D4.2 Process roadmap of participatory semantic-driven design

Deliverable Report: D4.2 Final version

Streamer - Optimised design methodologies for energy-efficient buildings integrated in the neighbourhood energy systems.

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D4.2 Process roadmap of participatory semantic-driven design

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Colophon

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Publishable executive summary

The traditional design approach to energy efficient health care is moving into a new era of digitalization and including participatory process. The STREAMER project has two main focus points: digital process and participatory process. The design process of health care districts involves a vast number of stakeholders and professionals. This complex situation of conflicting interests makes it difficult to interpret the design problem, communicate and make decisions. The work has focused on the pre-design and the design activities, including details of the mechanical, electrical and plumbing technologies.

This report relates the STREAMER digital design approach to the traditional design process and presents the interaction of the STREAMER tools with the common known design process of energy efficient health care districts. In addition, a future design process is addressed by weaving the STREAMER digital design process with a state-of-the-art participatory design process. The work has also investigated how STREAMER tools and process influence and how these can be used in the Construction and In-use phases.

The work is built upon the lessons drawn from the design workshops organized among the STREAMER partners, one was held in Arnhem during a general project meeting and four different workshops with Hospital personnel in UK, Italy, France and The Netherlands. In addition, research in the field has been reviewed. The workshops rendered information for development of the process-tool interaction.

The traditional design process and the STREAMER design approach are presented in three phases of pre-design and design aspects. The following aspects have been addressed:

- Core objectives
- Process steps
- Tools
- Products
- Stakeholders
- Demonstrations

The investigation of the potential use of STREAMER tools and process in the Construction and In-use phases deduced to the benefits of using building information modeling. A higher level of information aids in coordination and to produce clear document for interactions during construction and use and an efficient quality control tool. Several other areas have been suggested for potential areas of application during the In-use phase:

- Energy management
- Space management
- Data updating and creation
- Need for building component information
- Visualization at refurbishment

In conclusion, by this work the two main focus areas – STREAMER digital process and participatory process – are weaved together, forming a STREAMER design approach for energy efficient health care districts.

List of acronyms and abbreviations

AIA: the American Institute of Architects
BIM: Building Information Modelling
CSV: Comma Separated Value
DST: Decision Support Tool
EBD: Evidence Based Design
EDC: Early Design Configurator
EeB: Energy Efficient Buildings
FA: Functional Area
HD: Healthcare District
HVAC: Heating, Ventilation, Air Conditioning
IFC: Industry Foundation Classes
IPD: Integrated Project Delivery
KPI: Key Performance Indicator
LCC: Life Cycle Costs
MEP: Mechanical, Electrical, Plumbing technologies
RIBA: Royal Institute of British Architects
SoTA: State of The Art
FM Facility Management

Definitions

Building Information Modelling (BIM)
Digital representations of physical and functional characteristics of building which allows for modelling and simulation studies of building operational performance

Design Programme
The design programme is programme setting out the strategic dates in relation to the design process. It is aligned with the Project Programme but is strategic in its nature, due to the iterative nature of the design process, particularly in the early stages. (Sinclair 2013)

Integrated Project Delivery
"Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.

IPD principles can be applied to a variety of contractual arrangements and IPD teams can include members well beyond the basic triad of owner, architect, and contractor. In all cases, integrated projects are uniquely distinguished by highly effective collaboration among the owner, the prime designer, and the prime constructor, commencing at early design and continuing through to project handover" (AIA 2007).

Key Performance Indicator (KPI)

An indicator evaluates the success of an organization or of a particular activity. Often success is the periodic achievement of some levels of operational goal (e.g. zero defects, 10/10 customer satisfaction, etc.), and sometimes success is defined in terms of making progress toward strategic goals

Label

Property attached to spatial component, also called "STREAMER label"

Labelling Approach

Classification and labelling method introduce a set of codes and references that allow to identify the spaces through the relations between spatial, functional and energy related features.

Program of Requirements (PoR)

An ordered collection of data about an organisation's housing needs and the performance required in respect of the site, building, rooms, parts of the building and facilities in the building and on the site" (Voordt 2005).

Technology Strategy

The strategy established at the outset of a project that sets out technologies, including Building Information Modelling (BIM) and any supporting processes, and the specific software packages that each member of the project team will use. Any interoperability issues can then be addressed before the design phases commence. This strategy also considers how information is to be communicated (by email, file transfer protocol (FTP) site or using a managed third party common data environment) as well as the file formats in which information will be provided. The Project Execution Plan records agreements made. (Sinclair 2013)

SACS

This is a tool that provides the information about the current use of spaces

Content

1. Introduction

1.1 Background

Traditional design process is very time consuming and often inaccurate since it collects and converts the evidence and tacit knowledge regarding clinical protocols, patient's experience and expert's advice through consultations, focus groups, and quality circles. There are substantial difficulties in the design interpretation, communication and decision-making involving many different stakeholders (corporate directors, facility managers, medical specialists, building occupants, architects, engineers, contractors, etc.).

In spite of a solid track-record in the field of healthcare building design, the existing approach remains subjective and full of uncertainties. It is difficult to comprehensively gain the knowledge of the energy use and energy reduction potentials per typology from the descriptions and specifications of the healthcare processes and equipment, which are widely available. A few examples: Advanced energy design guide in the USA (2010); and Guidelines for Energy-Efficiency Measures in Hospitals (EU project LIFE 2004).

1.2 Scope

The scope of this report is to present a process roadmap of participatory semantic-driven design. The roadmap includes the development from traditional design methodologies to future design methodologies and shows how the STREAMER information process connects with these. The design process regards Energy efficient Buildings (EeB) and especially buildings for health care districts.
The following aims have been addressed in the work:

- Present the traditional design methodologies used for health care districts.
- Present the interaction between STREAMER tools and the traditional design methodologies – The STREAMER process.
- Present how the STREAMER process and participatory design is weaved together in a future design methodology.
- Present how the STREAMER tools and processes influence and can be used in the Construction and In-use phases.

1.2.1 RIBA and connection to STREAMER

The RIBA Plan of Work is published by the Royal Institute of British Architects (RIBA). The latest version is also is endorsed by the Chartered Institute of Architectural Technologists, the Construction Industry Council, the Royal Incorporation of Architects in Scotland, the Royal Society of Architects in Wales and the Royal Society of Ulster Architects.

Split into a number of key project stages, the RIBA Plan of Work provides a shared framework for design and construction that offers both a process map and a management tool. Whilst it has never been clear that architects actually follow the detail of the plan in their day to day activities, the work stages have been used as a means of designating stage payments and identifying team member's responsibilities when assessing insurance liabilities and they commonly appear in contracts and appointment documents.

The latest version, published in 2013 has moved online and has undergone a radical overhaul. It is now more flexible, with stages such as planning permission and procurement being moveable, it reflects increasing requirements for sustainability and Building Information Modelling (BIM) and it allows simple, project-specific plans to be created. In addition, the work stages have been re-structured and re-named:

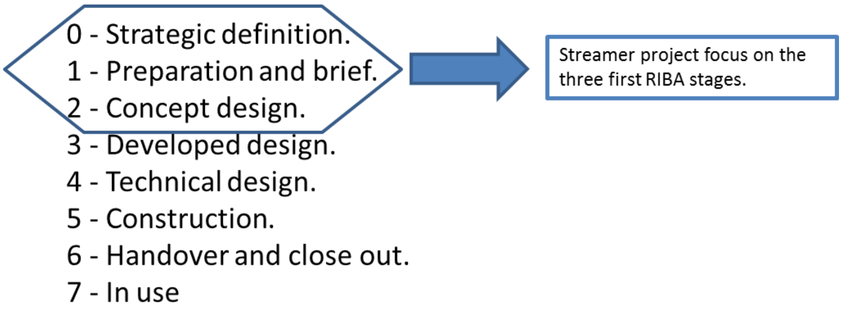

Figure 1: STREAMER project focuses on the three first phases of the building process.

In STREAMER, the focus is on early design. By the use of interoperable data, alternatives of design are created. In connection the RIBA plan of work the three first stages have been adopted: strategic definition, preparation and brief, and concept design, with weight on the concept design stage. In the traditional design process, the Concept Design phase is actually meant to be the stage after the final alternative has been selected. But, in the STREAMER Design Process, detailed designs of the alternatives are performed in the Concept Design phase. Below follows a short description of the three adopted stages:

Strategic definition considers sites, whether to extend, refurbish or build new and the key Project Outcomes, as well as initial considerations for the Project Programme and assembling the project team.

The preparation and brief stage involves:

- Developing an initial project brief. This may include; considering feedback from previous projects, defining overall spatial requirements, carrying out surveys and quantifying the budget.
- Carrying out feasibility studies.
- Undertaking a project risk assessment, including; planning risks, programme and procurement strategy.
- Assembling the project team and defining their roles and responsibilities.

During the **concept design stage**, the design team will develop:

- The design concept.
- Outline specifications.
- Schedules of accommodation.
- A planning strategy.
- The cost plan.
- Procurement options.
- Programme and phasing strategy.
- Buildability and construction logistics.

2. Traditional design process

2.1 Introduction

Starting from the analysis and conclusions developed in the previous WP4 Deliverables, this section offers a brief overview of the traditional design process.

In the last version of the RIBA Plan of Work (2013), consisting of eight stages – from the "Strategic Definition" to the undertaking of the "In Use" services –, the early design activities are those ones described in the first three stages: "0_Strategic Definition", "1_Preparation and Brief", and "2_Concept Design".

Therefore, according to the scope of STREAMER, these three phases – their processes, actors and tools - will be investigated highlighting the way in which they differ when it comes to Healthcare Districts and Energy Efficient Buildings.

In the traditional design process, the tasks implemented in the first phases include the definition and planning for the hospital project focusing on the client's requests, the user's needs, the assessment of the business case, the implementation of feasibility studies, and the creation of the project team that outlines the concept design.

Despite some relevant innovations introduced in the last years – as well as the development of BIM, the strengthening of communication tools between players and stakeholders, the dissemination of the concurrent design methodologies, etc. – some gaps and weaknesses still jeopardize the possibility for the project team to be proactive and effective for achieving a real EeB optimisation.

In particular, in the first phases of the design process, gaps and weaknesses depend among others on:

· a limited availability of tools, information and data for supporting the assessment of the energy efficiency related issues;

· a poor and limited cooperation between the players due to technical information and tools not easily accessible and not consistently provided to the different stakeholders (client, users, professionals and advisors);

· the habit of several players to work on an already detailed design limiting their cooperation and technical contribution in the concept design stage;

· lack of tools and data to evaluate the relationships between the technical/functional/architectural choices and the consequences related to the Quality – Energy – Cost.

In the following sections the traditional outline of the first three phases of the design process will be analysed; beside the theoretical description two demonstration projects, the construction of a new building in the Rijnstate Hospital (NL) and the retrofitting project in the Careggi Healthcare District (I), will be used for explaining the specific actions taken in the three phases.

RNS _ RIJNSTATE HOSPITAL

Rijnstate Hospital is a Teaching Hospital which was opened in 1996 on the site of a former hospital. The current building measures 82,150 m², in an area of approximately 89,000 m². Its total energy consumption is 128.705 GJ/year (425 kWh/m²/year).

The hospital is in need of an expansion of 10,000 m² to incorporate necessary services. With the knowledge that Rijnstate Hospital will need a mid life renovation around the year 2020 and knowing that the hospital will require future expansion, research has been started. In particular, it is investigated how to achieve these ambitions to expand in a most sustainable and cost effective manner, reducing, at the same time, the output of carbon dioxide gasses as much as possible.

A master plan design process has been developed (for the planned extension of 10,000 m²) and parallel to that, the main infrastructure project was initiated. The outcome of the main infrastructure project includes five possible design scenarios. Later on in the process an additional scenario was added. Parallel to this, Rijnstate has stated its ambition to reduce the carbon footprint by 50% in 2020.

The scope of the Rijnstate case study in STREAMER is as follows: the newly developed expansion 'North East' of 5,000 m² (phase one of the above mentioned master plan) was proposed as real case, together with the final design of the MEP systems. At the same time, Rijnstate started to make use of a requirements tool (BriefBuilder® software). Next to the newly built wing, Rijnstate needs to refurbish and expand its Operating Complex, its Intensive Care department and its Mother and Child health care department.

AOC _ CAREGGI HOSPITAL DISTRICT

The refurbishment programme to be undertaken in the "S.Luca Vecchio" aims to satisfy the change of needs and the functional reorganization of the oncological department of the Careggi Health District.

The works concentrate on the re-arrangement of the first floor, currently used as standard wards; a new layout is expected to host the following activities:

- Oncological Day Hospital (Haematology)
- Consultation and examination rooms for haematology and bone marrow transplantation

In addition to the change of lay-out, the refurbishment works include the retrofitting of facades and MEP systems for an improvement of the energy efficiency and the reduction of energy consumption. Facades will be retrofitted with an Exterior Insulation and Finishing System (EIFS) and the installation of new windows. Works on the MEP systems will include the installation of:

- heat pumps to replace the existing split system (including the complete removal of the old heat systems);
- an energy efficient lighting system.

2.2 Strategic Definition

2.2.1 Core objectives

The core objective of this phase, as defined in the RIBA Plan of Work definition (2013), is focused on:

- the definition of the scope of the project;
- the identification of the client's project requirements;
- the assessment of the client's business case.

"Strategic considerations might include considering different sites, whether to extend, refurbish or build new and the key Project Outcomes, as well as initial considerations for the Project Programme and assembling the project team." [RIBA 2013].

2.2.2 Process steps

The process starts with a first assessment of the strategic target of the project that is the base for the **statement of need** where the client's requirements are defined and described in outline.

Planning the construction of new buildings or their retrofitting within a Hospital District this step is focused on:

1. an assessment of how it will contribute to the HD strategy;
2. an analysis of the high level options (such as the combination scenarios/approach for the retrofitting projects described in D1.4);
3. a description of the business need that may result in a project and the assumed budget
4. a outline of the assumed programme
5. an assessment of the life cycle of the project and the potential for future changes

The next step is the **strategic brief** that develops data and information collected and analysed in the statement of need and preliminary business case. The main aim of this step is a first attempt to implement a brief for the project and to describe requirements and significant constraints.

The last steps of this phase, before starting the Preparation and Brief stage, include the **Establishment of the Project Programme** and the **assembling of the Project Team**.

2.2.3 Tools

The tools used in this phase generally include database and/or spreadsheets for scheduling information and requirements related to the statement of needs and to the strategic brief.

2.2.4 Products (milestones)

The milestone and the main product of this phase is the Project Programme that includes documents and technical reports owned by the client.

2.2.5 Stakeholders

Due to their interest, several stakeholders are involved in a project from the first stage.

Since they may not all have the same objectives and they do not use the same tools, it is not quite easy for them to identify, as soon as the project strategy has to be defined, the potential areas of convergent actions and a common platform for communication and consultation. Where the objective is to create the condition for a participatory design process, the tools that allow them to access the information, to properly understand the project and to influence this phase should be provided. In particular, the actions defined in the RIBA task description (Table 1) as “contribute”, “comment” and “feedback” should be properly enhanced.

Table 1: RIBA task description from RIBA ToolBox (2013) – Strategic definition

ROLE	TASK DESCRIPTION
Client and/or Client Advisor	Provide Business Case and other core project requirements and contribute to development of Strategic Brief as required
Project Lead	Collate comments and facilitate workshops to discuss Business Case and develop Strategic Brief with project team members
	Discuss initial considerations for assembling the project team
	Establish Project Programme
	Collate Feedback from previous projects
Lead Designer	Contribute to preparation of Strategic Brief
	Comment on project Programme
	Provide Feedback from previous projects
Architect	Contribute to preparation of Strategic Brief
	Discuss project with appropriate planning authority
	Provide Feedback from previous projects
Building Services Engineer	Contribute to preparation of Strategic Brief
Civil & Structural Engineer	Contribute to preparation of Strategic Brief
Cost Consultant	Contribute Cost Information to preparation of Strategic Brief
Construction Lead	N/A
Contract Administrator	N/A
Health & Safety Advisor	
All additional project roles	Contribute to preparation of Strategic Brief

2.2.6 Demonstration Projects

The following tables explain how the Strategic Definition phase has been implemented and managed in two demonstration projects. The same issues analysed in the previous subchapters (Core objectives, Process steps, Tools, Products/Milestones, Stakeholders) have been used for drawing a picture of the phase development in the real word.

The same tables will be included in the next chapters for highlighting the changes and improvements due to the application of the STREAMER tools.

RNS _ RIJNSTATE HOSPITAL _ Design for new building Expansion of 10,000 m² to incorporate necessary services	
Core objectives	Translate strategic objectives into a masterplan for housing. Defining the scope of the project.
Process steps	Masterplan, PoR, budget, first design, contracting, realization, in use, maintain
Tools	2D tools, Excel, Autocad
Products/Milestones	Masterplan, municipality zoning plan, PoR, early design,
Stakeholders	Municipality, Environment/neighbourhood, End user, Architect, Advisors, Board of Directors

AOC _ CAREGGI HOSPITAL DISTRICT _ Design for Retrofitting project Refurbishment programme of the building "S.Luca Vecchio" for satisfying the change of needs and the functional reorganization of the oncological department of the Careggi Health District.	
Core objectives	The core objectives are those explained in the matrix Scenarios/Approach as S3/A7 condition: SCENARIO S3 CHANGING FOR ADAPTATION Internal reorganization of spaces. The activities of a spatial area/department are partially or completely modified (e.g. operating theatres turned into offices). APPROACH A7 LAYOUT & ENVELOPE & MEP CHANGE Interventions include the change of activities changing the layout and minor retrofitting of envelope and MEP systems, as a consequence of the internal reorganization of spaces and activities, adapting improving their E-F-Q performances.
Process steps	Analysis of the requirements for the reorganization of the oncological department. Analysis of potential mismatch between the functional and technical requirements and the technical and functional characteristics of the existing building. Definition of a Programme of Requirements.
Tools	Basic info are collected from drawings (dwg files of layouts) and technical reports on building and MEP systems and components. SACS provides for all the information about the current use of spaces, specifically: - dimension and position of each room; - activities and personnel hosted in each room; - MEP system, medical equipment and assets of each room; - matching the properties of each room/functional area with the legislation in force (license).
Products/Milestones	Programme of Requirements Eco-fin Programme Evaluation of the project within the AOC General Programme of Interventions
Stakeholders	AOC management board (Client) Health and safety advisor (within AOC and University) AOC technical board (Client) Clinicians

2.3 Preparation and Brief

2.3.1 Core objectives

The RIBA Plan of Work (2013) describes the tasks of this stage as follows: “Develop **Project Objectives**, including **Quality Objectives** and **Project Outcomes**, **Sustainability Aspirations**, **Project Budget**, other parameters or constraints and develop **Initial Project Brief**. Undertake **Feasibility Studies** and review of **Site Information**.”

Therefore it can be said that, within a traditional design process, the core objectives to be reached in this phase include:

- the development of the initial project brief;
- the implementation of feasibility studies;
- the creation of the project team ready for concept design to commence.

2.3.2 Process steps

The development of the preparation and brief stage includes:

- the collection and analysis of the feedback from previous projects;
- the collection of site information
- the development of feasibility studies;
- the assessment of risks;
- the definition of a procurement strategy;
- the definition of overall spatial and technical requirements, carrying out surveys and quantifying the budget;
- the defining of roles, tasks and responsibilities within the project team.

2.3.3 Tools

Database and technical reports, already implemented in the previous stage, are deepened and used for putting the stakeholders in condition for comparing the different options, developing feasibility studies, defining the project strategy.

The development of the Project Brief and the undertaking of feasibility studies by the stakeholders more involved in the design tasks, can require the use CAD software programs, GIS systems and DSSs.

2.3.4 Products (milestones)

Products implemented are directly related to the project brief, the feasibility studies and creation of the project team (i.e. the three core objectives of this stage).

Products are usually presented as technical reports where data and information can be scheduled in a database or spreadsheet format that can be expanded and used to test whether proposals satisfy requirements later in the project.

2.3.5 Stakeholders

The stakeholders involved in this stage and the roles they play are not very different from those described in the previous one.

The client may need to appoint independent client advisers to assist them during this stage, prior to the appointment of the consultant team.

The stakeholders more involved in the design tasks focus their activities in the implementation of the Project Brief. As well as in the previous stage, the availability of proper tools can create the condition for approaching the next steps according the participatory design methodologies

Table 2: RIBA task description from RIBA ToolBox (2013) - Preparation and brief

ROLE	TASK DESCRIPTION
All roles	Provide information for and contribute to contents of Project Execution Plan as required
Client and/or Client Advisor	Contribute to development of Initial Project Brief including Project Objectives, Quality Objectives, Project Outcomes, Sustainability Aspirations, Project Budget and other parameters or constraints
Project Lead	Develop Initial Project Brief with project team including Project Objectives, Quality Objectives, Project Outcomes, Sustainability Aspirations, Project Budget and other parameters or constraints
	Collate comments and facilitate workshops as required to develop Initial Project Brief
	Prepare Project Roles Table and Contractual Tree and continue assembling and appointing project team members
	Prepare Schedule of Services and develop Design Responsibility Matrix including Information Exchanges with lead designer
	Review Project Programme and Feasibility Studies
	Prepare Handover Strategy, Risk Assessments and Project Execution Plan
	Monitor and review progress and performance of project team
Lead Designer	Where required, Contribute to preparation of Initial Project Brief
	Contribute to assembling of project team
	Contribute to preparation of Handover Strategy and Risk Assessments
	Comment on Project Programme
	Monitor and review progress and performance of design team
Architect	Contribute to preparation of Initial Project Brief
	Discuss project with appropriate planning authority
	Undertake Feasibility Studies
	Prepare Site Information report
Building Services Engineer	Contribute to preparation of Initial Project Brief
	Contribute to Site Information report

ROLE	TASK DESCRIPTION
Civil & Structural Engineer	Contribute to preparation of Initial Project Brief
	Contribute to Site Information report
Cost Consultant	Contribute to preparation of Initial Project Brief
	Prepare Project Budget in consultation with client
Construction Lead	N/A
Contract Administrator	N/A
Health & Safety Advisor	
All Additional project roles	Where required, contribute to preparation of Initial Project Brief

2.3.6 Demonstration Projects

The following tables explain how the Preparation and Brief phase has been implemented and managed in two demonstration projects. The same issues analysed in the previous subchapters (Core objectives, Process steps, Tools, Products/Milestones, Stakeholders) have been used for drawing a picture of the phase development in the real word.

The same tables will be included in the next chapters for highlighting the changes and improvements due to the application of the STREAMER tools.

RNS _ RIJNSTATE HOSPITAL _ Design for new building Expansion of 10,000 m2 to incorporate necessary services	
Core objectives	Feasibility study of different models. Choosing 1 model. First Design.
Process steps	Preliminary PoR, preliminary design, budget
Tools	AutoCAD, Sketchup
Products/Milestones	Different models and choice for final model. Technical design. Budget
Stakeholders	Municipality. Environment/neighbourhood, End user, Architect, Advisors, Board of Directors

AOC _ CAREGGI HOSPITAL DISTRICT Refurbishment programme of the building "S.Luca Vecchio" for satisfying the change of needs and the functional reorganization of the oncological department of the Careggi Health District.	
Core objectives	The development of the initial project brief and the implementation of feasibility analysis (evaluation of different options).
Process steps	Development of feasibility analysis. Assessment of risks. Definition of the procurement strategy to be applied. Definition of overall spatial requirements, implementation of surveys and estimation of budget; Definition of roles, tasks and responsibilities within the project team inside the technical department of Careggi (external consultants are not involved)
Tools	Microsoft, Autodesk, Adobe, SACS
Products/Milestones	General descriptive report - 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 - Technical and functional analysis of the project (schemes) - Timing and appraisal - Bureaucratic and administrative sustainability Financial report - Financial feasibility (budget) - Social feasibility (Cost-benefit analysis)
Stakeholders	AOC management board (Client) Health and safety advisor (within AOC and University) AOC technical board (Client) Technical advisor Clinicians

2.4 Concept Design

2.4.1 Core objectives

This stage, as defined in the RIBA Plan of Work (2013), includes the preparation of the "…**Concept Design**, including outline proposals for structural design, building services systems, outline specifications and preliminary **Cost Information** along with relevant **Project Strategies** in accordance with **Design Programme**." and the agreement on the "alterations to brief and issue **Final Project Brief"**.

The Concept Design can be considered the initial response given by the design team to the project brief. Therefore, the definition of a first configuration – including feasibility analysis – of the typological, functional and architectural solution can be considered as the core objectives of this phase.

2.4.2 Process steps

The preparatory actions implemented in the previous phases enable the design process to start working on the "Concept Design" following a sequence of tasks and steps that usually includes:

- the definition of the programme of requirements and outline specifications;
- the definition of a strategy for the project development including a phasing programme, the cost plan, the procurement options and the construction logistics;

- the development of the architectural, structural and service concept design;
- the implementation of the final concept design report (including drawings and technical deliverables) which provides description, specifications and instructions for the development of the preferred option in the next detailed design stages.

2.4.3 Tools

The development of the Concept Design and the undertaking of drawings and technical reports by the design team and the stakeholders involved (client's advisors and consultants) requires, in addition the tools used in the previous tasks, the use of CAD software programs, GIS systems and DSSs.
"Where building information modelling (BIM) is being used, at this stage, the built asset might be represented by massing diagrams or 2D symbols representing generic elements, with some critical elements developed in more detail. The project information model may also include drawings, reports and other structured information directly related to the built asset and its facilities, floors, spaces, zones, systems and components It can also be useful at this stage to generate presentation material such as photo visualisations and 3D walkthroughs that help facilitate employer assessments and consultations with user panels, champions, and other stakeholders." (Designing Buildings Wiki, 2016, "https://www.designingbuildings.co.uk")

2.4.4 Products (milestones)

The implementation of outline proposals provides the main outputs and products of the Concept Design stage. Proposals include the definition of the building shape, the configuration of draft layouts, the basic concepts for structural design and building services systems.
At the end of this stage, the design team provides a set of drawings and technical reports including in particular:
- the implementation of sketches of layouts compatible with the functional and organisational requirements defined in the previous stages (e.g. access and circulation systems, functional relationships between spaces according to users and their activities, external spaces and facilities, etc.);
- the architectural concept design, the schemes and the preliminary calculation of the structural and MEP systems;
- a preliminary analysis of costs related to the different options to be compared and evaluated;
- a Project Execution Plan including the procurement options, a possible phasing strategy, the buildability and construction logistics, the sustainability, maintenance and operational strategy.

2.4.5 Stakeholders

The increasing complexity of the design activities requires a greater need for specialists, consultants and technical advisors. For working effectively as a team the stakeholders should apply, in this stage, collaborative practices.

Table 3: RIBA task description from RIBA ToolBox (2013) - Concept Design

ROLE	TASK DESCRIPTION
All roles	Contribute to Health & Safety Strategy as required
	Provide information for and contribute to contents of Project Execution Plan as required
	Contribute to development of Final Project Brief
Client and/or Client Advisor	Comment on Concept Design proposals as they progress
	Sign-off Concept Design and Final Project Brief
	Comment on Project Strategies as requested
Project Lead	Monitor progress of Concept Design
	Collate and agree changes to the Initial Project Brief and issue Final Project Brief
	Review Handover Strategy and Risk Assessments with project team
	Review and update Project Execution Plan
	Review Project Programme and agree any changes with project team
	Comment on stage Design Programme and Cost Information
	Monitor and review progress and performance of project team
Lead Designer	Comment on design proposals and Project Strategies from design team members
	Prepare Sustainability Strategy and Maintenance and Operational Strategy with input from project team as required
	Prepare stage Design Programme with input from other design team members
	Comment on Cost Information
	Monitor and review progress and performance of design team
Architect	Prepare architectural Concept Design in accordance with the Initial Project Brief, Design Responsibility Matrix incorporating Information Exchanges and Design Programme
	Liaise with planning authorities as required
	Submit Planning Application (stage 3 recommended)
	Undertake third party consultations and any Research and Development aspects as required
	Assist lead designer with preparation of stage Design Programme
	Provide information for preparation of Cost Information and Project Strategies
Building Services Engineer	Prepare Concept Design for building services design in accordance with the Initial Project Brief, Design Responsibility Matrix incorporating Information Exchanges and Design Programme
	Undertake third party consultations as required and any Research and Development aspects
	Assist lead designer with preparation of stage Design Programme
	Provide information for preparation of Cost Information and Project Strategies

ROLE	TASK DESCRIPTION
Civil & Structural Engineer	Prepare Concept Design for structural design in accordance with the Initial Project Brief, Design Responsibility Matrix incorporating Information Exchanges and Design Programme
	Undertake third party consultations as required and any Research and Development aspects
	Assist lead designer with preparation of stage Design Programme
	Provide information for preparation of Cost Information and Project Strategies
Cost Consultant	Prepare preliminary Cost information
	Assist lead designer with preparation of stage Design Programme
Construction Lead	Prepare Construction Strategy
Contract Administrator	N/A
Health & Safety Advisor	Develop Health and Safety Strategy including statutory requirements
All Additional project roles	Liaise with project Lead and lead designer as required
	Provide information as set out in the Design Responsibility Matrix incorporating Information Exchanges in accordance with Design Programme

2.4.6 **Demonstration Projects**

The following tables explain how the Concept Design phase has been implemented and managed in two demonstration projects. The same issues analysed in the previous subchapters (Core objectives, Process steps, Tools, Products/Milestones, Stakeholders) have been used for drawing a picture of the phase development in the real word.

The same tables will be included in the next chapters for highlighting the changes and improvements due to the application of the STREAMER tools.

RNS _ RIJNSTATE HOSPITAL _ Design for new building Expansion of 10,000 m² to incorporate necessary services	
Core objectives	Final design of the extension (5000 m2).
Process steps	Several meetings with stake holders in different settings.
Tools	AutoCAD, Sketchup
Products/Milestones	Final design interior and exterior. Final technical design. Final budget.
Stakeholders	Municipality, Environment/neighbourhood, End user, Architect, Advisors

AOC _ CAREGGI HOSPITAL DISTRICT Refurbishment programme of the building “S.Luca Vecchio” for satisfying the change of needs and the functional reorganization of the oncological department of the Careggi Health District.	
Core objectives	Deepening of feasibility analysis and detailed evaluation of the possible options. Choice of the solution to be developed. In-depth analysis of technical, functional and financial aspects of the chosen solution
Process steps	Development of the concept design.
Tools	Microsoft, Autodesk, Adobe, SACS, Edilclima
Products/Milestones	§ Descriptive report - 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 § Preliminary report on the environmental feasibility - 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 _ Action required by the legislation but not needed in this project) - 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 _ Action required by the legislation but not needed in this project) § Site plan and graphic schemes § Preliminary recommendations related to the health and safety plan § Assessment of the costs § Other reports as seismic risk report, etc. if needed - Description of the requirements the project has to satisfy - Description of the general and specialized works - Table containing the technical elements forming the project
Stakeholders	AOC technical board (Client) Health and safety advisor (within AOC and University) Clinicians and nursing Technical advisor

3. STREAMER process

3.1 Introduction of the STREAMER process

One of the biggest changes of an IPD process in relation with a traditional process is a shift in time of the design process. More effort and resources are used at the beginning of a process where decisions have the biggest impact on time, outcome and resources (see Figure 2).

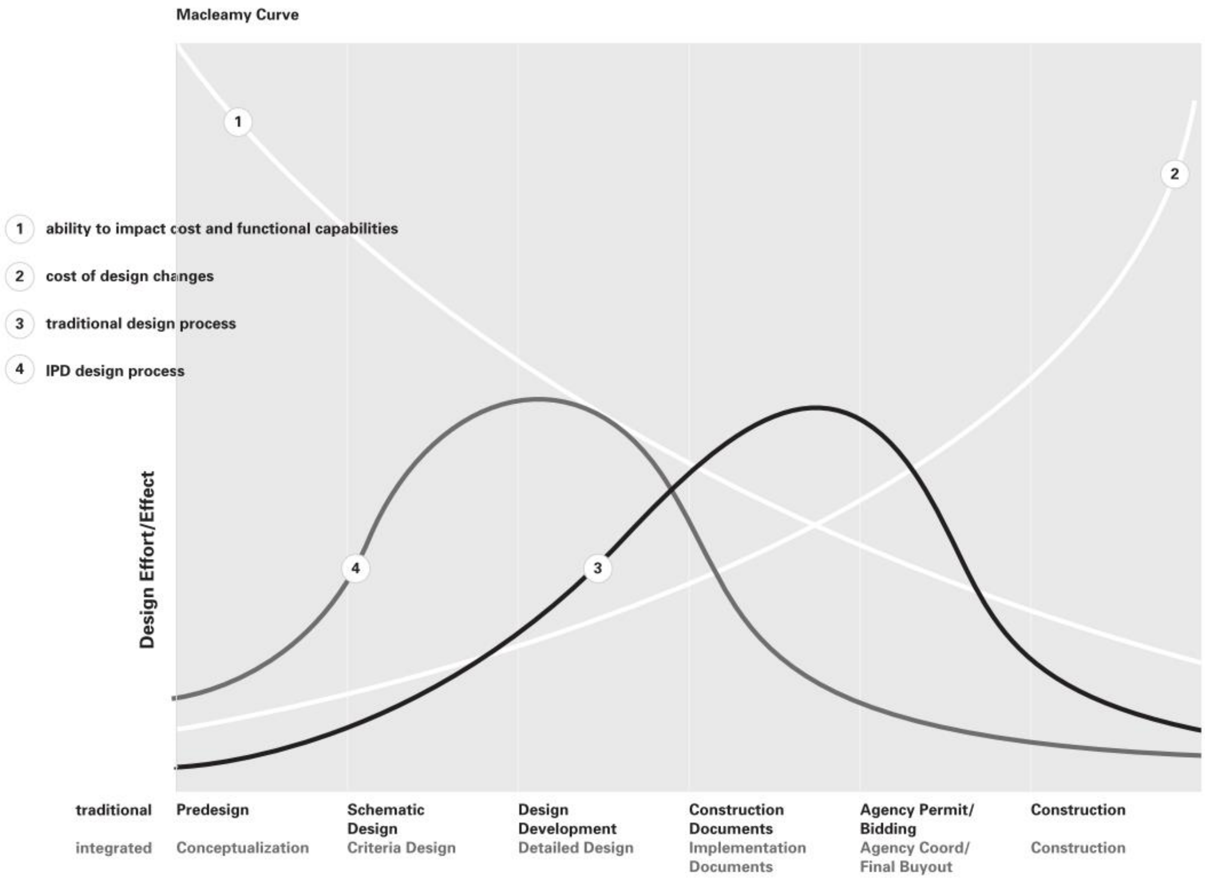

Figure 2: Macleamy Curve defining the design effort and effect over the phases of design and construction (AIA 2007).

To achieve the earlier peak in the design process some sub-processes need to be interlocked. This means some stakeholders in the process need to do their tasks earlier and often in a more collaborative fashion. In a more traditional process the tasks are more separated and the tasks will follow after each other. The interlocking of tasks and thereby roles implies also a change in tools and used technologies.

In the traditional design process 2D drawings were sufficient. These drawings are sent to other stakeholders if a (sub-)task is finished. But with the new interdependencies this is not enough; a civil and construction engineer cannot plan the structure of a project if he or she does not have the latest version of the building form and layout. BIM will help in achieving collaboration between stakeholders by implying one (combined) data source which is continually up-to-date and provides the necessary data for all stakeholders. For more differences between a traditional process and an IPD see Figure 3.

Traditional Project Delivery		Integrated Project Delivery
Fragmented, assembled on "just-as-needed" or "minimum-necessary" basis, strongly hierarchical, controlled	teams	An integrated team entity composed key project stakeholders, assembled early in the process, open, collaborative
Linear, distinct, segregated; knowledge gathered "just-as-needed"; information hoarded; silos of knowledge and expertise	process	Concurrent and multi-level; early contributions of knowledge and expertise; information openly shared; stakeholder trust and respect
Individually managed, transferred to the greatest extent possible	risk	Collectively managed, appropriately shared
Individually pursued; minimum effort for maximum return; (usually) first-cost based	compensation/ reward	Team success tied to project success; value-based
Paper-based, 2 dimensional; analog	communicatitons/ technology	Digitally based, virtual; Building Information Modeling (3, 4 and 5 dimensional)
Encourage unilateral effort; allocate and transfer risk; no sharing	agreements	Encourage, foster, promote and support multi-lateral open sharing and collaboration; risk sharing

Figure 3: Differences between Traditional Project Delivery and Integrated Project Delivery (AIA 2007)

For some stakeholders the process will change drastically. Some stakeholders must start with more general assumptions instead of a detailed design. The shift in time is also a chance to have a bigger impact on the design itself and decreases the chance of adaptations of a plan later on.

To overcome the information-gap for some of the stakeholders, the STREAMER methodology provides tools and information to overcome these gaps. Detailed requirements are caught in STREAMER labels. These labels are generic containers for several requirements on the level of activities. These requirements will be captured in a PoR.

With the support of design rules, the PoR will be translated into layout alternatives with support of the EDC tool. These design rules are relationships between space units or functional areas and determine the layout of a design alternative. The sources for these design rules can derive from different sources and stakeholders:

- Building regulations from architects, engineers, (semi)governmental institutes and advisors;
- Expert knowledge from architects, engineers and advisors;

- Culture preferences, like construction methods from engineers and architects;
- Functional requirements from hospital clients and their advisors;
- Climate preferences from engineers and advisors;
- Best practices from architects, engineers and advisors;
- Functional relationships from hospital clients and their advisors
- Personal preferences from all stakeholders.

Two other inputs for the EDC are the MEP system filter rules and a building shape including a location. The later is an input by creating first a building shape in the EDC with corresponding number of floors. This building is placed on an OpenStreetMap location with correct orientation. The shape and placement of the building will derive from a master plan or a mass study.

The MEP system filter rules are used to define the minimal requirements for generic MEP systems on the level of a room. These generic MEP systems are represented by a label, which can be used to apply a MEP system to a whole wing, storey or building. This larger scale is necessary as MEP systems cannot operate on a room by room level. Consider for instance a heat installation; it is impossible to have one room provided with a system that delivers heat through a water-based system, the next with an air operated system and the next room again with a water-based system. So with aid of the MEP system labels a choice can be made for a certain MEP system for a *group of rooms*.

When all the inputs (i.e. label enriched PoR, building shape and location, design rules and MEP system filter rules) are given the EDC can produce layout alternatives. The automated evolutionary script used by the EDC, will produce thousands of options and will remember the layout which scores the best on the predefined design rules and common restrictions, like the placements of all the rooms, the right dimensional ratios and the right size.

When the user is satisfied, the process can be stopped and exported as an IFC file. This IFC file can be manually checked for inconsistencies by using an IFC viewer with the ability to colour certain attributes, like the labels.

By the use of the colouring filter in an IFC viewer and the use of an overview with assigned MEP system labels, a choice or multiple alternatives can be made for a certain MEP system on a larger scale. By saving different larger options to different files several alternatives can be analysed later.

The several layout alternatives need to be compared through a comprehensive analysis of all the alternatives. For a balanced result, the alternative will be validated on three Key Performance Indicators, the KPIs. The KPIs will be calculated and visualised in the DST (Decision Support Tool). The three indicators were as described before; Quality, Energy and Finance (LCC). The DST features modules to calculate the LCC and the Quality indicators.

The energy KPI will be calculated by an external tool. There are many energy simulation tools, but one is especially adapted to the Early Design stage and for STREAMER; the CEN tool. This tool will simulate very quickly the predicted energy consumption on a room by room level. The tool will use the labels of the rooms as input next to default information where information is not provided for the simulations. For more on the inputs and outputs for Energy calculation, see D5.8. The big advantage of the CEN tool over other energy simulation tools is that it does not require manual inputs or adaptations. So in a situation with many alternatives, the use of the tool will reduce the required man-hours greatly. Next to that the CEN tool will be compliant to the new standard European norm regarding energy simulation (EN-ISO 52016).

The DST can represent the KPIs but also PIs, which are more detailed and precise indicators, for all design alternatives including the different MEP alternatives. With help of an overview the design alternatives can be compared and a choice can be made to continue with one alternative, or to go back to a previous step if the results are dissatisfying. When an alternative or multiple are approved, the IFC model enriched with data from MEP systems and simulation results from the different KPI simulation tools can be loaded into a BIM modelling tool to proceed with the design process. The later model can be validated by the design Validator developed within STREAMER to review the current design with the first requirements. As more detailed information will be available, other simulation tools than the CEN tool can be used as well for simulation energy.

Although not fully developed at the moment, the input for the KPI calculation is in general open source. By using open format data exchange formats, the data can come from any source capable of producing the data type in the needed structure and vocabulary. More on this subject can be found in D5.6.

The whole process is iterative as well as a more traditional process. But the risk of going far back into the design process is far less in a STREAMER process than in a more traditional process (see Figure 4). This is because more information is available simultaneously and by the multi criteria analysis of the design at the same time for all of the three KPIs. New information is a risk because it can mean some assumptions are not compliant with the new information or requirements.

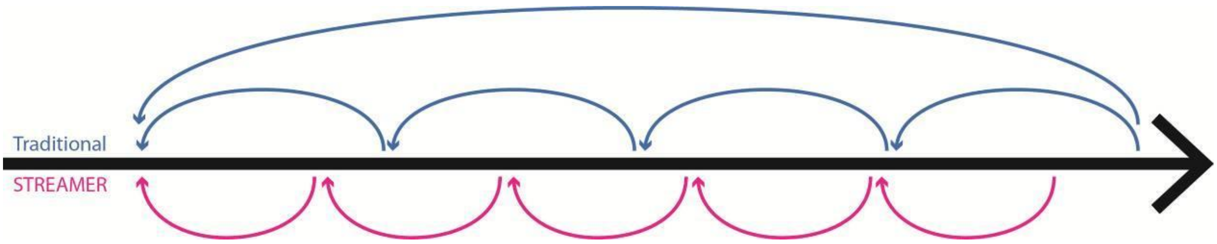

Figure 4: The figure describes the difference between a traditional design process and STREAMER´s, regarding the iterative cycles.

In the next chapters the STREAMER process will be discussed in more detail with the (traditional) RIBA process.

3.2 Strategic Definition

3.2.1 Core objectives

The STREAMER methodology will not change the objectives (Chapter 2.2.1) of this stage. The Methodology can support defining the scope of the project, the client's project requirements and the assessment of the client's business case.

3.2.2 Process Steps

The STREAMER process is essentially a *design process* therefore this non-design stage will not be changed (drastically) through the STREAMER methodology. However the STREAMER methodology could support some of the process steps within this stage.

The process steps of Chapter 2.2.2. are taken and analysed on which aspects they differ in a STREAMER driven process:

1. STREAMER could support the assessment of how a new or retrofitted building contributes to the HD strategy by setting up clear goals in the form of Key Performance Indicators KPIs, the current status can be monitored with the KPIs as well. This will improve the communication regarding the benefits of a new design project.
2. The STREAMER tools and process are applicable for fast alternative generation and making fast KPI analysis on those alternatives. This process can be used to identify and evaluate high level options. For retrofit driven process a scenario/approach matrix is available where the crossing of the two identifies the required workflow, tools and scale of a project.
3. STREAMER focuses on the whole life cycle costs instead of the initial costs which will result in other design decisions and a stronger focus on energy efficient measurements that have a Return On Investments (ROI) that are within the lifespan of the measurements.
4. The outline of the assumed programme can be tested in a proposed building shape through a fast design alternative development in the EDC.

The strategic brief can be described as goals for KPIs and required minimal STREAMER labels for achieving the requirements. The label methodology of STREAMER support the fast development without much ambiguity of the requirements as requirements are bundled and standardised. In a situation with a client is part of a design team, the client should already prepare the Project Brief with the applicable STREAMER typologies and labels. When the process includes a public tender, the design team needs to translate the brief first into the STREAMER required typologies and labels.

Another application of the STREAMER methodology is the reusing of previous data. As the data in the form of typologies and labels is standardised previous projects can be compared and easily reused in new projects.

3.2.3 Tools

Smart Program of Requirement (PoR) tool

Although not STREAMER specific, smart PoR tools like dRofus and Briefbuilder can be enhanced with the STREAMER labels. Previous requirements from other projects can be reused and analysed. Next to that, data collected in a smart PoR can be attached to certain objects like rooms. These rooms will be enriched with more and more information in later stages, thereby reusing the data that was collected during this stage. Output templates will ensure the PoR is useable for the STREAMER methodology.

Label methodology

Classification and labelling method introduce a set of codes and references that allow to identify the spaces through the relations between spatial, functional and energy related features.

The labels will support to reuse data from previous projects, filtering out exceptions and specifics, because these are translated into more generic information containers.

EDC

The EDC can be used to perform feasibility studies on retrofit or new build. Although a generic PoR and design rules are necessary to perform a study. The Decision Support Tool (DST) will be used to validate the different options by comparing the alternatives on KPIs and PIs.

3.2.4 Products (milestones)

Strategic Brief

The Strategic Brief includes the first direction for a project; to continue with a retrofit or a new building for instance. STREAMER tools can be used to do fast feasibility studies on which scenario is preferable. It also includes the first predicted project outcomes, different site considerations and ideas on the project team. For the project programme the first planning is done. For STREAMER it is important that in relation with traditional processes the concept design phase will be more intensive and will cost somewhat more resources. So flexibility in spending resources in the different phases is preferable.

3.2.5 Stakeholders

Table 4: STREAMER Enhanced RIBA task description from RIBA Toolbox [2013] for Strategic Definition Stage

ROLE	Task description from RIBA ToolBox (2013)	STREAMER ALTERATION
All roles		
Client and/or Client Advisor	Provide Business Case and other core project requirements and contribute to development of Strategic Brief as required	The Client has to have knowledge of the label methodology if the client is making use of the labels. The need for action can be substantiated by using the difference between performance and requirements in labels. The consideration of the strategic brief can be substantiated by KPI results of a feasibility study for a certain direction.
Project Lead	Collate comments and facilitate workshops to discuss Business Case and develop Strategic Brief with project team members	Collecting comments and considerations from team members with a smart PoR tool is an option
	Discuss initial considerations for assembling the project team	Consider assembling a team with some experience in the STREAMER methodology

	Establish Project Programme	Consider some flexibility in resources admission for some stages. As a STREAMER process needs more resources in the concept design than in a more traditional process and less for a developed design this could mean other considerations. Especially in a public tender, design teams that will perform a STREAMER process will have a disadvantage as they spend more time and resources in the concept design stage.
	Collate Feedback from previous projects	With use of the smart PoR tool and the label methodology, data from previous projects can be reused in a manageable human-readable way.
ROLE	Task description from RIBA ToolBox (2013)	STREAMER ALTERATION
Lead Designer	Contribute to preparation of Strategic Brief	Expectations regarding the initial project outcomes can be described as KPIs. The Lead Designer has to have knowledge of the label methodology if he/she is making use of the labels. The need for action can be substantiated by using the difference between performance and requirements in labels. The consideration of the strategic brief can be substantiated by KPI results of a feasibility study for a certain direction. Can support to perform feasibility studies for considerations on new build or retrofit.
	Comment on project Programme	Consider some flexibility in resources admission for some stages. As a STREAMER process needs more resources in the concept design than in a more traditional process and less for a developed design this could mean other considerations. Especially in a public tender, design teams that will perform a STREAMER process will have a disadvantage as they spend more time and resources in the concept design stage.
	Provide Feedback from previous projects	With use of the smart PoR tool and the label methodology, data from previous projects can be reused in a manageable human readable way.
Architect	Contribute to preparation of Strategic Brief	An Architect can support considerations for a new build or retrofit by carry out feasibility studies. Initiate collecting requirements and performance through the labels.
	Discuss project with appropriate planning authority	
	Provide Feedback from previous projects	With use of the smart PoR tool and the label methodology, data from previous projects can be reused in a manageable human readable way. Possible also the reuse of design rules when doing a feasibility study.
Building Services Engineer	Contribute to preparation of Strategic Brief	Can provide input for the MEP system assessment and for comfort class and equipment label categories. Can perform the calculation of energy in a feasibility study.
Civil & Structural Engineer	Contribute to preparation of Strategic Brief	Provide input for the construction label classes, especially in a retrofit scenario
Cost Consultant	Contribute Cost Information to preparation of Strategic Brief	Check and provide input for feasibility studies by comparing LCC KPIs.
Construction Lead	N/A	
Contract Administrator	N/A	

Health & Safety Advisor		Provide input for the hygienic and access security label classes
All additional project roles	Contribute to preparation of Strategic Brief	Provide input for identifying the mismatch between requirements and performance through labels.

3.2.6 **Demonstration Projects**

RNS _ RIJNSTATE HOSPITAL _ Design for new building	
Core objectives	Translate strategic objectives into a masterplan for housing. Defining the scope of the project.
Process steps	Masterplan, PoR, budget, first design, contracting, realization, in use, maintain
Tools	2D tools, Excel, AutoCAD
Products/Milestones	Masterplan, municipality zoning plan, PoR, Early Design
Stakeholders	Municipality, Environment/neighbourhood, End User, Architect, Advisors, Board of Directors

AOC _ CAREGGI HOSPITAL DISTRICT _ Design for Retrofitting project Refurbishment programme of the building "S.Luca Vecchio" for satisfying the change of needs and the functional reorganization of the oncological department of the Careggi Health District.	
Core objectives	Within a STREAMER process the core objectives do not change and are those explained in the matrix Scenarios/Approach as S3/A7 condition: SCENARIO S3 CHANGING FOR ADAPTATION Internal reorganization of spaces. The activities of a spatial area/department are partially or completely modified (e.g. operating theatres turned into offices). APPROACH A7 LAYOUT & ENVELOPE & MEP CHANGE Interventions include the change of activities changing the layout and minor retrofitting of envelope and MEP systems, as a consequence of the internal reorganization of spaces and activities, adapting improving their E-F-Q performances.
Process steps	The application of the STREAMER methodology would not change the process steps that remain the same of the traditional process: • analysis of the requirements for the oncological reorganization of the oncological department; • analysis of potential mismatch between the functional and technical requirements and the technical and functional characteristics of the existing building; • definition of a Programme of Requirements.
Tools	Basic info (Labels, MEP systems and components) are included in the BIM model. SACS enhanced with Streamer provides for all the information about the current use of spaces, specifically: • dimension and position of each room; • activities and personnel hosted in each room; • MEP system, medical equipment and assets of each room; • matching the properties of each room/functional area with the legislation in force (license).
Products/Milestones	The application of the STREAMER methodology would not change the products and milestones that remain the same of the traditional process: - programme of Requirements - Eco-fin Programme - evaluation of the project within the AOC General Programme of Interventions

Stakeholders	Also the Stakeholders involved in this phase are the same involved in the traditional process: - AOC management board (Client) - Health and safety advisor (within AOC and University) - AOC technical board (Client) - Technical advisor

3.3 Preparation and Brief

3.3.1 Core objectives

The next stage after the Preparation and Brief (the Concept Design Stage) can be initiated as a STREAMER driven project without the need to change the objectives and even the methods of this stage. In some situations like public tenders the relation between client and design team is not present. So in these cases it is expected the client would still be using the traditional way of preparing an initial project brief and doing feasibility studies.

However using STREAMER tools and methods in this stage could provide input for the client in the development of the initial brief. The Brief can be described in terms of room typologies and labels. This makes the development of a brief more standardised and interchangeable. Another possibility of using STREAMER in this stage is to do feasibility studies with the STREAMER tools and methodology. The fast development of design alternatives by using defaults and expert knowledge in the form of labels and design rules is ideal for testing the objectives according a budget and other restrictions.

3.3.2 Process Steps

This stage is moderately iterative and the precise process steps cannot be determined in a linear structure. In this stage often a chicken or the egg question occurs. Is for instance the size of the requested program determinative for the budget or is the budget determinative for the size of the program? The answer is mostly both; it is a bidirectional relationship between different objectives, stakeholders and factors. Therefore the separate objectives and factors are described here and with them a description on how these can be established with the support of STREAMER tools. The end product will be an initial project brief which is a balanced requirements product.

Quality objectives

By creating fast design alternatives through the EDC, the quality can be checked in the DST. In the DST Quality is one of three KPIs. A fast generated alternative can support to check the Quality objectives in relation to the other three objectives.

Project Outcomes

Other project outcomes include operational aspects and a mixture of subjective and objective criteria. The Quality KPI of STREAMER translates some of the subjective criteria to quantitative measurements. One of key aspects of the Quality KPI is for instance the predicted patient and staff satisfaction. This is based on numerous Evidence Based Design (EBD) researches conducted by TNO. Evidence Based Design can also help to achieve for example a reduction of recovery times of patients. On the requirement side these quality criteria can be captured in the labels and a certain Quality KPI aim.

Sustainability Aspirations

Regarding sustainability, STREAMER will handle the energy aspects of sustainability. For new build designs at least the minimal legal requirements are covered by the STREAMER approach with at least the minimal values captured in the labels and additional objects. But the STREAMER approach is adapted to achieve a higher standard as well. As energy is one of the three KPIs, it is an important factor in the decision making process. With feasibility studies a range or a goal for sustainability can be determined.

Making use of design rules that will improve the energy efficiency is a way to achieve a higher standard in sustainability. Pre-selection of design rules could be a scope of this stage.

Project Budget

Regarding the resources for the design process, it is important to realise that the STREAMER methodology means a shift in resources in relation with a more traditional process. More resources are spent at the early stages of the process.

In the case of a public tender, the client has no direct relations ship with a design team. Several design teams will try to get a contract from the client. This will include design teams that work in a traditional fashion. As STREAMER is currently not the standard the Brief will also be described in a traditional way in the form of a sheet or document.

A design team that uses the STREAMER methodology will need to translate the traditional Brief first into the STREAMER structure and vocabulary. This means the first two stages of the process will be followed as if a traditional process (see line 3 in Figure 5). The design team using STREAMER needs to catch up and put additional effort (see line 5). to come to the ideal IPD process (line 4). For instance the rooms in the traditional Brief need to be put in the required STREAMER structure and vocabulary with additional requirements described as labels.

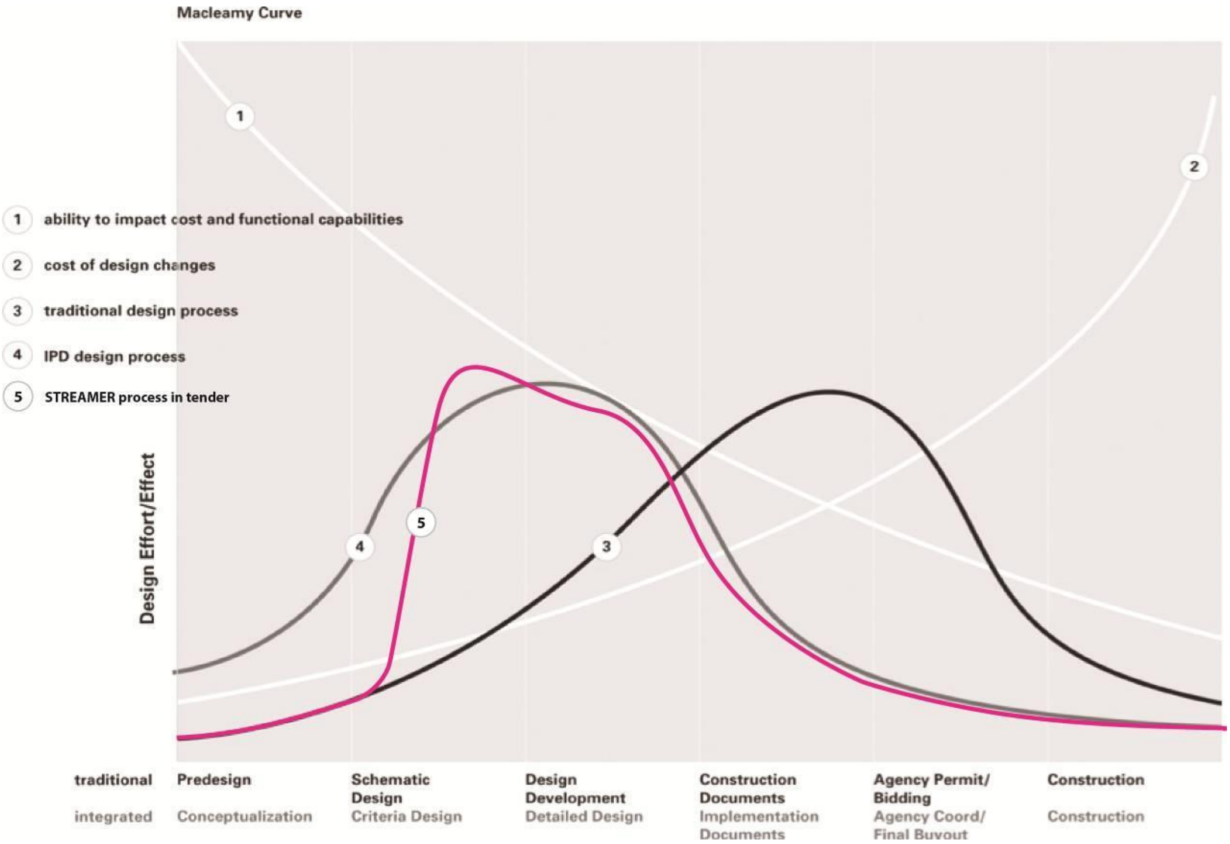

Figure 5: Macleamy curve with projected STREAMER curve in Tender situation (AIA 2007)

Another aspect of the project budget is the cost of the design subject. The fast early design alternative development through the EDC and the validation by the LCC simulation tool support checking the planned budget in relation with other KPIs and the project size.

Feasibility Study

Feasibility studies can be performed to check if certain objectives are realistic given time and budget. But a study can also be performed to check the initial project brief. This can be supported with the help of the STREAMER methodology. By going through the process of make a (generic) PoR, make a (generic) set of design rules, set up a building in the EDC and generate an alternative, one could check if the program fits at the proposed site. If also KPIs analyses have been conducted, the objectives on Quality, Sustainability and Budget can be checked as well.

3.3.3 Tools

Feasibility studies in EDC

See Feasibility studies in chapter 3.3.2.

Smart PoR tool

Smart PoR tools like Briefbuilder or dRofus support the development of the initial Project Brief. A smart PoR tool can have a template for the preparation of a STREAMER ready PoR; with a readable label-enriched PoR for tools. This will lower the impact if a client does not develop it's PoR with support of STREAMER and a design team applying STREAMER have to adapt the PoR to STREAMER standards.

The tool can also be used to reuse label enriched information from other projects or the STREAMER default. The tool will also support fast change management to change requirements for a whole range of rooms as data can be filtered and changed in a more automatic fashion than for instance in a sheet environment.

Label methodology

Labels can be used to capture rapidly different requirements. The labels can be used for the swift development of feasibility studies as well. The labels are generic information containers; multiple requirements are stored in one label. Thus not every separate requirement needs to be defined for each room. This will reduce the time consuming task to define for each function the requirements. A default mapping list is presented of room typologies with labels and FA's with labels in D1.6, which can be used to fill in missing/unbeknownst information. The labels can be reused in other projects and labels from other projects can be reused as well.

Some of the demands in quality, energy and LCC could have their reflection in the chosen requirement labels. The intention of the design should be clear through the labels.

3.3.4 **Products (milestones)**

Initial Project Brief

The initial Project Brief for STREAMER needs ideally to consist of a list of rooms with the following parameters:

- Room Name; A project specific name
- Room Type; The STREAMER room typology
- Amount; Number of occurrences
- Area; The requested floor area
- Functional Area; the STREAMER department typologies
- BouwCollege layer; Typological definition of a hospital in four typologies
- Label requirements; e.g. Hygiene class, Comfort class, Access Security class, Construction class, Equipment class, User Profile class

If the role of the client is more traditional this means the Brief probably will need to be translated by the Design Team first to STREAMER standards. A smart PoR Tool with standard templates will support the translation. The template output should be in a CSV format according the STREAMER structure and needed vocabulary.

Ideally the Quality, Sustainability and Budget are described in a way they are easily translated to KPIs or even *are* KPIs.

Design rules can be a separate file that comes with the brief as the relationship requirements in the Brief. If not, the design team needs to translate the information first into design rules. This information can come from an adjacency matrix, but also on other functional requirements, legal requirements etcetera.

A feasibility study with support of the labels, design rules and EDC is initiated to check the consistency of the different objectives and their relations. This could also mean a master plan for the building shape is determined and incorporated in the brief. This process is iterative and can be validated by performing KPI simulations. If the results are not satisfying the inputs can be adapted and the process can be repeated.

3.3.5 Stakeholders

Table 5: STREAMER Enhanced RIBA task description from RIBA Toolbox [2013] for Preparation and Brief Stage

ROLE	RIBA TASK DESCRIPTION FROM RIBA TOOLBOX [2013]	STREAMER ALTERATION
All roles	Provide information for and contribute to contents of Project Execution Plan as required	A handover strategy and data validation for STREAMER needs to be established. Interdependencies between partners in an IPD are important. This means also a protocol on the to-be-used tools, location and updating of files and agreeing on milestones.
Client and/or Client Advisor	Contribute to development of Initial Project Brief including Project Objectives, Quality Objectives, Project Outcomes, Sustainability Aspirations, Project Budget and other parameters or constraints	Two options: 1: Use STREAMER tools to do fast feasibility studies. Produce a brief in a traditional way. Then the design team needs to translate everything into the STREAMER standard in the Concept Design Stage. 2: Use STREAMER to define the PoR, with labels, KPIs and design rules. In this way the STREAMER default and other project conducted in a STREAMER way can be reused to develop the brief
Project Lead	Develop Initial Project Brief with project team including Project Objectives, Quality Objectives, Project Outcomes, Sustainability Aspirations, Project Budget and other parameters or constraints	Two options: 1: Use STREAMER tools to do fast feasibility studies. Produce a brief in a traditional way. Then the design team needs to translate everything into the STREAMER standard in the Concept Design Stage. 2: Use STREAMER to define the PoR, with labels, KPIs and design rules. In this way the STREAMER default and other project conducted in a STREAMER way can be reused to develop the brief
	Collate comments and facilitate workshops as required to develop Initial Project Brief	Development of Initial Project Brief can also be supported by the use of a Smart PoR tool. Comments and input can be gathered in a central database.
	Prepare Project Roles Table and Contractual Tree and continue assembling and appointing project team members	Consider team members with STREAMER experience. Project Roles table could have some shifts due the STREAMER methodology.
	Prepare Schedule of Services and develop Design Responsibility Matrix including Information Exchanges with lead designer	Flexibility in schedule of services for STREAMER related tasks. Design Responsibility Matrix will not be very different in relation with traditional design processes, but have greater interdependencies and shifts in time.
	Review Project Programme and Feasibility Studies	Consideration of more flexible admission of resources. The STREAMER methodology requires a shift in resources with more attention (and resources) at the early stages of a project in relation to a more traditional process. Feasibility Studies can be reviewed through KPIs analysis.
	Prepare Handover Strategy, Risk Assessments and Project Execution Plan	This part is really different from the traditional process. The Project Execution Plan will be described according the STREAMER process. The Handover Strategy is far more important as all the STREAMER tools and process steps are depending on each other. The Risk Assessment should consider the following for a STREAMER driven process; the greater interdependencies and the shift in time, which is unfamiliar for some parties.
	Monitor and review progress and performance of project team	

ROLE	RIBA TASK DESCRIPTION FROM RIBA TOOLBOX [2013]	STREAMER ALTERATION
Lead Designer	Where required, Contribute to preparation of Initial Project Brief	Give input for labelling, mapping of typologies and by doing feasibility studies with the EDC. Information from previous projects can be reused.
	Contribute to assembling of project team	Consider team members with STREAMER experience or at least experience with BIM. An established relation with other members of the team is advisable; to already know how the corporation with another member will go.
	Contribute to preparation of Handover Strategy and Risk Assessments	Consider the tools that are used within the own daily work and which are required in a STREAMER driven process. Requires a review of own capabilities mainly related to BIM. Risks in exchange and sharing of data have to be mapped as well.
	Comment on Project Programme	Check if there is attention paid in the fact that STREAMER requires a shift in resources in relation with a traditional process.
	Monitor and review progress and performance of design team	
Architect	Contribute to preparation of Initial Project Brief	Give input for labelling, mapping of typologies and by doing feasibility studies with the EDC. Information from previous projects can be reused.
	Discuss project with appropriate planning authority	Feasibility studies with EDC and KPIs results can provide insights for planning authorities.
	Undertake Feasibility Studies	Can be done with the EDC. Using the STREAMER default requirements or data from previous projects. The studies can be evaluated with support of the KPIs.
Building Services Engineer	Contribute to preparation of Initial Project Brief	Give input for Comfort Class and Equipment requirement labels. Give input for MEP system labels and advice on clusters of rooms. Information from previous projects can be reused
Civil & Structural Engineer	Contribute to preparation of Initial Project Brief	Give input for the construction label. Information from previous projects can be reused
Cost Consultant	Contribute to preparation of Initial Project Brief	Provide (design rule) considerations for cost reduction. Establish LCC KPI goals and evaluate feasibility studies.
	Prepare Project Budget in consultation with client	Consider flexibility for Stage budgets and resources as the traditional process and a STREAMER driven process require different budget allocations.
Construction Lead	N/A	
Contract Administrator	N/A	
Health & Safety Advisor		Provide input for the access security and the hygiene labels. Information from previous projects can be reused. Could also give input for clustering of functions for health and safety reasons.
All additional project roles	Where required, contribute to preparation of Initial Project Brief	Consider the use of the labels and KPIs in defining the Initial Project Brief. Or use the STREAMER methodology to produce Feasibility Studies.

3.3.6 Demonstration Projects

RNS _ RIJNSTATE HOSPITAL _ Design for new building	
Core objectives	The core objectives are those explained in the matrix Scenarios/Approach as S3/A7 condition: SCENARIO S5 UPGRADING Internal extension of department, increase of services, upgrade of technologies. Internal extension of services and activities modify substantially the layouts. Interventions include significant changes of envelope and/or MEP for compliance with the requested upgrade. APPROACH A7 LAYOUT & ENVELOPE & MEP CHANGE Interventions include relevant changes of the layout due to reorganization of spaces and services. Changes include the extensions of spaces within the existing buildings (e.g. roof top extensions, covering of internal spaces, partial extension of wings, etc.) and relevant changes and retrofitting of the envelope and MEP systems for improving their E-F-Q performances
Process steps	Using BriefBuilder to capture the demands in the environment. Using STREAMER labels and typologies to prepare a strategic Brief. Masterplan is followed regarding the location and shape of the extension. Using the Early Design Configurator for possible lay outs and LCC calculations.
Tools	Briefbuilder is used to capture the first requirements for the strategic brief. Use of the label methodology to standardise the requirements for the strategic brief. Use of the EDC to do feasibility studies on the Masterplan layout of the proposed requirements. Identify energy goals (and Quality/LCC) taken into consideration the available outputs of STREAMER simulation tools. 3 D Viewer. Revit is used for BIM. Energy simulation tool. RE Suite calculation KPI's.
Products/Milestones	Different models and choice for final model based on simulation and KPI's.
Stakeholders	Municipality, Environment/neighbourhood, End user, Architect, Advisors, Board of Directors, All relevant internal stakeholders.

AOC _ CAREGGI HOSPITAL DISTRICT _ Design for Retrofitting project Refurbishment programme of the building "S.Luca Vecchio" for satisfying the change of needs and the functional reorganization of the oncological department of the Careggi Health District.	
Core objectives	The STREAMER process does not imply changes in the core objectives that include the development of the initial project brief and the implementation of feasibility analysis (evaluation of different options).
Process steps	STREAMER tools support a reliable analysis and comparison of the two possible options: demolition and rebuilding or retrofitting. In any case the process follows the same steps: - development of feasibility analysis; - assessment of risks; - definition of the procurement strategy to be applied; - definition of overall spatial requirements, implementation of surveys and estimation of budget; - definition of roles, tasks and responsibilities within the project team inside the technical department of Careggi (external consultants are not involved).
Tools	Microsoft, Adobe, SACS, Revit, EDC
Products/Milestones	The application of the STREAMER methodology would not determinate relevant changes the products and milestones but the comparison between the different options/scenarios and demolition/rebuilding implemented with the STREAMER tools is included). As well as in the traditional process the main products and milestones are the following. General descriptive report - 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 - Technical and functional analysis of the project (schemes) - Timing and appraisal - Bureaucratic and administrative sustainability Financial report - Financial feasibility (budget) - Social feasibility (Cost-benefit analysis)
Stakeholders	AOC management board (Client) Health and safety advisor (within AOC and University) AOC technical board (Client) included technicians with specific training on STREAMER Technical advisor Clinicians

3.4 Concept Design

3.4.1 Core objectives

A STREAMER driven process will not inflict with the proposed core objectives. A STREAMER driven process will change the way the objectives will be achieved and how they will be represented in relation with a more traditional process. As STREAMER has focused most of its energy to the early design, the concept design stage will have the largest overlap with the STREAMER process. In the next chapter the change in process and in products will be explained.

3.4.2 Process Steps

In D4.4 (Bektas et al. 2013) the concept stage is divided into two sub-stages for the STREAMER process:

- Sub-stage 1: Early Design. Includes the development of layout alternatives by the EDC by applying design rules and a building form to a PoR. These alternatives will be validated through an early KPI analysis on Quality, Energy performance and LCC. A possibility is to enhance the layout alternatives with MEP specific information in generic system comparisons and layouts. In retrofit scenarios a somewhat other process could occur especially in retrofit scenarios where a layout change is not the topic. In such situations the EDC input will be minimal or absent. See D1.4 (Di Guilio and Werensteijn 2016) for other retrofit workflows.

- Sub-stage 2: Concept Design. Takes the considered alternatives into a new iterative design process with the same end products as the RIBA defined stage description.

As stated in chapter 3.2.2 the PoR needs to be in the correct STREAMER format. If the Brief is conducted in a traditional way, the brief need to be translated first into a STREAMER PoR and design rule file.

Another way to come to the shape of the building considering the energy performance as an important aspect is to produce different shapes in the EDC and validate them by KPIs simulation. In the EDC an important decision factor; the compactness ratio will be live displayed for each building shape. So alterations to the shape can have a on the spot impact on the compactness ratio. This is an important ratio for energy efficiency. If a building is more compact, less surface area is required for the floor area. So less finance is needed for the development of the envelope and less energy will be lost through the envelope.

If the building shape is determined, the building will be placed on a geographical location including an orientation. This will fix the context to the later BIM model.

Another input for EDC is the MEP filter rule table. These filter rules will assign generic MEP system labels to rooms according the required properties of the rooms. So every room gets a minimal required generic MEP system. The mapping of MEP system labels occurs according the MEP filter rule table, which can be changed if needed.

The layout generation of the EDC can be started when all inputs are given. The EDC will produce thousands of layouts by an evolutionary algorithm, but will only remember the layout with highest performance at that moment depending on constraints and design rules. Constraints consist of the placements of all the rooms, the right width/depth ratio, the right size of the rooms and the connection of corridors. The EDC will try different corridor typologies but the appropriate corridor typology can also be locked by the user.

Once the user is satisfied with a layout the process can be stopped and the current best scoring alternative can be exported as an IFC file. Between these steps the EDC will automatically generate walls, doors and windows. It is also possible to produce multiple IFC files with different layouts as layout alternatives which can be validated later.

The output of the EDC can be validated by all stakeholders through a coloured visualisation of the project in an IFC viewer. In this way inconsistencies in groups of rooms with homogeneous attributes can be checked and validated. The visualisation together with a MEP table can provide input for a choice on the MEP system.

The required minimal system is attached to the room. But MEP systems don't operate on a room by room scale. The systems mostly operate on larger scales. So the individual requirements need to be translated to an actual choice for a system. Several different choices for MEP systems can be validated as separate alternatives.

All alternatives (i.e. MEP system alternatives, building shape alternatives and layout alternatives) are evaluated by a KPIs analysis. This includes a simulation for Energy, for Quality and for LCC. Both the Quality and the LCC simulation will occur at modules for the Decision Support Tool, where also the outcomes of the energy simulation are collected. The DST can visualise the IFC models of all the alternatives and their KPI scores. So at one place all the alternatives can be compared and considered for further developing. The ultimate decision for continuing with a certain alternatives layout will be done by the client.

The energy simulation can be done with various tools, but one is really adapted to the needs of STREAMER; the CEN tool. This energy simulation tool, which is developed by TNO, simulates energy at a room level according the new EN ISO norms (ISO 2017). The tool is adapted to use the label information provided in the PoR and passed through by the EDC directly to simulate the energy demand. Without the need for conversion or manual adaptation the CEN tool is well adapted to simulate several alternatives, as the tool does not need a manual adaptation.

In this tool also several inputs can be given, for instance the insulation values of the objects generated by the EDC. These factors will have an impact on the other KPIs as well, so the inputs must be captured in the IFC file and after the input is given the other two KPIs need to be simulated. If the other two simulations use the IFC file provided by the EDC directly, the impact of the choices done in the CEN tool will not be taken into account.

After a choice is made for a certain layout to continue with, the sub-stage will end. The IFC file of the choice will be used to continue the design process.

To conclude these are the steps to be taken in a chronological order:

1. Translate PoR to STREAMER structure and vocabulary; output is a CSV file.

Will be done by design team or is already done by the client.

2. Translate relation requirements of the Brief and own experience into design rules; output is an XML file

Will be done by the design team, each responsible for their own knowledge field

3. Confirm MEP filter rules; output is an XML file

Will be done by a Building Service engineer

4. Insert the building shape in the EDC; output is an internal configuration

Will be done by the Architect, studies regarding the shape can also be done by the Architect in relation with a Building Service engineer for envelop advice and a Civil & Structural Engineer for structure advice Can also be an alternative plan

5. Insert the building location and orientation in the EDC, placement on OpenStreetMap

Will be done by the Architect, different orientation can be multiple alternatives

6. Run EDC to generate layout alternatives, output is an IFC file for each alternative.

Run will be controlled by the Architect

7. Coloured visualisation of properties of the model, is done with the IFC file, can be done with the DST or any other IFC viewer (e.g. Solibri, FZK Viewer, Tekla BIMsight)

Will be done by the design team, each checking their own knowledge field

8. Choice for a certain MEP system based on the MEP system requirement labels, output is an IFC model

Will be done by a Building Service Engineer, multiple choices can be stored as separate alternatives

9. Input for other objects in the CEN tool, is stored in an IFC file

Will be done by a Building Service Engineer

10. Simulate the Energy demand in the CEN tool (or with any other energy simulation tool capable of producing an IFC file in the required structure and used vocabulary. Although other like eveBIM-TRNSYS, SBEM and VABI need far more human adaptions before performing a single simulation), output is an IFC file

Will be done by a Building Service Engineer

11. Simulate the LCC and Quality KPI in the DST, output is an IFC file

Can be done by design team (lead designer, project leader) or client (advisors)

12. Show KPIs simulation results in Dashboard, choice for a certain IFC alternative

Ultimate decision with design team in a public tender or the client if he/she is involved

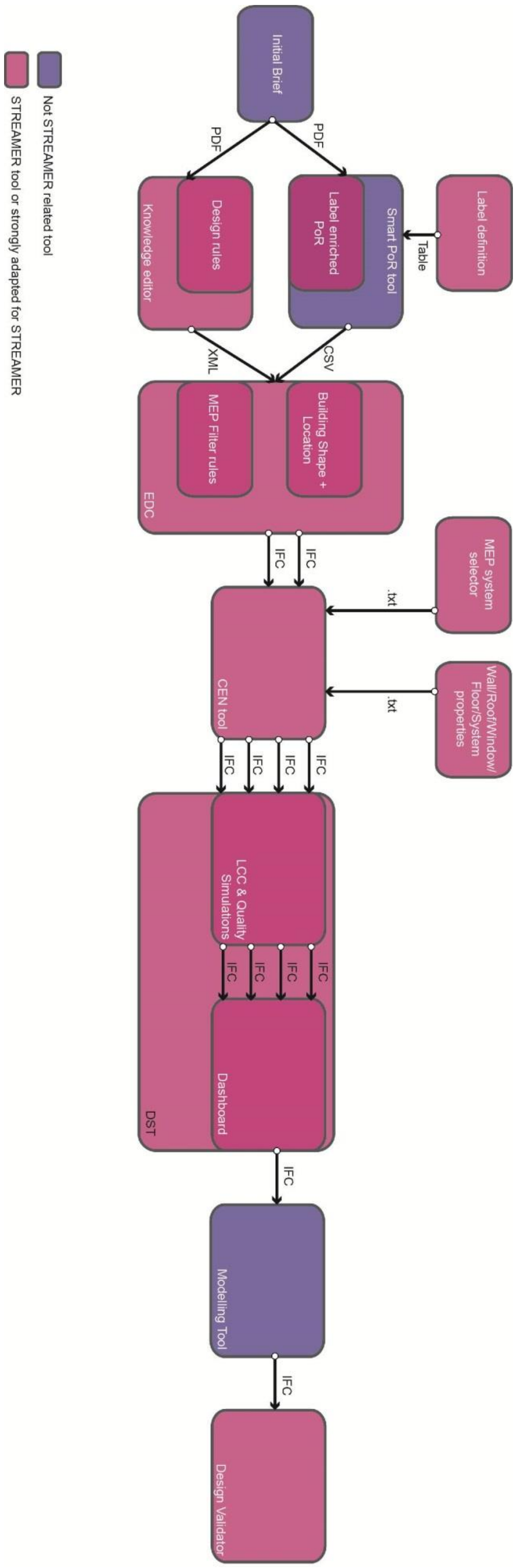

Figure 6 Overview of the STREAMER workflow

Between each step the BIM-Q tool can be used to evaluate the consistency of the data and provided information. This tool will ensure the correct use of the vocabulary and exchange between tools.

The second sub-stage is for developing the IFC of the choice, with the EDC output and the additional CEN tool settings stored, into what is expected at the end of a concept stage. The end product of this stage is the Concept Design. Although the output of sub-stage 1 is comprehensive some aspects need to be developed further. To analyse the work that needs to be done, the different needed outcomes from RIBA are described and compared to the previous mention IFC output.

The concept design described in the RIBA plan of work includes a structural design. The main parts of the structural design regarding the horizontal and vertical traffic spaces are already included in the outcome of the EDC. Also the main distribution of spaces is an output of the EDC. The so called inconsistencies in the distribution of spaces can be identified with the use of a colour filter in an IFC viewer. The inconsistencies can be adapted in a BIM modelling tool (for instance Revit) or the need arises to go back to the EDC to develop a new layout. In either way the structural design will mostly be covered by the EDC.

A second aspect of Concept Design is the building service systems. The MEP requirements and other building service requirements are incorporated in the BIM model by the EDC. Also some choices are made for applying a certain MEP system on a larger scale. Choices are made as well for glazing percentages and insulation values for walls, windows, doors, floors and roofs. So the building service systems aspects are general finished for the Concept Design Stage. One aspect that could be stated in a document is which lighting system will be used, the requirements on the amount of illumination are stated but no choice is made for a certain system.

The Concept design will include Project Strategies. These Project Strategies will include various knowledge fields that need to be addressed:

- Acoustic Strategy;
- Fire engineering Strategy;
- Maintenance and Operational Strategy;
- Sustainability Strategy;
- Construction Strategy;
- Health and Safety Strategy;
- Technology Strategy.

The requirements of the Acoustics are semantically stored in the comfort class label. This will affect the choice of materials and zoning of a building design. The materials are typically not a part of the Concept Design, but an acoustic advisor could provide directive recommendations for achieving the required acoustic quality. The larger acoustic strategies, as for instance zoning should already be part of the design. Acoustic zones can be achieved through applying cluster design rules for rooms with the same comfort class labels.

The Fire Engineering Strategy is also a part that needs to be addressed in the sub-stage 1. The maximum lengths of fire escape routes have an impact on the layout of a building and can be addressed by using design rules. The design should be checked if the maximum lengths are met, otherwise big changes are expected. Other aspects of the fire engineering strategy need to be determined after the output of sub-stage 1. This includes for instance the smoke departments and the fire resistance rates of wall, doors, windows and floors.

The Maintenance and Operational Strategy is not hard coded in the IFC model. Part of the strategy is the costs which are included in the LCC KPI. The use and cleaning of materials is described as requirements by the hygienic class labels. For other aspects this strategy has to be further developed.

The Sustainability Strategy should and can be addressed in the BIM model in sub-stage 1. First of all the clustering of rooms with the same properties can ensure a lower energy demand. This will mean lower energy transfers between rooms and a more tailor made system can be applied. The energy can also be reduced by a compact building. This is an input and a consideration of the EDC. Several layouts and finally MEP systems can be tested and validated on energy aspect, by an energy KPI simulation. In this way the direction of the design can be monitored and measured against the sustainability aspirations.

The Construction Strategy is not really incorporated in the IFC Model. The requirements for construction (height, minimal floor load capacity and minimal floor thickness) are captured in the construction label for each room. The actual floor height of the model is determined according the label requirements for a whole floor (the room with the highest demand will determine the floor height). The grid is input for the EDC as part of defining the building shape. The only consideration left open is the construction method (e.g. steel, concrete, columns and structural walls). This is typically determined in the second sub-stage and could be included in the BIM model by placing generic walls or columns in the model.

The requirements regarding the Health and Safety Strategy are partly stated in the hygienic and access security class labels. To improve the health and safety in a design, design rules can be applied to cluster the rooms with the same properties. In this way the Health and Safety becomes more manageable. The specific demands should be input for the later design stages and be included in the BIM model or stated in a document.

The Technology Strategy for sub-stage 1 is sharply defined by the STREAMER tools and processes. Not many deviations are allowed. In sub-stage 2 the tools that are typically used by most of the stakeholders can also be used here. Only requirement is that the tools can read an IFC file if they provide input for the BIM model. Some STREAMER tools are used in sub-stage 2 as well. The *BIM-Q* tool for instance could help to define the data exchanges. The KPI analyses can be repeated with more information. And the design can be validated by the Design Validator.

The Cost information is processed by the LCC assessment. Next to the KPI output, the module in the DST will provide actual cost information. However, not every country will be supported with accurate numbers, as the key figures are not available. So these will need a local translation.

The Concept Design will provide input for redefining the Initial Project Brief. The Initial Project Brief will be developed into the Final Project Brief. A very useful tool is the, for STREAMER developed, *Design Validator*. The

Design Validator will compare the original requirements with the current model and will notify the differences between them. The differences that need to be addressed can be assigned to specific roles, so the expert can choose to change the design or explain why this change is acceptable. The report with all resolved differences will be input for the Final Project Brief.

3.4.3 Demonstration Projects

RNS _ RIJNSTATE HOSPITAL _ Design for new building	
Core objectives	To present a concept design together with LCC costs.
Process steps	Further develop the design from 'preparation and brief', validation functional specification.
Tools	Revit, Energy simulation, RE Suite KPI calculation
Products/Milestones	Final design
Stakeholders	Municipality, Environment/neighbourhood, End user, Architect, Advisor, Board of Directors, All relevant internal stakeholders.

AOC _ CAREGGI HOSPITAL DISTRICT _ Design for Retrofitting project Refurbishment programme of the building "S.Luca Vecchio" for satisfying the change of needs and the functional reorganization of the oncological department of the Careggi Health District.	
Core objectives	The STREAMER process does not imply changes in the core objectives that include: - deepening of feasibility analysis and detailed evaluation of the possible options. - choice of the solution to be developed. - in-depth analysis of technical, functional and financial aspects of the chosen solution
Process steps	Development of the concept design. NO CHANGES AND ADDITION
Tools	Microsoft, Adobe, SACS, Revit, Design Builder with Energy Plus, CEN tool, EDC (only if the choice is demolition/rebuilding), Dashboard
Products/Milestones	The application of the STREAMER methodology would not change the products and milestones that remain the same of the traditional process: - descriptive report; - technical report; - preliminary report on the environmental feasibility; - (preliminary geological, hydrogeological and archaeological surveys - Action required by the legislation but not needed in this project); - site plan and graphic schemes; - preliminary recommendations related to the health and safety plan; - assessment of the costs; - other reports as seismic risk report, etc. if needed.
Stakeholders	AOC management board (Client) Health and safety advisor (within AOC and University) AOC technical board (Client) included technicians with specific training on STREAMER Technical advisor Clinicians

3.4.4 Tools

Smart PoR

Essentially used to produce a label enriched PoR in CSV format as input for the EDC. BriefBuilder provides templates for the needed output structure to be exported to an Excel format, which in return can be exported as CSV file.

The tool can be used to fast assign labels if not assigned previously through a matrix where the user can assign labels to multiple room typologies at ones.

The initial brief from the preparation and brief stage has to be validated and renewed as the Final Project Brief. A smart PoR tool can support to identify the deviations from the Initial Brief. The tool can compare for instance the labels assigned in the initial brief and compare them to their actual representation in the concept design model. The realised Final Project Brief can be translated to standardised room typologies to be used in other future projects as well.

Label methodology

If the labels are not attached to the PoR in the Preparation and Brief stage, the labels need to be applied to the PoR. A standard default set of labels can support this action, although specific demands from the Initial Project Brief should be considered.

The EDC will use the label properties for relationships, such as clustering of homogenous groups of rooms with a certain label. By the use of the label properties the EDC can generate efficient building layouts (supported by the design rules) in terms of Energy, Costs and Quality.

Knowledge editor

The knowledge editor is used to produce design rules in the desired XML output, which serves as input for the EDC. The knowledge editor forms the links between a human readable language and a computer readable structure. The Design Rules derive from different sources (e.g. Expert knowledge, legalisations, building codes, functional relations, best practices, etc.) and most of the rules can be reused in other projects. Project Specific rules will derive from the Initial Brief or the Client.

EDC

The EDC is the core in most of the STREAMER driven design projects, except for retrofit scenarios that don't include any layout changes. The EDC will be used to fast develop in an automated way design alternatives which can be stored as an IFC file. The design alternatives consider the PoR, the relationships through design rules, the building shape and its location. The PoR is a separate input for the EDC in a specified structure. This also accounts for the design rules. Within the EDC a building shape has to be developed and be placed on an OpenStreetMap.

The EDC will generate thousands of the layouts according the Program of Requirements and the building shape. Together with internal constraints (e.g. room size, placement of rooms, width/depth ratio), the design rules will determine a satisfaction number. This number represents the fulfilment of the constraints and design rules and is used to remember the best scoring layout during the generation of the layout options. The user can stop the generation of layouts at any time and export a satisfying layout as IFC. The export includes walls, floors, roofs, doors, windows, spaces and the geographic location with their appropriate data. The user can support the EDC by locking the applicable corridor layout template of each building block.

CEN tool

The output of the EDC is validated through the use of the CEN tool. Which is an energy simulation tool based on new European norms (i.e. EN-ISO 52016). The tool is capable of processing the IFC output structure of the EDC and to use the labels as input for the energy simulation.

The CEN Tool is done before the other two KPI simulations as the tool does enhance the IFC file with new data which can be used as input for the Quality and LCC simulation.

Quality simulation model

The Quality simulation is done through a module in the DST. The module will use the IFC file to simulate quality aspects of a design.

LCC module

The LCC module of the DST is the tool to simulate the Finance KPI. The IFC file is used as input for the simulation. Mainly the floor area numbers are important figures as the finance figure are now based solely on square meters.

Decision Support Tool

Next to supporting the two KPI simulation tools (i.e. Finance and Quality) the DST also collects all IFC files and their information. With this information, the KPIs are calculated based on key figures of the simulations. This is done for each alternative that is produced in the concept design stage. All the alternatives are under one project and thereby comparable. The KPI results will be displayed on a dashboard for all the alternatives, so the best suitable alternative can be picked for future development.

The DST also includes an IFC viewer, which can be used to validate the design alternatives based on visual 3D representations of the properties of the rooms. In the IFC view, the properties (i.e. labels) of the model can be changed into more suitable values if needed. However changing the properties will need a redo of the simulation process, as the results will differ.

Modelling tool

Once an alternative has acceptable KPI results, the alternative can be imported as IFC file into a modelling tool like Autodesk's Revit. The modelling tool will be used to further develop the IFC model towards the definition of the end product of the Concept Design.

BIM-Q tool

As STREAMER is a tool driven design process and especially in the Concept Design Stage, data management is of utmost importance. The BIM-Q tool ensures the right structure and content of data is used between each step by data validation. Predefined templates check if the data is complete and if the structure is compatible with the tool to be used.

3.4.5 **Products (milestones)**

Concept Design

The Concept Design includes an outline for a structural design, building services systems and specifications. Within STREAMER the Concept Design will include the following objects and specifications:

- Building;
- Geographical location and orientation;
- Floors;
- Roofs;
- Outer walls including glazing, assigned with insulation values and heat capacity;
- Inner walls including doors, assigned with insulation values and heat capacity;
- Corridors;
- Elevators;
- Stairs;
- Fire Escape Stairs;
- Rooms;
- Room requirement labels;
- MEP system requirements;
- Applied MEP system.

Project Strategies

See chapter 3.4.2.

Cost Information

See chapter 3.4.2.

Final Project Brief

Changes from the Initial Project Brief according the concept design are incorporated in the Final Project Brief. Possible deviations are explained and accepted.

3.4.6 Stakeholders

Table 6: STREAMER Enhanced RIBA task description from RIBA Toolbox [2013] for Concept Design stage

ROLE	RIBA TASK DESCRIPTION FROM RIBA TOOLBOX [2013]	STREAMER ALTERATION
All roles	Contribute to Health & Safety Strategy as required	Provide input for Hygienic and Access Security label categories. As well suggestions for clustering rooms according their Hygienic class and Access Security class.
	Provide information for and contribute to contents of Project Execution Plan as required	Data validation through BIM-Q. Need for clear protocols regarding steps and used tools.
	Contribute to development of Final Project Brief	Support the translation of the Initial Brief towards the STREAMER vocabulary. Changes in requirement labels in the Concept Design have to be clarified.
Client and/or Client Advisor	Comment on Concept Design proposals as they progress	Supported commenting through KPIs.
	Sign-off Concept Design and Final Project Brief	In between step of accepting a design alternative after KPI simulation and dashboard.
	Comment on Project Strategies as requested	Check if the required enhancements of the STREAMER model are included.
Project Lead	Monitor progress of Concept Design	Check each step of the STREAMER process. Additional effort in validating translation of a static PoR into the STREAMER vocabulary.
	Collate and agree changes to the Initial Project Brief and issue Final Project Brief	Support translation of static PoR into STREAMER required PoR. Track changes with smart PoR tool by comparing different label requirements and area requirements. Deviations should be clarified in the Final Project Brief.
	Review Handover Strategy and Risk Assessments with project team	BIM-Q can be used to ensure data management. Assessment is needed on experience with STREAMER and access to the STREAMER specific tools. The STREAMER process is largely interlocked and dependable on the input of the stakeholders. So clear agreements have to be made for the deliverance of products and much be held.
	Review and update Project Execution Plan	Data validation through BIM-Q. Need for clear protocols regarding (sub-)steps and used tools.
	Review Project Programme and agree any changes with project team	Provide input for a different allocation of resources; the STREAMER project requires more resources at the concept stage in relation with a more traditional process. Consider team member with (some) experience with STREAMER.
	Comment on stage Design Programme and Cost Information	Provide protocols if sub steps are unsatisfying and a process needs to be repeated. Cost information regarding the building can be managed through the Financial KPI.
	Monitor and review progress and performance of project team	Check if the sub steps are accomplished. Design can be validated through KPIs and Design Validator. Check if the products are delivered on time and are complete.

ROLE	RIBA TASK DESCRIPTION FROM RIBA TOOLBOX [2013]	STREAMER ALTERATION
Lead Designer	Comment on design proposals and Project Strategies from design team members	KPI simulation provides input for design proposal comments together with a visual analysis of room locations and their attributes. Project strategies should be for a large part covered through the use of labels and design rules. Additional strategies that are not included need to be inline with the BIM model and further developed in sub-stage 2.
	Prepare Sustainability Strategy and Maintenance and Operational Strategy with input from project team as required	Sustainability strategy has to be translated into design rules for an efficient layout. Choices for systems and envelop solutions need to be in line with the sustainability goals. Will be validated through the energy KPI. Operational strategy is partly covered through the LCC simulation, but has to be further developed in sub-stage 2.
	Prepare stage Design Programme with input from other design team members	Provide protocols if sub steps are unsatisfying and a process needs to be repeated. Validate the access to tools and experience of team members.
	Comment on Cost Information	Comment on LCC simulation.
	Monitor and review progress and performance of design team	Check the sub steps of the design process. Important milestone is the KPI analysis in the DST at the end of substage 1. In sub-stage 2 deviations from the model from sub-stage 1 have to been monitored.
Architect	Prepare architectural Concept Design in accordance with the Initial Project Brief, Design Responsibility Matrix incorporating Information Exchanges and Design Programme	Support translations of requirements into labels. Support translation of static PoR into a label enrich PoR. Define the building shape in the EDC in one or more alternatives. Generate design alternatives with the EDC. Check and validate the input from other stakeholders regarding the labels and give feedback on those. Give input into and development of the design rules with own expert knowledge. Provide input for the validation of the Quality KPI.
	Liaise with planning authorities as required	Provide input through KPI simulations results, a decision can be supported with the results.
	Submit Planning Application (stage 3 recommended)	
	Undertake third party consultations and any Research and Development aspects as required	Develop feasibility studies with the support of the EDC. Check if there are new developments in the label requirements. Check if new regulations or insights should lead to new design rules. If not experienced with the STREAMER methodology, training should be undertaken.
	Assist lead designer with preparation of stage Design Programme	Provide protocols if sub steps are unsatisfying and a process needs to be repeated. Validate the access to tools and experience of team members.
	Provide information for preparation of Cost Information and Project Strategies	Cost information can be communicated through the LCC KPI. Regarding the Project Strategies: - The architects should support the development of design for creating acoustic zones - The architect should also provide for design rules regarding the fire engineering strategy, mainly maximum walking distances are important - Provide (label) information for suggestions on to be used materials for the Maintenance and Operational Strategy - Provide design rules to improve the energy efficiency for the Sustainability Strategy and provide input for the Energy KPI - Consider building methods and structural engineers advices when developing a building shape in the EDC for the Construction Strategy. Insert representative figures for the thickness of the building envelope. - Provide for design rules that relate to the Health and Safety Strategy.

ROLE	RIBA TASK DESCRIPTION FROM RIBA TOOLBOX [2013]	STREAMER ALTERATION
Building Services Engineer	Prepare Concept Design for building services design in accordance with the Initial Project Brief, Design Responsibility Matrix incorporating Information Exchanges and Design Programme	Support translation of requirements into Comfort Class Labels, Equipment labels and Hygienic labels. Support translation of systems into generic MEP systems. Make a choice on the basis of the filtered MEP systems per room for a certain MEP system on a larger scale. This choice could also lead to several design alternatives that can be validated. Advice on design rules that have a positive impact on the energy efficiency. Compliance to the Design Responsibility Matrix has the highest priority in Sub-Stage 1 of this stage.
	Undertake third party consultations as required and any Research and Development aspects	If not experienced with the STREAMER methodology, training should be undertaken. Check if there are any developments that could influence the labels, their semantic meaning, the typologies and the generic MEP systems.
	Assist lead designer with preparation of stage Design Programme	Provide protocols if sub steps are unsatisfying and a process needs to be repeated. Validate the access to tools and experience of team members.
	Provide information for preparation of Cost Information and Project Strategies	Provide information regarding the cost of the MEP systems. Provide input for the Sustainability Strategies by simulation of the Energy Use and provision of the Energy KPI. Provide suggestions for design rules to improve energy efficiency.
Civil & Structural Engineer	Prepare Concept Design for structural design in accordance with the Initial Project Brief, Design Responsibility Matrix incorporating Information Exchanges and Design Programme	Support translation of requirements to construction labels. Need to have general dimensions for developing a building shape. IFC output of the EDC should be developed further with a general idea of the structure.
	Undertake third party consultations as required and any Research and Development aspects	If not experienced with the STREAMER methodology, training should be undertaken. Check if there are any developments that could influence the labels and their semantic meaning.
	Assist lead designer with preparation of stage Design Programme	Provide protocols if sub steps are unsatisfying and a process needs to be repeated.
	Provide information for preparation of Cost Information and Project Strategies	Provide cost information regarding structural system choices.
Cost Consultant	Prepare preliminary Cost information	Provide input for differentiation of costs for different choices. Provide input for design rules that could improve the cost efficiency. Provide input regarding the validation of the LCC KPI. If possible provide new figures for calculation the LCC.
	Assist lead designer with preparation of stage Design Programme	Provide protocols if sub steps are unsatisfying and a process needs to be repeated.
Construction Lead	Prepare Construction Strategy	Provide input for the building shape and translation of the Construction class labels.
Contract Administrator	N/A	
Health & Safety Advisor	Develop Health and Safety Strategy including statutory requirements	Provide input for the translation of the requirements into Hygienic Class and Access Security class labels. Provide input for design rules that affect the Health and Safety Strategy.
All additional project roles	Liaise with project Lead and lead designer as required	

	Provide information as set out in the Design Responsibility Matrix incorporating Information Exchanges in accordance with Design Programme	Provide input for the translation of the requirements into labels. Provide input to develop design rules. Provide input for the Building Shape. Provide input regarding the validations of the KPIs. Provide input for the final choice on a certain alternative.

4. STREAMER tools and process in construction and operation

The information generated in the STREAMER process by the STREAMER tools can be stored in the form of BIM-compliant database and thereby useful for several FM practices, like closeout and commissioning, energy management, space management, quality control and assurance, maintenance and repair. In the following sections, a review of the use of STREAMER tools and process in the construction phase and during operation is given.

4.1 Use of STREAMER tools and processes in the construction phase

The design, development, and construction of energy efficient healthcare districts rely on a variety of tools developed and integrated in the STREAMER project. As healthcare projects continue to grow in size and complexity, information management and integration become an imperative. Building Information Modelling (BIM) is one method that has been growing in popularity among architects, engineers, and contractors. Because of the cost and complexity inherent in healthcare projects, BIM tools and methods are an effective platform to aid both their design and construction. Today, the use of BIM as an asset for coordination and updating during the design phase is generally supported by all organisations.

BIM can be an efficient quality control tool in order to save time during construction. The use of computers on the job site, instead of rolls of drawings, allows quick and easy access to the most recent documents and sometimes the 3D model. Tablets and smart phones can also be used to access data. The rise in pre-fabrication in healthcare design can also benefit from BIM. If the original design and layout is made in BIM the model can be used as a quality control and for faster decision making due to unforeseen obstacles in the construction process.

Development of Health care districts requires coordination with public agencies and private health care owners. The strict requirements for healthcare facility documentation make a strong case for the use of BIM in its ability to aid in coordination and to produce clear document for interactions and handover. While there’s a trend toward specifying less on initial design documentation and relying more on contractors, suppliers, and manufacturers to supply this later in the construction process, it could be a future requirement that information models must entirely describe the building.

The proposed STREAMER process integrates different stakeholders into the design and construction process. An important input is when surgeons and other professionals are surveyed for their opinions and input on room layouts, operations, and work flow. Adding BIM processes to a project can help all of the parties recognize points of conflict during refurbishing projects as well as new constructions. In addition, hospitals accommodate a vast amount of tools and instruments and BIM can be used to place all of these directly into the model for visualization and inventory.

4.2 Use of STREAMER tools and processes during operation

The In-use costs are normally considered to take up around 60% of total cost of the construction and the activities in this phase are largely related to the planned maintenance and the more expensive reactive repair. The cost differences between planned maintenance and reactive repair can be up to four times, thus the cost as a driving force for planned maintenance is self-describing. In order to plan maintenance, a database over the as-built information as well as a catalogue of the components of the facility that are maintained are relevant. In the STREAMER approach, this **information storage** is developed already during the early stages of design; by a process that includes the facility managers' needs.

In order to make cost effective maintenance decisions, store and manage design and construction information –in any kind of information model suitable for maintenance activities, including historical information of repair and maintenance activities – are crucial for several areas of application: building component information, real time data, visualisation, maintainability, digital assets management, energy, emergence and space management. In the following sections, an overview of areas of application is presented.

4.2.1 Suggested areas of application

Building component information: A main activity for the facility manager is to locate MEP system components and other building components that need to be accessed for maintenance. Common examples of systems that need attention are equipment like HVAC system and electrical, gas and water lines. This kind of equipment is nearly always hidden behind false ceilings or walls and locating these can be an onerous problem creating cost ineffectiveness. Researchers at University of Florida have questioned the functionalities provided by the current BIM-based FM software companies those actually required by FM professionals in a study of what data is required by FM professionals in the operation and maintenance (OM) phases of facilities (Liu & Issa 2013). They found by making a survey that maintainability considerations should be taken into consideration during the facility design phase. The result also showed what information that is needed for reparation of equipment. Figure 7 presents this result.
In addition to the listed information, the respondents asked for more information, such as connectivity and affected spaces for the out-of-service equipment, geospatial link from the element to the model, date of installation and warranty information, and repair history should be available for equipment repair work.

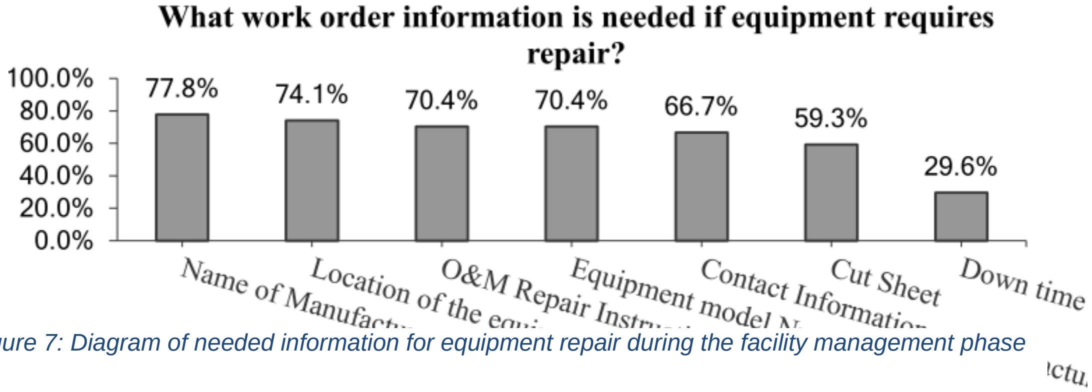

Figure 7: Diagram of needed information for equipment repair during the facility management phase

In the STREAMER design process an information system holds information about the facility and the design criteria, such as need of space, logistics, energy usage, etc. This system is also suitable for storing information needed for repair of equipment as it is based on common used BIM standards.

Visualisation at refurbishment and relocating of work stations: The use of building information models in the FM phase can help managers to visualise, discuss and make decisions about the consequences of larger refurbishment as well as smaller work, such as relocation of workstations. For larger refurbishment, the consequences of construction methods on important areas with high density of health care activities can be visualised. An information model can help planning and training construction personnel of the impact their presence has on the health care activities and the health care personnel can be visually informed of the construction work. The increase in possibilities to give information and discuss consequences decreases the conflicts during the intervention. By studying two healthcare related projects which implemented BIM in the programming phase, the benefits and challenges from the process used, and the results found were assessed. The study identified challenges such as data transfer bottlenecks and apprehension due to a lack of knowledge of parametric tools in general, and benefits such as visualization, time saved relative to concept updates, and quantity take-offs (Manning & Messner 2008). The major benefits sighted were:

- Instant 3D visualization of spaces and alternatives that could quickly be evaluated by technical and non-technical staff alike;
- Sections, perspectives, plan views and quantity take offs could quickly (in many cases automatically) be updated to effectively ascertain potential costs;
- The parametric attributes allowed programming information to quickly be compiled for comparison to original authorization documents with a high degree of confidence in its accuracy. These comparisons under non-parametric design tools were largely assumed and only spot checked due to amount of time involved relative to updates.

To help facility management to visualise, discuss and make decisions, STREAMER has developed the decision support tool – called the Dashboard. With the dashboard, alternatives can be discussed, alternated and a basis for decision can be presented for a multitude of stakeholders.

Need for information for facility management personnel: Facility management requires that personnel can access a great quantity of information while performing their tasks. This information is often stored in different databases and requires different software to be accessed. A study of two scenarios of maintenance activities rendered an overview of the needed information and where this information resides, Figure 8 (Becerik-Gerber et al. 2012).

	Information needed		
FM information systems	Computerized maintenance management system (CMMS)	Electronic document management system (EDMS)	Building automation system (BAS)
Troubleshooting broken equipment	■ Open work orders for the equipment, ■ Work order history, subcomponent information, and ■ Test and balance information	■ Operation and maintenance manuals, warranty ■ Start-up reports, ■ Functional test reports, Location of the equipment, ■ Occupancy information and schedule, ■ Design schedule information, ■ Design narrative briefly describing the system, and ■ 3D view showing major components and distribution only	■ Areas served by the equipment, ■ Sensor information, verify set points, ■ Compare design versus start-up versus actual data ■ Reference points for data for verification, ■ Sequence of operations, ■ Network analysis on distribution system, and ■ Various points for troubleshooting
Customer uncomfortable with room temperature	■ Open work orders for room/zone/floor/building, and ■ Work order history for hot/cold calls	■ Location of the variable air volume (VAV) box of that zone, and ■ Location of thermostat	■ Room sensor information, room to zone coordination, ■ Zone serviced by various equipment, and ■ Toggle back and forth between VAV and AHU readings/controls

Figure 8: Potential information needs of FM personnel (Becerik-Gerber et al. 2012). Marked are the information generated by STREAMER tools.

Data updating and creation: It has been pointed out (Becerik-Gerber et al. 2012) that information management throughout the design and construction stages including the stakeholders interest provide an opportunity for owners of heath care buildings to capture and digitalize these assets as soon as the project has been delivered. To this could be added, through a STREAMER Integrated Project Delivery process, that the equipment manufacturers and vendors should provide equipment with associated databases that can be interpreted by the common information system. Examples of identified (Becerik-Gerber et al. 2012) assets that should be stored in the information system are

- Equipment and systems: HVAC, plumbing, electrical, fire/life safety, specialty equipment, building sensor networks, and net- working systems;
- Data: manufacturer/vendor information (i.e., serial, model, and part numbers), location information (i.e., building, floor, room, and zone where the equipment is located), description (i.e., type, asset number, equipment group, criticality, and status), and at- tributes (i.e., weight, power, energy consumption),
- Documents: specifications, warranties, operation and maintenance manuals, manufacturer instructions, certificates, and test reports.

Space management: Space is connected to cost and thus an effective space management is of great importance. The STREAMER tool Early Design Configurator takes into account space and logistic aspects. However, the optimised use of the space is part of the facility management and not directly considered in the early design, but based on the information generated in the early design facility management can forecast space requirements, assign space, and streamline a move process. And in the information system the facility management personnel can input required extra information such as attributes of each space (space numbers, descriptions, boundaries, areas, volume, intended use, and actual status (Becerik-Gerber et al. 2012).

Monitoring the space usage and storing this information can be used as an input for the STREAMER Early Design Configurator in the future. For example the information of space use can be used for influencing the decision by establishing new design rules and/or the need for new labels for new functional areas.

Energy management: There are some 15,000 hospitals in the EU responsible for at least 5% of the annual EU carbon emission (~ 250 million tonnes). Healthcare accounts for nearly 10% of EU's GDP, and hospitals can take up to 60% of a country's health expenditure[1]. State-of-the-art energy efficient building technologies are available, but they can only function optimally if well-integrated in the facility management of these buildings. The use of STREAMER tools in the "In Use phase" is one way to manage the energy. By assessing and evaluating interventions such as refurbishments and minor renovation work or the change of equipment and use of the space enables the facility manager to have control over the energy use and to optimise it. The different STREAMER energy assessment strategies are suitable for this work as well as the decision support tool for evaluating the alternatives.

4.2.2 Definition of data requirements for the requirements of BIM-enabled facilities management

In order to achieve a qualitative usage of the STREAMER tools and process, as discussed in the previous chapter, the data must be defined in an appropriate way so that the requirements of BIM-enabled facility management are met. Researchers from USA categorized the requirements for data into two types: geometric and non-geometric (Becerik-Gerber et al. 2012) and concluded on the following requirements:

- Geometrical data
  - Accurate as-built models of all building components, including architectural, structural, mechanical, electrical, plumbing, and fire protection systems, and site plan including safety accesses;
  - Accurate as-built model for main utility lines to the buildings;
  - Accurate telecommunication representations, including proper placing and annotation of outlets;
  - Labeled, annotated, and colored spaces according to FM guidelines, which should include standards for space type, description, space usage, and so on;
  - Built-in schedules in the model; and
  - Logical object tree organization to manage the various components within the model;
  - Accurate clearance requirements for mechanical, electrical, and plumbing (MEP) equipment to provide maintainability based on technical specifications.
- Non-geometric data:

[1] WHO and European Hospital and Healthcare Federation, 2012 statistics

- manufacturing data,
- operational instructions and procedures,
- spare parts and maintenance specifications,
- warranty information,
- sensor data, and
- maintenance history.

4.3 Information/tool update and maintenance

The STREAMER information databases and tools need to be maintained and updated as new knowledge is introduced and tools are updated. In the following sections update and maintenance aspects of STREAMER databases and tools are listed. This has little to do with a project process but with the STREAMER methodology itself. It applies for all the tools and databases used within STREAMER.

4.3.1 Databases

The **Label List** with the label classes, their values and semantic knowledge should reflect the current standards. Due changes in demands, regulations or insights the labels should be updated and maintained. Because the labels are used through a bunch of tools (e.g. EDC, CEN Tool, PoR, Knowledge editor, DST) the database should be maintained centrally to provide for the interoperability of the database.

Design Rules in itself are not a database, the database of design rules will be a product of a user of the design rules. The user will collect design rules from different sources. The user should consider the change of regulations to be adapted to the applicable design rules; otherwise a false safety feeling will occur during a design process. Mainly for architectural firms it is important to have an up-to-date database of design rules with the latest findings in Evidence Based Design (EBD) to have a market advantage.

As is the case with the label list, the **Room Typologies List** should be maintained in a central file as multiple tools will use the room typologies as input to work. New developments in the healthcare sector could lead to new concepts which need new typologies or adapted typologies. Consider the shift from multi-bed patient rooms towards single bed patient rooms. These changes need a central organised database to have the same impact and meaning for all of the tools and make the STREAMER methodology comparable for each project. Defaults lists with labels could be provided and monitored for a better mapping of the typologies and labels.

The current status of STREAMER is that the **Functional Area typology lists** are not treated as objects but as attributes of rooms. In that way the typologies can be treated in the same way as labels. If in the future the FAs are seen as objects in themselves the tools need a significant update to handle with the new reality. When the FAs are objects, the FA typology list should be treated in the same way as the Room typology list.

The **MEP systems list** is made out of generic systems translated into labels with global parameters such as energy efficiency ratios. The MEP system labels are assigned in the EDC to rooms, chosen for a larger scale with support of the MEP selector and used for the simulation of the Energy usage of the design for one or more alternatives. The system labels are thus used by multiple tools and should be managed centrally to comply with this interoperability. New technologies could mean adjusted figures for the labels or a whole new label to represent a new technology.

In the first place the **Building Envelope List** is an input in the CEN tool, the EDC produces only a wall/roof/floor with a certain thickness and not with additional parameters such as thermal heat capacity and insulation values. These attributes are input in the EDC and it is not certain that they will influence other tools as well, such as the LCC simulation tool. Until there are other applications for the envelope attributes than energy simulation, the building envelope solutions can be managed locally for the CEN tool. Often an energy advisor is aware of the needed standards for insulation values for instance.

As with the building envelope solutions (**Windows, Floors, Walls, Doors, Roofs)** the windows are generated by the EDC with dimensions and have some attributes that need to be assigned to the window objects for the use of the energy simulation. As up to now, the attributes are only used for the energy simulation and are only assigned by the CEN tool and thus are in no need for a central organised file or list.

The **stairs and elevators** is an object normally not included in a PoR but which is planned to be generated in the EDC. However, the amount of stairs, the size of the stairs and its attributes have to be incorporated in the IFC output of the EDC. Therefore default values have to be incorporated in the EDC. So new developments of the stairs (e.g. dimensional, fire regulations etc) have to be part of the EDC, in the appearance of an update for instance. Or the stairs and its attributes have to be manually set in the EDC, so the user has more control on the output.

4.3.2 Tools

The **Smart PoR Tool** (e.g. BriefBuilder, dRofus) need a regular maintenance regarding the labels, typologies, default lists and output template(s). Especially for the EDC and the KPI simulations the latest databases are required. This could be part of an update for the software but could be an external file that needs to be updated or read from an online source, so every tool uses the same assumptions and starting points. If the required structure of the EDC changes the output template of the Smart PoR tool need to change as well.

The **Knowledge Editor** uses the latest versions of the Room typologies, Functional Area typologies and labels to relate to. The structure of the design rules output and the spatial relationships can change as well and should be maintained. The BIM-Q tool could check if there are any labels or typologies used in the output that are not compliant with the latest status. The output structure could be checked as well but are essentially part of the maintenance of the Knowledge Editor.

The **Early Design Configurator** is the spine of the STREAMER workflow for new buildings and relates to almost all databases and inputs. The Room typologies, the FA typologies, the labels, the spaces that are not part of the PoR and their attributes, the MEP filter rules and the design rules are all input for the EDC. If something changes for one of the databases it will probably affect the whole design process. Ideally the databases are stored in an online source so every time a change occurs; the software tool just loads the latest version. However, this change is not appropriate during a design process, because the database changes will mean different interpretations within the same process. So an alternative could be that the databases are external files stored locally that need to be updated for every new design trajectory.

The **Decision Support tool** itself only uses the outcomes of the simulation tools to display the different scores on KPIs for design alternatives. The scores based on the simulation have a certain weighing factor to recalculate those figures to an indicative number for a KPI. For instance the energy simulation results of a certain energy use in kWh will be recalculated as a score from 1 to 10. These recalculations can be manually set for each project, but could also benefit from a more suggestive approach, by providing defaults. The DST will not use labels, typologies etcetera directly only through integrated modules. That implies that the DST does not require regular maintenance or an external database in relation with new developments within the STREAMER databases.

The **Quality KPI simulation tool** is an integrated module within the DST. Based on a model of TNO the Quality simulation tool uses among others room typologies and labels of an IFC file to simulate a Quality outcome. Therefore the tool needs the latest databases regarding the labels and the typologies to perform a simulation. New developments in EBD need to be translated to the Quality simulation in relation with the established STREAMER databases. As with the EDC, the best option is that the databases are stored in an external file which can be updated on a project base.

The same applies for the **LCC simulation tool** as for the Quality simulation tool. Both are modules for the DST and both use a TNO model to simulate the results. The current version of the LCC module only uses the area (square meters), which does not require a STREAMER specific database. The figures can be part of regular maintenance of the module itself and possibly differentiated for other countries as it is now based on Dutch figures. However, if the future the LCC module differentiates on for example labels, it needs an external database as well.

New developments in MEP systems (e.g. whole new generic MEP systems or improved or decreased efficiency scores) need a translation into the database of the MEP systems. Whereby the EDC will filter the MEP labels on a room level, the **MEP selector** will apply one system over a larger scale and the CEN tool will simulate the energy use with support of the applied MEP systems. So in general only the applicable MEP system labels are required as an input for the MEP systems, which is a list of 12 labels at the moment. So the labels can be checked manually as a database.

The **CEN tool** uses the semantic information *behind* the labels and MEP system labels to perform an energy calculation. Therefore it needs to use the databases that are used in a project. It is recommended to store these databases in a separate file so the right information on a project base can be selected.

Other simulation tools like Vabi and Energy+ have the option to integrate the databases of STREAMER into a native database or map the information *behind* the labels into useable parameter (in some situations with support of an external mapping tool). This means that keeping the databases up to date is a time intensive endeavour and has a high human error risk. At the moment the appliance of an external file to use as a database seems to be out of the picture.

To proceed with STREAMER or to produce an existing situation **other modelling tools** such as Revit and ArchiCAD are used as well. When producing an existing situation all inputs, except the design rules, of the EDC need to be applied (i.e. labels, room typologies, FA typologies and MEP system labels). In a retrofit situation the model of the existing situation is probably the starting point. This means the latest version of all the databases need to be applied in the modelling tool.

The **Design Validator** will use all above mentioned databases to validate the design. Therefore it needs the databases that were used during the design process; or the latest version to check if the design is compliant with the new databases. Therefore it is recommended to use databases in external files to manually control the used databases.

5. Conclusions

The ambition of the STREAMER project is to develop a participatory semantic-driven design. The report consists of three main parts: a description of the traditional design strategy and the task of the active parties and how STREAMER tools interact with the design process of that strategy. Then the STREAMER design strategy is described focusing on how the digital information process is weaved together with the state-of-the-art participatory delivery processes. The description is made by addressing six different areas of the strategy:

- Core objectives
- Process steps
- Tools
- Products
- Stakeholders
- Demonstrations

These six areas are defined in the scope of pre-design and design phases chosen from the RIBA platform: Strategic definition, Preparation and Brief, and Concept design. With this overview, a basis is given for how the STREAMER strategy can be used in order to transform the design effort to earlier stages of the project and thereby gain the cost and time effects reported in literature.

The main result from this work is presented in Chapter 3. For each of the three phases addressed, a STREAMER alteration of the roles of the participants is presented. The alteration refers to the task description of the roles in the traditional design strategy presented in Chapter 2. This explanation of need for transformation of the roles, from the traditional to the STREAMER design strategy, identifies the obstacles that each party of the construction sector need to overcome in order to reach a participatory semantic-driven design.

This work also presents the potential use of STREAMER tools and process in the Construction and In-use phases. It is concluded that using Building Information Modeling – a higher level of information management – aids the coordination and makes it possible to produce clear document for interactions during the “Construction” and “In-use” phases. In addition, the higher level of information is an efficient quality control tool. Several other areas have been suggested for potential areas of application during the In-use phase:

- Energy management
    - Assessing and evaluating interventions such as refurbishments and minor renovation work or the change of equipment and use of the space, enables the facility manager to have control over the energy use and to optimise it. The different STREAMER energy assessment strategies are suitable for this work as well as the decision support tool for evaluating the alternatives.
- Space management
    - Based on the information generated in the STREAMER design approach, facility management can forecast space requirements, assign space, and streamline a move process.
- Data updating and creation
    - Building Information Modeling gives the opportunity to owners of heath care buildings to capture and digitalize these assets during the STREAMER design process

- Visualization at refurbishment and relocating of working stations
  - The STREAMER generated Building Information Models help facility managers to visualize, discuss and make decisions about the consequences of larger refurbishment as well as smaller work, such as relocation of workstation
- Building component information
  - Additional component information facilitates the location activities in a complex MEP system and other building components that need to be accessed for maintenance. The STREAMER design strategy has the potential to add this information in the design phase.

In order to overcome technical, organisational and cultural hindrances, the STREAMER design strategy as explained in this report is essential. The soft parameters – organisational and cultural hindrances – were studied and elaborated in the STREAMER Deliverable D4.5, (Rempling, 2016). The conclusion from that work was that an IPD enhanced STREAMER design strategy is not yet ideal for Europe. The main reason for this is that the autonomous states of Europe have to a large extent very different working traditions in the early phases of design. In addition, the local procurement laws of the EU states are still divergent. Though, within the construction sector there is a strive for increasing the number of participatory design projects – a strive that makes contracts that ensure collaboration necessary, it is not appropriate to point out that Integrated Project Delivery implemented on an EU level is the main path to follow contractually. However, the core elements of IPD, collaboration, early involvement of parties, sharing of risk and reward, and the use of ICT, are important for the construction of energy efficient health care districts and should be pursued. The main advantages of applying these core elements are better products and quality.
The relationship between the technical and the soft parameters is the main conclusion of Chapter 3. In order to visualise this relation, the design stages in focus in the STREAMER process are visualised together with the tools and their connections in Figure 9.

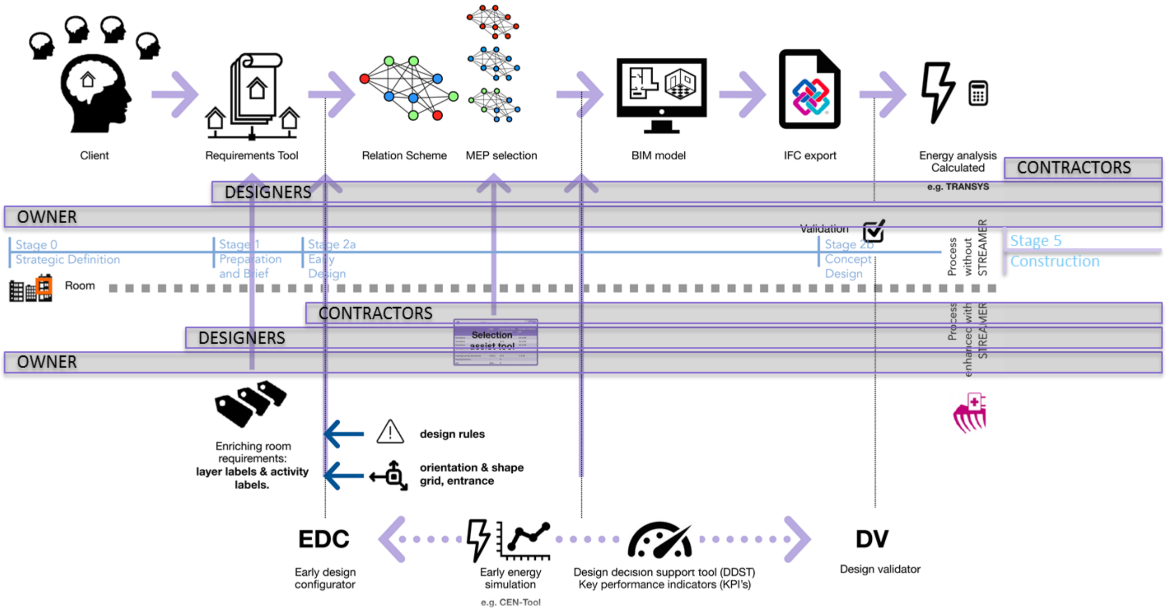

Figure 9: Illustration of the STREAMER tools interoperation in relation to a traditional design approach (above dotted line) and an Integrated Design Strategy (below dotted line). In the STREAMER design approach, the tools and parties interaction is strongly connected the common known RIBA stages of design.

There is no legal entity in the sector that can act as a driver for change. Therefore, all parties (clients, organisations, architects, designers and consultants, etc) must actively strive for a transformation and take responsibility for the hindrances that are closest to their responsibility or business. The client can in many cases push a transformation by changing the demands and criteria, but as long as it is not a business related to a demand an implementation cannot be expected. For a transformation, the STREAMER project is essential as it includes all necessary parties.

With the description of the needed transformation, from a traditional to a STREAMER design approach, a process roadmap has been described. The process roadmap identifies the current and future roles of the parties in the construction sector and connects the transformation of roles with the continuous development of a seamless information flow. This connection advances decision-making and management of design conceptualisation by an iterative validation made possible with interoperable tools. With this report it is proven that the sector can reach consensus and take an active broad responsibility in order to impact energy usage, costs and time for design and construction of energy efficient health care districts.

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