

## CYCLICAL SYSTEM MODEL – THE CONTEXT OF CONTRACTING AND MODULAR SYSTEMS

### JÖRG LAMSTER

Competence Centre for Typology & Foresight Planning in Architecture (CCTP)  
Lucerne University of Applied Sciences and Arts / Switzerland  
joerg.lamster@hslu.ch

### PROF. DR. PETER SCHWEHR

Competence Centre for Typology & Foresight Planning in Architecture (CCTP)  
Lucerne University of Applied Sciences and Arts / Switzerland  
peter.schwehr@hslu.ch

#### Abstract

*The massive refurbishment backlog in asset property requires innovative structural, processing and organisational strategies that make refurbishment services more economic, efficient and simple. Most common strategies are too expensive, take too long, and have too many disciplines involved.*

*For this reason, the following paper initiates the ‘Cyclical System Model (CSM)’ [1]. It considers building structures, life cycles and building processes as a whole. The CSM specifies a new hierarchy of structural elements made up of modular systems. The level of prefabrication of modular retrofit systems will increase and the level of mounting will decrease.*

*Contracting, which was invented by energy suppliers, is integrated in the CSM as an adequate process management. The contractor as the performer renders services such as financial investments, constructions, mountings as well as operating components and modules of the building structure. For clients, contracting is an outsourcing model. Financial investments, risks and responsibilities can be delegated. Planning, building servicing and refurbishing a building can be made more efficient and calculable [2]. Beyond that, contracting implies two further essential improvements: the functional tender to enable an immediate completion of clients’ needs (= quality) and the cyclical considerations of all processes and structures of a building.*

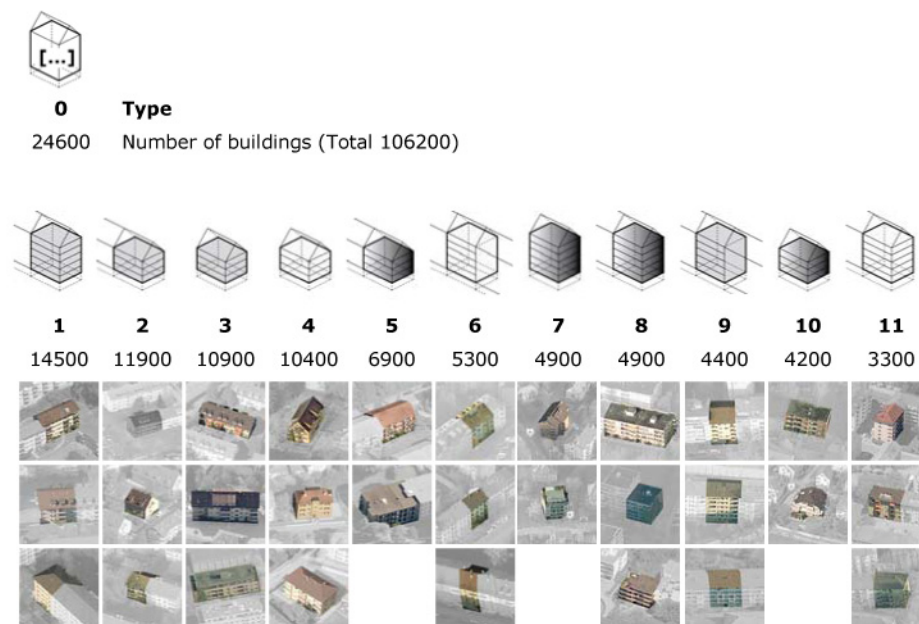
**Keywords:** refurbishment, sustainability, modular structures, lean processes, new alliances of clients, architects and contractors

#### INTRODUCTION

The urgent breakup of the massive refurbishment backlog in European asset property requires holistic and sustainable retrofit services solutions to manage future social challenges. Because of the given reasons (credit crunch and global warming), retrofit services have to be geared towards economical and ecological aspects. To face future demands, buildings are to prove their adaptability and are to be revalued immediately [3]. This has to be done with a minimum effort of resources and technological solutions in line with optimized processes and organisations.

For this reason, the Competence Centre for Typology & Foresight Planning in Architecture (CCTP) has started the research cycle ‘*Contracting for Building Constructions – the*

*Initiation of the Cyclical System Model (CSM)*'. Contracting, which was invented by the energy suppliers, holds great potential for upcoming challenges for architects and building industry. It is not a matter of finding new technical solutions, but of finding new forms of organisation, investment and services models. The objective is to find lean process organisations and technical solutions for efficient retrofit services. The current state of the art is the forecited CSM which considers innovative organisations such as contracting, prefabricated modular building structures and life cycles as a whole. Buildings from 1919 and later occupy economies of scale that will benefit contracting and modular prefabrication. In German speaking Switzerland there are 106'200 multifamily apartment buildings from 1919 and later. 81'600 of the buildings can be reduced to 11 types made up of characteristics like number of stories, number of flats, roof types or balcony types [Fig. 1]. This means that the market is given for new models as CSM.



**Figure 1:** Typology of multifamily apartment buildings in German speaking Switzerland [4]

## FOCUSES OF CSM – STRUCTURES, PROCESSES AND LIFE CYCLES

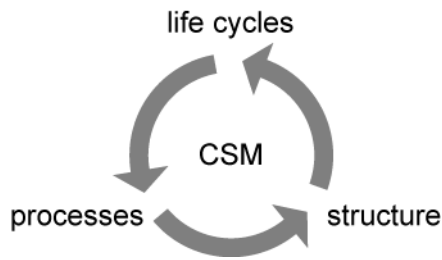
Each single building consists of *structures*, *processes* and *life cycles* – the three focuses of a building system.

*Structures* have physical or technical characteristics such as building components, space, building services, energy carriers and other sources.

*Processes* such as constructing, operating, managing and utilisation show how these structures need to be built, operated or used. The same structures can give a completely different building if the processes are different.

*Cycles* show certain temporal constancies and limitations of all elements of a building such as materials, components, construction, refurbishment or utilisation.

The CSM aims to consider structures, processes and cycles as a whole [Fig. 2]. The achieved cognition will be transferred to future challenges in planning, constructing and operating buildings.



**Figure 2:** Focuses of the Cyclical System Model CSM

**What are the goals of the CSM?**

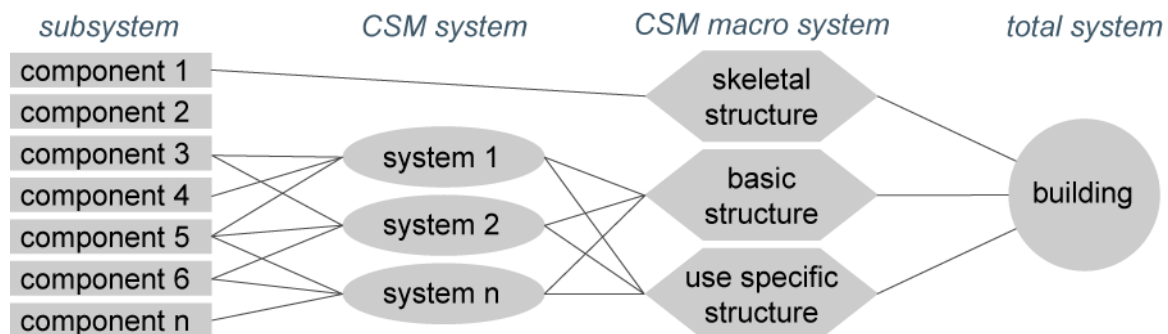
The CSM may eliminate single-track solutions based on only one or two of the three focuses of a building system. In sustainable development, it is necessary to look beyond technical innovations as these alone may cause unexpected problems in the future. The concurrent consideration of structures, processes and cycles allows the application of adequate technical equipment in the right place and at the right time. It permits modest services to be carried out within a reasonable time and without wasting sources and energy.

The main objectives of the focuses are:

- Structures:* Modular building structures that can easily be mounted, serviced and dismantled for retrofit measures.
- Life cycles:* Cyclical considerations to harmonize different correlating or contradicting cycles of a building.
- Processes:* Lean processes by creating new organisations and alliances of architects, contractors and clients.

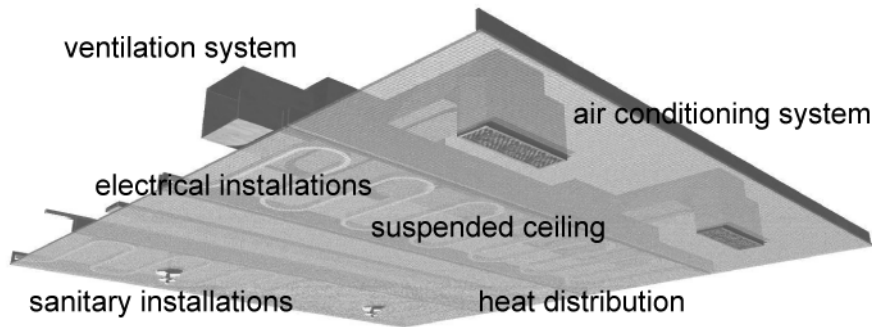
**Focus I: Modular Building Structures**

The main benefit of modular systems is that particular components can be easily separated. In CSM, the physical structure of a building is classified into subsystems, CSM systems, CSM macro systems as well as the building as the total system [Fig. 3]. Conventional systems of different component classes will be rearranged in CSM systems (subsystems > CSM systems). In this way, the huge amount of conventional component classes can be reduced to 20 systems. The macro systems bundle single systems by tender, utilisation, ownership and refurbishing cycles (CSM systems > CSM macro systems). The summation of all systems and/or macro systems is the building as the total system (CSM system / macro system > total system).



**Figure 3:** Cyclical System Model: The plan of modular systems

To guarantee troublefree assembly, CSM systems have elementary shapes with simple connecting devices. In this way, the level of prefabrication can easily be increased, and the level of mounting on site - a very inefficient process - can be reduced to a minimum. Systems and components will become simpler and more robust - a lean production. Maintenance will be more efficient – a lean process. Different functions are integrated in one modular system such as heating / cooling, ventilation, electrical and sanitary services are integrated in the ‘suspended ceiling’ modular system [Fig. 4].



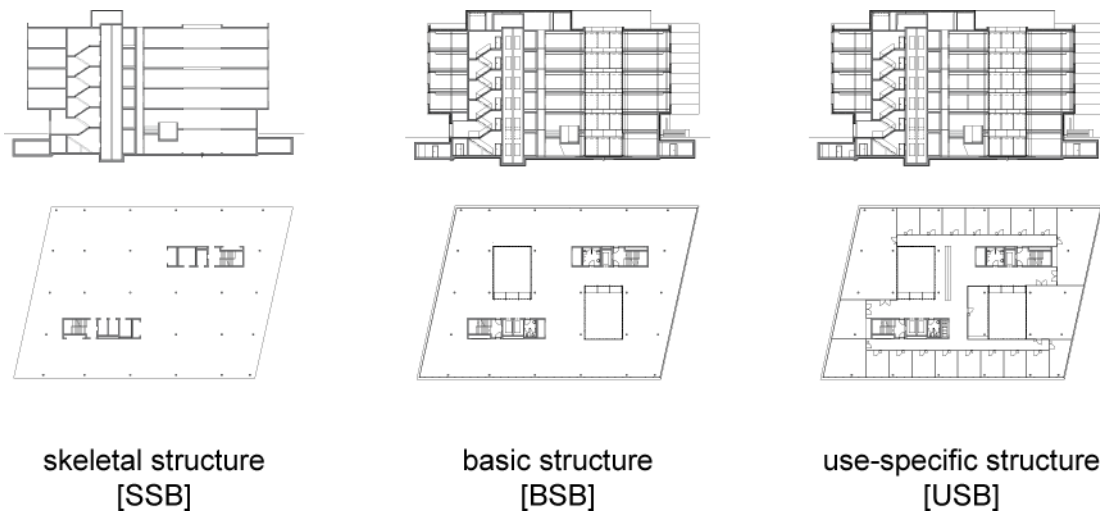
**Figure 4:** CSM system 11 ‘Suspended Ceiling’ showing the implied functions

CSM macro systems differentiate features such as ownership, usability, tendering or cycles of refurbishing that have an impact on the main structure of a building.

The CSM macro systems are [Fig. 5]:

- Skeletal structure of a building (SSB)
- Basic structure of a building (BSB)
- Use-specific structure of a building (USB)

The skeletal structure (SSB) is – nomen est omen – the statical skeleton of a building. The implemented systems have low maintenance and long life cycles. The basic structure (BSB) combines all elements that make a building; functionality, safety, serviceability, usability, capable of obtaining a building permit. A building can be assumed and used by customers. In addition, customers provide several systems in accordance to their own needs. These systems belong to the use-specific structure (USB).



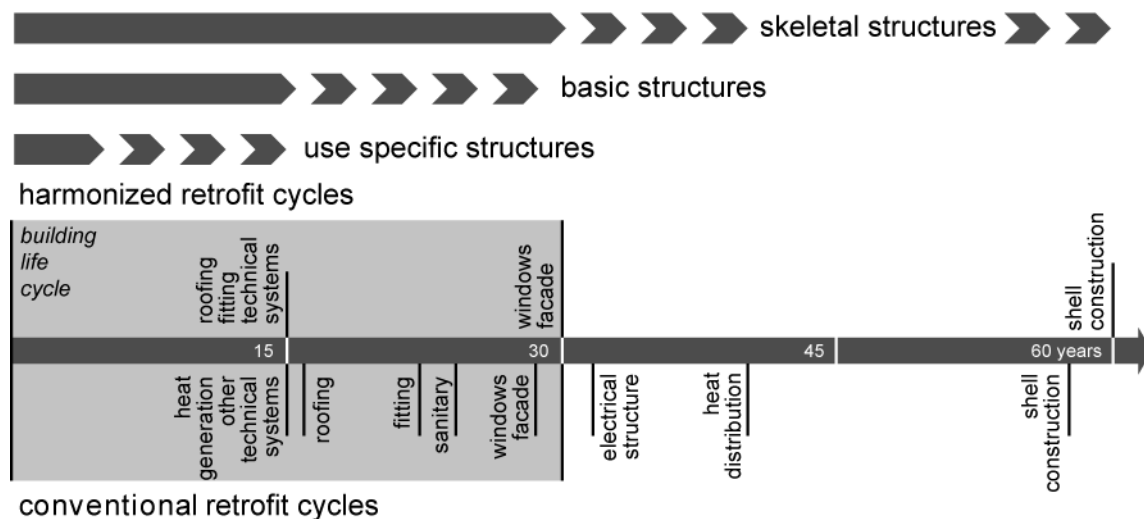
**Figure 5:** CSM macro systems

Using the macro systems, a building can be constructed and serviced within the scope of different contracts with different ownerships and customers. Considerations of differing usability cycles form the basis of planning and construction. The macro systems, as packages of single systems, help to harmonize the different maintenance cycles of the systems [1].

### Focus II: Cyclical Harmonization

Cyclical harmonization combines building cycles, maintenance cycles and system cycles with the cycles of usability implemented in a building. Systems are designed, constructed and maintained according to these harmonized cycles. In this way, the cycles of usability have an effect on the duration of the building cycles and the cycle of the macro systems, which on their part, affect the single system cycles. Consequently, all systems are able to perform their tasks throughout their life cycles without needless value destruction.

A simple example illustrates the numerical reduction of refurbishment cycles of several component classes on three cycles within the CSM [Fig. 6]. These three cycles are geared towards the life cycle of the building, which is established by the clients or occupants. This enables planners and contractors to adjust every single part of a building to the main purpose of the building – its utilisation.



**Figure 6:** Refurbishing cycles of conventional models and of the CSM

### Focus III: Lean Processes – Contracting

A building contains a vast amount of processes such as mounting and dismounting concrete formwork, or maintaining the heating system of a complex building. Processes combine single systems in a specific and unique context. Processes generate added value to each system, product or structure. For this reason efficient planning and execution of all processes is essential for the functional capability of a building.

The CSM process management considers all processes throughout the life cycle of a building. It assumes responsibility and competence for constructing and maintaining systems.

Contracting is included in the CSM, as it can be regarded as an approved cyclical process management.

Contracting is the concentration of financial investments, constructions, mountings and maintaining of building structures to be performed by one party – the contractor, who renders all these services [5]. Contracting is an outsourcing model; it helps the client to assign

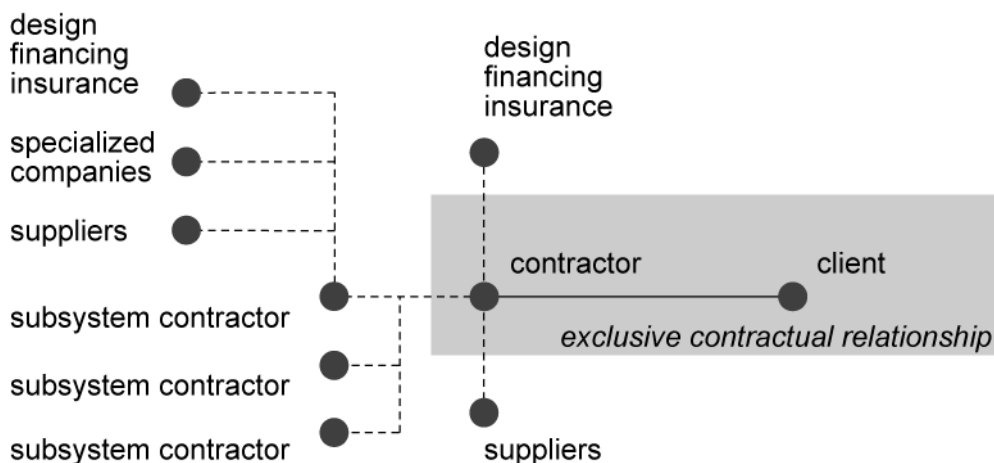
financial investments, processes, responsibility and risks to the contractor. This enables the client to make his own organisation lean and more efficient.

Contracting has two core processes:

- Raising specific profits of clients to cover their specific needs (functional tendering).
- Concentration of all services and investments throughout a fixed period by one party.

### The expansion of contracting services

Contracting liberates the clients from investments in building systems as well as from the acquirement of building knowledge and skills [2]. The economical factors of success for contractors are a more efficient management of resources, the application of present-date technologies as well as lean processes and organisations. Without these success factors, contracting would not arouse any interest on the open market. Energy contracting has shown its marketability by opening up new customer segments and it has shown the benefit of using technologically-efficient systems and new alliances between clients and contractors [6]. The required services systems must be ecologically and economically efficient. Only in this way can the contractor capitalize on the contracting rent and reach the stipulated target of building and operating buildings efficiently. However, not only the services engineering systems but also the other systems make a contribution to efficient buildings. This argues for an expansion of contracting services for the whole building. It has to be figured out; how can contracting services change building typologies and which means are needed.



*Figure 7: Contracting organisation plan*

### KEY FACTORS OF SUCCESS

The marketability of the CSM for retrofit services is given as it outmatches other services that are common today. To make CSM comparable, the three main key factors – quality, costs and time– will be introduced briefly. Due to the present day economical and ecological issues two additional key factors are added: organisation and sustainability.

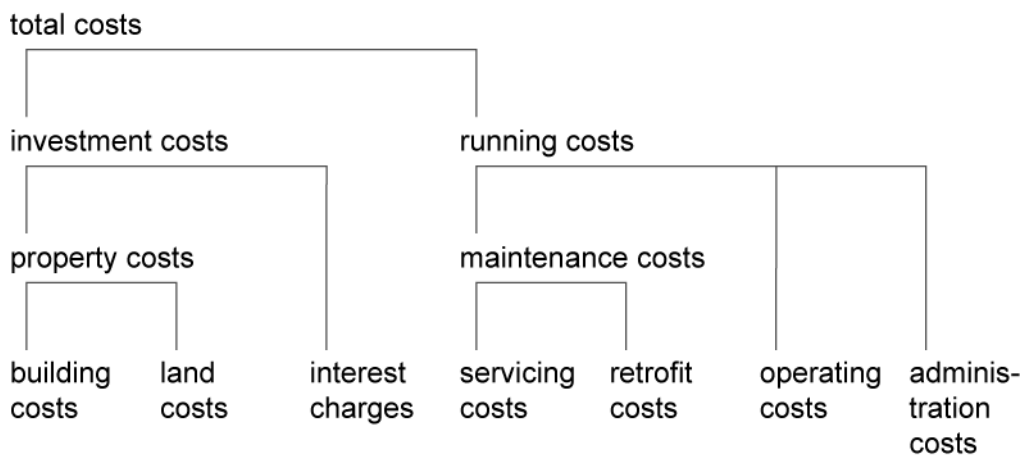
#### Quality

To measure quality, it is necessary to define, follow and document processes. This is the only way to discover failings and find advancements. A guideline compendium was created as part of the research project. This documents processes and risks by means of common building work phases. The guideline shall facilitate the co-operation of architects, clients and

contractors in all work phases from the early design to the dismantling of a building. In this manner, the CSM is embedded into the project management.

### Costs

For a successful building project, cost is as critical as quality. But costs do not only appear as production costs. During the life cycle of a building, there are different types of costs; land costs, interest expenses, operating costs, rebuilding costs, recycling costs and so on [Fig. 8]. The CSM cost management tries to display the total costs of a property throughout its life cycle. It aims to make total costs calculable even in early work phases. For this reason, there is a need for object-orientated data bases and numerous reference objects. In the research project an existing cost management tool was taken and advanced to register total costs.



**Figure 8:** Total property costs model as part of the CSM

### Time

The CSM time management considers and aligns not only terms and deadlines of a building project, but also captures the critical life cycles of a property such as materials, components, buildings, refurbishment or utilisation. The ambition is to harmonize all structures, cycles and processes [Fig. 6].

### Organisation

In the context of the CSM, an accurate consideration of organisations is necessary, as they will be redesigned. For this reason, project organisations and value added chains are considered cohesive and analysed from case to case. The typical CSM organisation model [Fig. 7] illustrates the exclusive contractor-client-relationship. The contractor has the main task of coordinating the certain positions of the organigram. Beyond that, the contractor is responsible for all services delivered by architects, planners and suppliers.

### Sustainability

Sustainability within the CSM can be achieved by planning and constructing simple and robust structures that can be easily maintained. In addition, processes and organisation can be improved. The premise to act sustainably is given, as the CSM is aimed at the avoidance of waste (lean management) [7] or the consideration of life cycles (contracting) [1].

Meanwhile sustainability has become an accepted economical argument. Clients are willing to make an extra investment for sustainability (10% of the building costs to attain the Minergie Label in Switzerland), as the property will rise in value accordingly.

## EXEMPLARY SOLUTIONS FOR RETROFIT SERVICES

### Retrofit services on freehold flats

An exemplary refurbishment backlog can be diagnosed with freehold flats in Switzerland. The first freehold flats appeared in the 1960s. These buildings are approximately 40 years old and need retrofit services. The different freehold flat owners are a heterogeneous group (young / old, single / families) in one building. The result is a difference in needs and disposable for investment. Retrofit services will be obviated for years. The transfer of the investments to a CSM contractor could break the backlog, as investment is no longer an argument.

### Servicing a building

Normally, the building companies hand over a new building to the owner. The owner either manages the running and servicing processes on his own, or he transfers them to a facility manager. That means that processes of planning and constructing are in one hand, the running and servicing of a building in different hands.

The transfer of responsibility, ownership and investments to the contractor means that all processes (planning, building, running, servicing and dismantling) are in one hand.

## OUTLOOK

The implementation of the CSM on the open market is a long-term goal. By then, the expansion of contracting services for the whole building will have to have been effected and modular systems available on the market. Prefabricated façade systems with integrated technical services have been designed especially for refurbishing and revaluing buildings. Thanks to these modular systems, the organisations of system providers [Fig. 7] are on the right track. In favour of the broad application of CSM systems the market potential must be analysed and information strategies developed. Architects, clients and contractors will have to learn and understand the coherence of utilisation and operation characters on the one hand, and of building structures on the other.

Contracting services will have to achieve a multiplicity of complex clients' needs. At the beginning of a project, architects, clients and contractors will have to be able, to couch these clients' needs in terms and to tender for them. Technical tender will be substituted by functional tender. The clients' tender may sound like this: "This 40 years old multifamily apartment building needs an urgent refurbishment and revaluing. The flat units have to be converted to modern and flexible flats that cover the needs of different customer groups. A simple and robust technical equipment will have to be serviced efficient and sustainably". The CSM may be able to cater for these needs immediately.

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