |

| en | it | IAA architect | AOC hospital |
|---|---|---|---|
| As built | *As built* | ■ | ■ |
| **THE DESIGN ACTORS FROM THE SIDE OF THE HOSPITAL** | | | |
| Estates Personnel | *Personale tecnico interno* | ■ | ■ |
| Superintendence for Environmental and Architectural Heritage | *Sovrintendenza per I beni culturali* | ■ | ■ |
| Fire Officer | *Vigili del Fuoco* | ■ | ■ |
| Health & Safety Adviser | *ASL per sicurezza* | ■ | ■ |
| Clinicians | *Personale medico* | ■ | ■ |
| Nursing | *Personale infermieristico* | ■ | ■ |
| Infection Control | *Controllo delle infezioni* | ■ | ■ |
| Healthcare Assistants | *Assistenti sanitari* | ■ | ■ |
| Logistics Personnel | *Personale logistico* | ■ | ■ |
| Cleaning Services | *Personale per le pulizie* | ■ | ■ |
| Waste Management | *Gesture dei rifuti* | ■ | ■ |
| Pharmacy | *Farmacisti* | ■ | ■ |
| Patients | *Pazienti* | ■ | ■ |
| Other Stakeholders | *Altri* | ■ | ■ |
| **THE DESIGN ACTORS FROM THE SIDE OF THE CONSTRUCTION** | | | |
| Conservation Architect | *Architetto restauratore* | ■ | ■ |
| New build Architect | *Architetto* | ■ | ■ |
| Quantity Surveyor | *Geometra - Perito edile* | ■ | ■ |
| Landscape designer | *Paesaggista* | ■ | ■ |
| Lighting designer | *Illuminotecnico* | ■ | ■ |
| M&E Consultant | *Impiantista* | ■ | ■ |
| Structural engineer | *Strutturista* | ■ | ■ |
| Fire Strategists | *Esperto per l’antincendio* | ■ | ■ |
| Health and safety coordinator | *Coordinatore per la sicurezza* | ■ | ■ |
| Archaeologist | *Archeologo* | ■ | ■ |
| Geologist | *Geologo* | ■ | ■ |
| Environmental Impact Analysts | *Esperto di impatto ambientale* | ■ | ■ |
| Acoustician | *Acustico* | ■ | ■ |
| Access consultant | *Esperto per l’accessibilità* | ■ | ■ |
| Travel Impact Assessor | *Esperto di viabilità* | ■ | ■ |
| Principal Contractors | *Impresari* | ■ | ■ |