

## From Modular Architecture to Adaptable Collective Housing: A design charrette bringing the open building knowledge to the “Solar Decathlon 2012 Europe”

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### ABSTRACT

*The design workshop is a central part of the academic module on “Industrialized housing” within the MSc in Industrialized and Prefab Architecture, at the Faculty of Architecture, CEU-Cardenal Herrera University in Valencia (Spain). The workshop constitutes an opportunity for students to get acquainted with several aspects of “4th dimension architecture” applied to housing, particularly on the articulation of levels and domains of control. This feature is made patent by changing the roles of students from designers to users during the workshop. This year, the main objective was to bring a “4th dimension” input to the CEU-UCH proposal for the Solar Decathlon Europe 2012. Students were asked to outline a design strategy that should allow turning the single family module of the competition into a prototype for collective, multi-storey, adaptable housing. The paper’s aim is dual: on the one hand it illustrates the background, development and results of the workshops held during the Master. Particular attention was paid to the learning process and the broader influence it has on the students’ view of collective housing. On the other hand, it will describe the impact of this approach on the current development of the SDE 2012 prototype.*

### KEYWORDS:

architectural education, Open Building, Solar Decathlon Europe, collective housing

### INTRODUCTION

The paper describes two teaching experiences led by the authors at the School of Architecture, CEU-Cardenal Herrera University in Valencia (Spain).

On the one hand, it explains the experience of a short studio housing workshop held every year since 2010 as a part of the Master’s module on Industrialized and Modular Housing. This module is set up on two main assumptions. First, that focusing on collective housing, instead of single family housing, makes a lot more sense within the Spanish (and European) context. Second, that the Open Building theory may help to structure in a stronger way the discourse on prefab and modular housing, especially when sustainable criteria is taken into account. The studio workshop is focused therefore on the design of a support building conceived within the framework of the Spanish socially accepted standards for housing, although not exclusively limited to it.

On the other hand, the paper describes the development of the university proposal for the Solar Decathlon Europe 2012 and the attempt to imbue it

through this year studio workshop and further work within the SD 2012 team with some of the concepts developed along the Master’s module.

### THE SYLLABUS OF THE MODULE ON HOUSING AT THE MASTER ON INDUSTRIALIZED AND MODULAR ARCHITECTURE IN THE SPANISH FORMATIVE CONTEXT

#### *The Spanish context*

Teaching and practice of housing design in Spain does not usually put users’ control and the 4th dimension of architecture in the centre of the debate. Very seldom, Open Building concepts have overtly been incorporated into the academic discourse in Spain, not to mention inside real projects. Since the early attempts in the ‘70s, when Fernando Ramón (Ramón, 1975), architect and professor at the School of Architecture in Madrid, introduced the Support theory in Spain, these concepts have not gained any broader diffusion among scholars and professionals. In the last decade, publications and competitions as result of the joined European research program Manubuild (or the Spanish one named INVISO), have introduced Open Building theory in relation to industrialized construction, but with reduced impact in schools and practices. “Flexibility” in housing has been a common concern for housing through academic research and, occasionally, in practice. Some exercises of “economy of space” have been enhanced by certain “economy of means” in public housing. However, very little room for such flexibility discourse was applied during the last real estate boom, partially also because of the constraints of the regulation system. As a result, users and customers deal now with a monotonous, inflexible and repetitive housing stock which is unprepared for changes over time.

#### *The syllabus of the module and the diagram on industrialized collective housing*

The syllabus of the module of industrialized housing provides the framework for developing a critical discourse on the layout inflexibility and construction standards of collective housing in Spain. It also advances a broader view on housing adaptability and on “housing as a process”, integrating user’s control. The program introduces a historical and geographical context of industrialized collective housing, and places N.J. Habraken’s legacy at the center of the debate. It helps students identifying several qualities of the industrialized housing project throughout the

XX century. These are: economy, efficiency, adaptability, sustainability and customization. The case studies reviewed during the lectures and seminars are shown in a diagram and are evaluated in relation to the performance of these qualitative indicators.

The diagram on industrialized collective housing is a graphic resource allowing a dialectical approach to several subjects studied along the module. It is open to the students' seminars research, updated every year. By doing so, it enhances both their research and active participation during the class sessions, and helps to build up a wider knowledge about industrialized housing. The information in the diagram is organized according to qualitative criteria and provides a dual reading of data with reference to chronological and geographical coordinates. Since it is intended to become both a survey of industrialized mass housing and an academic tool, data is not limited to projects and buildings, but also to those relevant texts, agents and programs that contributed to the development of industrialization of the housing sector. The picture portrayed in this snapshot addresses both the achievements made in the field of architecture as well as the results of "non architectural fields", as described by Colin Davis in his book (Davis, 2005), which are indeed largely responsible for technological progress. The taxonomy for each entry in the diagram is defined by a graphical code. Different symbols classify the information according to the type of industrialization, i.e., closed and open systems; finally, a specific graphic code distinguishes the Open Building residential projects. Different colors classify entries according to geographical criteria and case styles introduce information about tenure. Once the entries are set on the diagram, the relationships among programs, texts and projects are drawn vertically.

*The Workshop on Industrialized and Modular Housing.* The workshop takes up a central part of the module and is structured on a four-day full time design studio. First, students receive an introduction to the concept of levels that operate in the dynamic processes which affect our environment, both according to control and responsibility as well as in relation to the lifecycle of buildings. Second, they are given a brief detailing of the design requirements for a collective housing prototype of 30 housing units approximately, to be conceived according to the Open Building principles. The exercise is an opportunity for students to get acquainted with the 4th dimension in housing design and test the general approach on dwelling adaptability and users' control elaborated during the module seminars and lectures.

The structure of the workshop invites students to design from the permanent and collective scale to the changeable and personal one. In the first 6-hour stage, they are requested to conceive the "support level" focusing on the "collective layers", which include the access system, load bearing structure and

main service systems. No specific units' layout is defined in this early phase, though they must size up several spatial arrangements in order to develop support systems. In the second 6-hour stage of the workshop, students swap their proposals so as to test others' supports capacity by developing single units. They change their role and act as potential users. At the third and final stage, students take back their designs with the range of layouts developed by others in order to optimize the performance of the support and to adjust the dwellings' layout according to the feedback received. In this final stage students are also invited to test their support designs with non architectural literates, for example, with friends or family members.

Several educational strategies are designed to strengthen the "levels approach" learning process: The articulation of the design process in several stages according to levels' life-cycle criteria reverse the usual design process in housing, giving the adequate autonomy to the support level in relation to the layout level.

By swapping their support proposals, students exercise the levels of control and responsibility, and partially experience the role of designers and users at the same time.

Team work, quite unusual in architecture studio pedagogy in Spain, brings students closer to the professional practice, where multiple agents intervene and negotiate to produce a collective work.

Each stage ends up with a short presentation of the work undertaken. The students group acts as a collective forum in which, through debate, a critical knowledge about the concept of levels is constructed, allowing the introduction of the 4th dimension in collective housing design.

#### *The 2011 workshop and the Solar Decathlon Europe (SDE) 2012 design charrette*

This year, the Master workshop ran in parallel with the SDE 2012 proposal development and involved the same group of students. It is then worth to explore the synergy between both experiences and the way they inform mutually. Some preliminary information about the SDE competition and the UCH CEU team participation is needed.

#### *SDE Competition*

SDE is an international universities competition in the European context, originally held in US, to design, build and test a single family prototype, energetically eco-efficient and limited to 74 sq. meters. The "decathlon" term refers to the evaluation process by an external jury which, since the first European edition in 2010, tests the following ten features: architecture, engineering and construction, energy efficiency, electric power balance, comfort, functionality, communication and social consciousness, industrialization and market feasibility, innovation and sustainability. The main goal of the competition is the learning experience of

the students taking part in the development and construction of a 1:1 scale project. The brief of a single family unit should be understood in these terms. However, it is a serious limitation to a broader sustainability discourse on housing. The single family housing scale, a legacy of the North American edition, doesn't fit neither in the present European context, nor in the future urban development trends.

Moreover, the SD evaluates the performance of an isolated object treated as a readymade machine. This view is unsuitable when housing is understood as a process in which users shape their habitat over time. Both a collective dimension as well as a time dimension could improve the competition's objectives.



**Figure 1:** Support design by students M. Villar, B. Ferrer (2011)

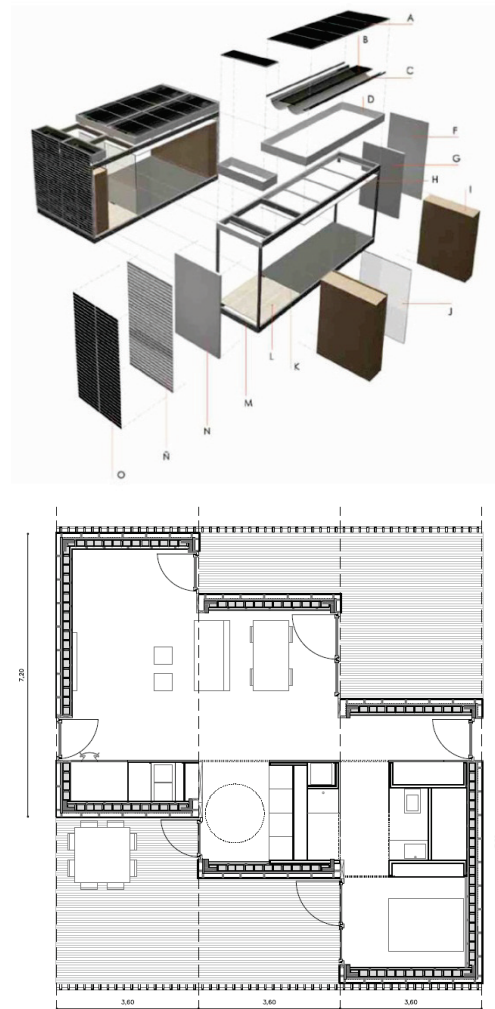
The house designed and built for the Solar Decathlon Europe 2010 by the School of Architecture at the CEU-UCH University in Valencia was conceived on a strong modular concept that allows users to configure their own house according to changing spatial needs and financial resources. The proposal was in fact a system of configurations based on the combination of modules which originated S, M, L or XL units. There was a basic 3D full prefab module, 1,85 x 7,80 m long, at the core of the project which offered spatial diversity thanks to the different position of the small courtyard inside.

The system variations were both at the module level and in the composition of different modules at the whole housing unit level. Users, according to their space requirements, (for a family, as a second home, workplace, etc) may choose the number of modules of the house and their specific internal variation. The dimensional limit of the competition reduced the possible configurations of the built house to 6 modules. The modules' design and construction were the result of a detailed and thorough process that involved many faculty members together with a group of graduate students. The two main courtyards were used here both for the articulation of the

interior space, segregating three basic areas of the dwelling, as well as for the efficient bioclimatic behavior. Living-dining room, kitchen, and bedroom-study are organized around them, making cross-ventilation and indirect natural light easier. Moreover, the contact of these courtyards with the façade helps defining the entry area and strengthening the spatial depth of the house. The SML House was the highest ranked of those presented by Spanish universities during Solar Decathlon Europe, received the most votes from the 190,000 people who visited the works of the 17 universities participating in the competition and won the Industrialization & Market Viability test.

The SDE 2012 proposal inherited the modular concept and the patio as a spatial and bioclimatic device of the previous SDE edition. Both strategies fit into the Spanish national housing regulations in terms of space and natural ventilation requirements while they allow for a wide variety of combinations. As a further guarantee of continuity, many students taking part in this year's Master edition were already involved in the SDE 2010 competition. At the time of starting the Master workshop, the basis of the design strategy for the house were already settled and they

focused on the addition of several spatial modules in order to create customized units. The reduced space inside each module was initially designed for polyvalence: a fitted out envelope contains part of the furniture as well as the main necessary services, liberating space for users who may qualify it according to their needs.



**Figure 2:** Axonometric of SDE 2010 module (top), and layout of current SDE 2012 proposal, sept 2011(bottom)



**Figure 3:** SMLsystem CEU-UCH, SDE 2012 proposal (sept 2011)

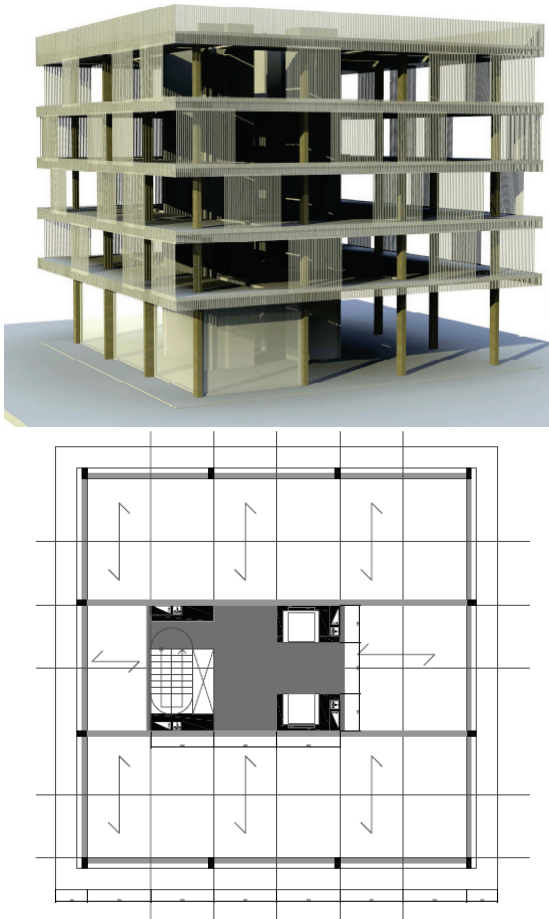
#### *Interaction between Master module's Workshop and SDE 2012 proposal development*

The brief of the Master's workshop held this year invited students to apply levels concept design in order to explore the collective aggregation prospects of the basic spatial modules that they were simultaneously designing for the SDE proposal. The SDE 2012 initial proposal did not differentiate levels clearly, due to the practical requirements of the competition. Building in a short time by inexperienced students slanted the initial design toward prefabricated 3D modules. Material and dimensional choices already taken in the SDE housing proposal were to bias strongly the supports design. However, the workshop tried to construct an alternative lecture starting again from the identification of levels. Students were asked to define an access system, a load bearing structure and the collective services layout according to capacity criteria, taking modular coordination for granted, components and wood construction as defined in the SDE proposal.

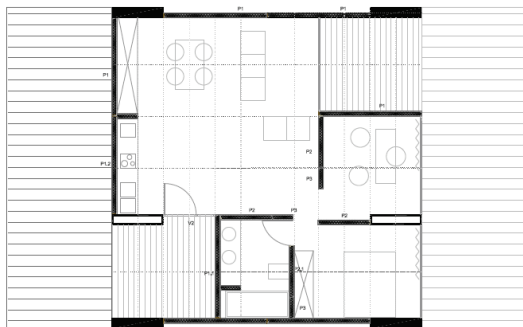
Students split into 4 groups: each of them explored design solutions capable to provide an optimal capacity to the support level in a synchronic and in a diachronic mode. Each group picked one of the two different access systems suggested, the corridor and the central access core. Students should design in other to allow diachronic change in terms of future units' split. It meant testing the capacity in terms of access from bigger to smaller units. Students also had to determine the location of the main service ducts, as well as the load bearing system around the access core and within the façade system, allowing the synchronic configuration of different SDE proposal layouts, named respectively XS, S, M, L, XL after their size. They also had to consider the accessibility of the collective services shafts by means of floor trenches, raised floor, double ceilings, etc., in order to make interior layouts changes possible, attaining the position of kitchens and bathrooms.

Although the infill level development has been basically understood as a mean for testing support capacity, students had the opportunity for approaching the design of industrialized modules and components such as bathrooms, prefab panels for layout and cladding, lattice components, etc, which connects with the materials developed for the SDE 2012 proposal.

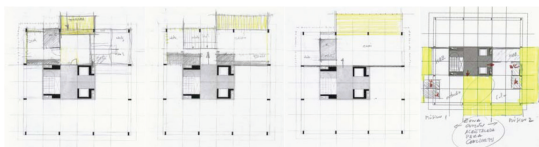
Time constrictions brought to restrict the analysis and development of urban level at the end of the exercise. As a kind of final test on the support proposals, the students were asked to reflect on the insertion of their prototype in a real urban context freely chosen. In some cases this process leads to a further detailing and adaptation of the façade system as a response to the surrounding environment, considering the significance that envelope portray to the public space.



**Figure 4:** Support design by students L. Navarro, I. Soler (2011)



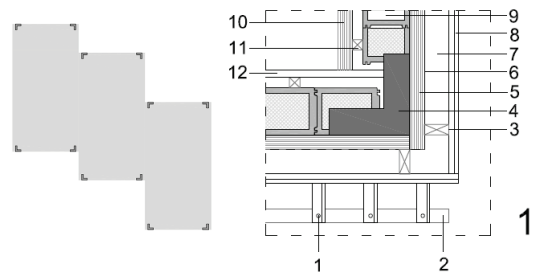
**Figure 5:** Dwelling layout proposal by students M. Villar, B. Ferrer (2011)



**Figure 6:** Support capacity test: layouts developed with non architectural literates by students L. Navarro, I. Soler (2011)

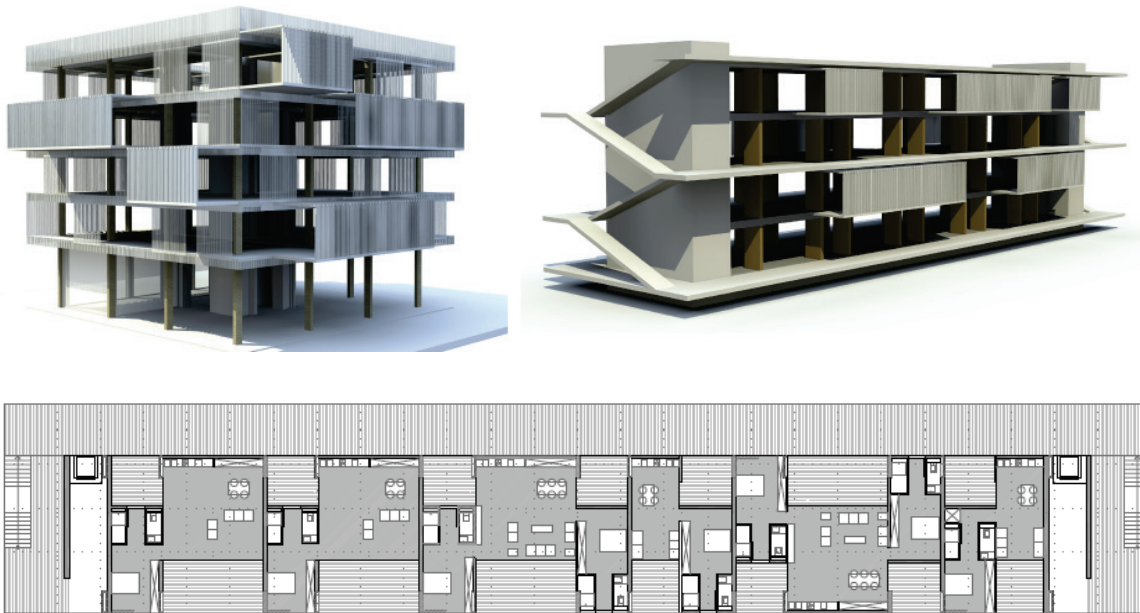
The current (September 2011) development of the proposal reinforces the input from the Open Building theory as introduced in the master module. The new SMLsystem house adopts now a concept of dimensional coordination and of compatible elements leaving behind the idea of 3D modular construction. A basic structural system made out of L wood columns (that combined can form X shape supports) and cross laminated wood slabs (CLT) made possible a great variety of layout combinations both horizontally and vertically. The main L supports grid is stiffened by vertical CLT panels making possible the superposition of up to 5 levels. However, for the 2012 final phase in Madrid, the house will be pre-assembled in three sub-modules 3,6 x 7,2 m in order to fit into the tight competition schedule. These elements reflect the main spatial modulation of the SMLsystem that combined with sliding wooden lattice allows widening the patio/terrace outside, stretching the modulation up to 10,80 m. Now a clearer distinction between levels is made. The support consists of the wood structural system, a ventilated larch wood cladding, and the vertical lattice system which combines wood and ceramics. In the multilevel and collective configuration a vertical core, that is subject to the same spatial modulation (3,60 x 3,60), is added to the support configuration. In the specific case of a lineal building a further access deck 3,60 m width extends the basic 10,80 m span of the housing units.

The infill is organized into two main levels. The first one is fixed during the customization process of the units. It consists of pre-fab “wet units boxes” that bring together all the necessary connections for the kitchen and the bathroom(s) and, in the specific case of the competition, an “services box” where most of the photovoltaic, electric, HVAC, home automation and plumbing elements have been joined up. The second one is a variable level and includes the furniture and the home appliances.



**Figure 7:** The structural L shape supports grid at floor level and a detailed horizontal section of the SMLsystem house (Sept 2011)





**Figure 7:** Lineal and tower supports preliminary design as resulting from the assembly of compatible elements of the SMLsystem, above. A possible layout of a lineal block that includes vertical cores and the access deck, below. (Sept 2011)

## CONCLUSIONS

The Open Building approach to housing, by taking into account time, the 4th dimension, and the users' control in shaping their own domestic environment, when introduced to the studio learning format, helps students to question themselves about their previous skills and knowledge. The focus of the Master module exercise is not the product as much as the process and students are challenged to develop a more critical vision of urban habitat and of housing solutions.

In response to the module's evaluation questionnaire, students revealed their surprise in discovering not only a different way of conceiving collective housing, but also recognized the value of a more collaborative process in design. In this case, thanks to the team work and the swapping of proposals, they understand in a straight but effective way the necessary distinction between the more permanent parts and the less permanent ones in housing design. It questions the idea of dwellings as a finished product, due to the existence of discontinuity between building uses over time. Moreover, when requested to test their design proposals outside the classroom and with non professional subjects, the question of users' control and the surge of unexpected variety of lifestyles clearly emerge. This experience brings into the discussion the architect's role not only as a mediator between different parties involved in the design and construction of a building, but also as a mediator in the spatial negotiations about dwelling. Testing the "capacity" of others' design put under scrutiny not only the design's qualitative aspects in terms of space adaptability and

technical systems feasibility, but it undermines as well the "average user" syndrome that too frequently underpins housing design.

The hybridization between de SDE 2012 proposal and the collective housing module resulted initially (March 2011) in a design charrette that made clear the intrinsic limitations of the SDE competition rules. However, it also challenged some of the assumptions on flexible design and space adaptability previously imbued in the ongoing proposal development. The contradiction stems out from the contrast between the need for delivering a fully equipped prototype and the application of the concept of users' control at infill level. Moreover, the collective dimension that is a preliminary condition for the module theory itself clashes with the SDE rules, since there is not enough room, literally and figuratively, for developing a proposal that tackles this issue without losing any chance of competing on equal terms with other teams.

Nevertheless the current development of the 2012 SDE CEU-UCH proposal has steered towards a better integration of the Open Building concepts as learned by students during the master module: a sharper definition of subsystems and compatible elements, a dimensional coordination and a renewed role given to users as developed in the market viability draft of the SMLsystem house. A significant progress has been made in tuning up Open Building criteria into the SDE proposal since first proposal drafts and it is now commonly understood by the student team that there is still room for improvement during the development of the proposal from now until the competition in September 2012.

#### REFERENCES

- Davis C., The prefabricated home, Reaktion Books, London, 2005
- INVISIO, "Optimizacion de la produccion de viviendas, Industrialización de viviendas sostenibles", Instituto de Ciencias de la Construcción Eduardo Torroja, Madrid (Spain), viewed 26th September 2011, <  
<http://www.ietcc.csic.es/index.php?id=1501> >
- MANUBUILD, Open Building Manufacturing, viewed 26th September 2011, <  
<http://www.manubuild.org/> >
- Ramón Moliner, Fernando, 1975. Foreword, spanish edition of "Supports", "Soportes: Una alternativa al alojamiento de masas, J. Habraken, Comunicación, Serie B, Madrid