Strategies for Housing Rehabilitation in the search for mixing generations and family types. An approach based on a transformation grammar.

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Abstract

This abstract describes a Ph.D. research that sets off with the premise that the future of real estate market in Portugal will require the rehabilitation of existing residential areas and that it will be of utmost importance the incorporation of Information, Communications and Automation Technologies (ICAT) as well as the transformation of dwellings to respond to the new demands of dwellers which incorporate the rising of different forms of co-habitation. The study focus on a specific building type ("rabo-de-bacalhau") built between 1945 and 1965. The final research objective is the definition of design guidelines to support architects in the adaptation of existing residential areas with the purpose of ICAT incorporation and the creation of diversity within the building and the sorrowing residential area. The goal is to use Shape Grammar and Space Syntax as tools to identify and encode the principles and rules behind the adaptation of the existing houses.

Keywords: Housing, rehabilitation, ICAT, shape grammar, mixing generations.

Introduction

This abstract describes a Ph.D. research that is currently being developed at Technical University of Lisbon - Instituto Superior Técnico (TUL - IST) and at the National Laboratory for Civil Engineering (LNEC) on the subject of "*Methodology for the integration of Information, Communication and Automation Technologies in Housing Rehabilitation*". The Ph.D. thesis sets off with the premise that the future of real estate market in Portugal will require the rehabilitation of existing residential areas and that it will be of utmost importance the incorporation of Information, Communications and Automation Technologies (ICAT) as well as the transformation of dwellings to respond to the new demands of dwellers. Nowadays dwellers demands incorporate the rising of different forms of co-habitation that are having a great expression in Portuguese cities. Elderly people, single-parent households and single-person families represent co-habitation groups in expansion. The INE classification of classic families according to size reveals that in Lisbon the most representative families consist of two individuals (31.01%), followed by 1 individual (30.55%) and, in third place, 3 individuals (19.58%) (INE 2001). For this new population reality it is necessary to define different models of housing that could be integrated in the existing residential areas through their rehabilitation and conversion.

The study focus on a specific building type ("rabo-de-bacalhau") built between 1945 and 1965 in Lisbon. The final research objective is the definition of design guidelines to support architects in the adaptation of existing residential areas with the purpose of ICAT incorporation and the creation of diversity within the building and the sorrowing residential area. The goal is to use Shape Grammar and Space Syntax as tools to identify and encode the principles and rules behind the adaptation of existing houses to new requirements. With these tools we want to achieve several strategies for rehabilitation that respond to different family needs.

Framework

Family typology

An architectural design programme is based on various kinds of data, amongst which knowledge of the future occupants is an essential element in conception. When architects consider a design programme they are faced with a group of future occupants who may either be known (e.g. in the case of a commission for a single family dwelling) or partly unknown (e.g. in the case of a multi-family residence).

In order to address the research aims concerning the definition of the various profiles required for the integration of ICAT and for occupancy, it is necessary to begin by defining the potential groups that may share the accommodation.

However, an *a priori* definition of groups of residents may imply that the proposed rehabilitation is intended only to address specific groups, thereby excluding, for example, integrated rehabilitation projects for multi-family residences developed with the aim of eventually placing the dwelling on the housing market for sale or rent. This thesis aims to address both cases – rehabilitation of a single dwelling for a known family and rehabilitation of one or more dwellings for unknown residents – and the chosen methodology therefore responds to both.

In order to address situations in which the future inhabitants are unknown, two types of strategy are proposed: i) through the use of market studies the developer knows which target group the housing is to be designed for and, on this basis, can choose one or more profiles from amongst those defined here; ii) rather than choosing a specific profile, the developer can opt for an undefined group of residents characterised solely on the basis of family size.

In order to categorise the different domestic or residential groups literature on the subject was studied, with a particular emphasis on the characterisation of the population of Lisbon in terms of the families emerging from the last available Census – in 2001 – and the work of Wall (2003)(2005), Aboim (2003), Vasconcelos (2003) and Morgado (2005). The latest INE (Statistics Portugal) statistics were used for some population indicators.

The classification of households enables certain groups to be established, either on the basis of their shared living structure or the age of their members. The traditional family structure which includes one man, one woman and their children does not necessarily reflect the family life of many households. In fact, the traditional family structure – the nuclear family consisting of a couple with children – has become less important and the presence of other groups has increased in society.

The word "family" is used in the context of this research to designate a domestic group or unit residing the same household regardless of whether its members share blood or marital ties and regardless of the number of occupants. This use of the term "family" covers nuclear families, classic families and "complex families" as defined by Wall (2003) (the nuclear family plus other individuals or other nuclei). In the restricted sense of the word, "family" means a group of people linked by blood or marital ties and

affinities or residence. According to Wall, in addition to blood or marital ties and affinities, the links between the various members of the group may also be work-related (Wall 2003: 84).

In the scope of the described research and with the literature previously cited the classification of family typology was based on the following criteria:

- − Classification according to circumstances: living in a group or living alone;

- − Classification according to age or phase of life of residents (e.g. young people, adults, elderly people);

- − Classification according to situation regarding children (married with/without children, single-parent families/single adults);

- − Classification according to mobility and/or disability (inclusion of those with restricted mobility or disability);

The simplified classification adopted for families was: co-residence (couples with children, couples without children, single-parent families, young people, adults, elderly people, other types of family) and single people (young people, adults, the elderly).

The aim of categorise the different domestic or residential groups was to enable them to be cross-referenced with the available ICAT solutions, the housing programme and the physical dwelling that is to be rehabilitated by making use of an expert system. The definition of family groups was therefore justified solely by the fact that they have different living arrangements and therefore different functional and ICAT needs.

Within the family groups three criteria are essential to the definition of space and ICATs: the possible presence of an elderly person or an individual with restricted mobility or a disability; the possible presence of children from different marriages; the possible presence of residents other than the parent/children nuclear family. In the event that one of the residents is elderly person and/or has restricted mobility or is disabled, the functional criteria and criteria for the use of ICAT are more demanding and their specifications are different. Simultaneously in the context of recomposed families with children from different marriages, it is important to consider that the different children belonging to the new couple have a greater need for privacy than would be the case if they were siblings and the children of the same parents. In families which include one or more other individuals (grandparents, aunts or uncles, cousins, friends, etc) in addition to parents and children, the need to recognise the independence of these individuals and to ensure privacy for the different groups within the family is greater.

The family typology relevant to determining the functional programme and pack of ICAT functions should be understood not as an end in itself, but as a beginning. In other words, housing rehabilitation should not only take the present-day occupants into consideration, but also their likely future development. It is therefore necessary to cover the different phases in the life cycle of the occupants as broadly as possible

Lisbon statistical data

The resident population of the city of Lisbon has been declining rapidly and nowadays totals 564.000 inhabitants, reflecting a fall of 14.9% in 10 years (INE 2001). The continuing depopulation of the city has been accompanied by dispersal into the metropolitan area, which has driven the Lisbon population to the borders of the municipality.

The average age of Lisbon city residents is 44.11, as opposed to 39.01 in Portugal as a whole, with the two most representative groups, according to INE data, falling within the age range 20 - 24 and 25 - 29. There has been a fall in the birth-rate over the last 20 years, with very low figures registered for young people under the age of 19 (i.e. born between 1981 and 2001) which, within a few years, will be reflected in the figures for adults of working age.

Elderly people (aged over 64) represented one quarter of the population (24.18% in 2007), Lisbon being one of the most elderly cities in Europe which, in turn, is the most elderly continent in the world. At 180.8%, the ageing index for the city of Lisbon is the highest in the Lisbon Metropolitan Area (LMA), compared with 109.3% for the Greater Lisbon area and 98.4% for the Setúbal Peninsula. Lisbon is also the city with the highest old age dependency index in the LMA, at 38.7%. The cities with the lowest old age dependency index are Vila Franca de Xira, at 18.3%, and Seixal, at 16.7% (INE 2007).

With regard to the elderly population, it should also be stressed that almost half (14.4%) of the classic single-person families (30.5%) are composed of individuals aged over 65.

It has been calculated that by 2050 almost one third of the Portuguese population will be aged over 65. In fact, according to the INE (2003), the resident population projections for Portugal for the period 2000-2050 reveal that the population will continue to age as a result of the estimated increase in life expectancy, as well as the continuation of sub-replacement fertility levels. In the various scenarios defined by the INE for 2050, the percentage of elderly people always remains higher than that of young people and in the most pessimistic ageing scenario may total 395 elderly people per 100 young people (a figure that has quadrupled since 2000).

With regard to living arrangements in the city of Lisbon, nuclear families represent 68% of classic families. The INE classification of classic families according to size reveals that in Lisbon the most representative families consist of two individuals, followed by 1 individual and, in third place, 3 individuals (Figure 1). It is interesting to note that nationwide there are far fewer families consisting of 1 individual, and these are ranked fourth. The size of the average family has fallen over the years. In 2001 the average family size in Portugal was approximately 2.76 people per family, a figure lower than the 3.1 recorded in 1991 and 3.4 in 1981. The average family size is 2.57 in Greater Lisbon area and 2.85 in the Greater Porto area. This does not vary significantly throughout the country: the highest figures are found in Madeira and Tâmega (3.27 people per family) and the lowest in the Baixo Mondego (2.50) and Beira Interior Norte (2.51) regions.
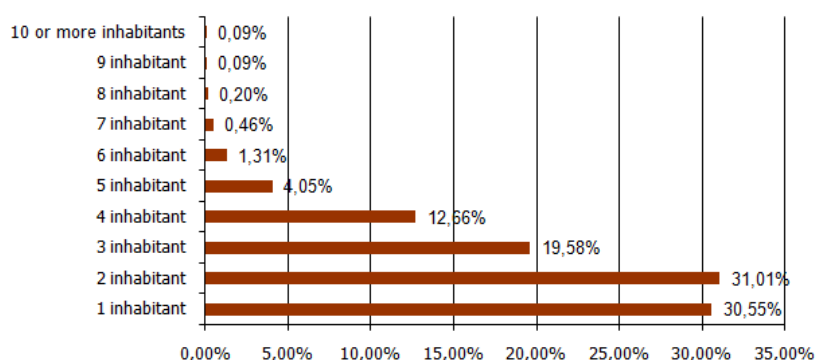

Figure 1 – Classic families in Lisbon, by family size. Source: (INE 2001)

In terms of nuclear families, the couple with children remains the most representative nucleus in Lisbon, at 44% (56.7% in Portugal as a whole), followed by couples without children, at 35.8% (30.9% in Portugal) and single-parent families, at 18% (11.5% in Portugal). With regard to the number of children, in nuclear families with children the most representative figure is 1 child (37.22%).

The characterisation of families presented indicates a series of objective housing needs. The required housing size and functional needs as well as the possibilities for the use of ICAT can be extrapolated from the statistical data on families resident in the city of Lisbon and their composition (number of people and kinship).

As Morgado states (2005: 48), family values, lifestyle, attitudes towards work and leisure and types of living arrangements are very subjective variables that are difficult to quantify and will influence the overall characteristics of the desired residence. In addition to these factors, the phase in the life cycle also has a major influence on the choice of housing, since this is established either by the age group to which the family members belong or their socio-economic level.

Housing and lifestyles

One of the objectives of this thesis is to define the new functions and requirements for housing in the current Information Society (IS) by analysing the impact of the integration of technology, namely ICTs, within living space, both in terms of spatial-functional organisation and construction.

Within the context of this work, given that recommendations are made for housing rehabilitation and the intention is to focus on changes in life styles created by the use of ICTs, basic functions and requirements were defined on the basis of the existing bibliography - a priori of ITC considerations – then developed to incorporate needs emerging out of the use of ITCs.

Therefore, use was made predominantly of research studies and a survey carried out during the course of this work. Specifically, this involved studies on the housing programme produced by João Branco Pedro (Pedro, 1999a and 1999b), (Pedro 2002), (Pedro 2006), the use and computerised implementation of the Pedro housing programme in the Malagueira grammar by José Duarte (2007), the work of Sandra Pereira (Pereira, 2006) on developments in housing over the last 30 years (case studies), the work of Luís Morgado on emerging types of housing (Morgado, 2005), the work of Francisco Oliveira on new housing models and forms of contemporary housing appropriation (Oliveira, 2000), the work of Paiva, Aguiar and Pinho (Paiva et al, 2006a), (Paiva et al, 2006b) on housing rehabilitation, and the results of the survey applied to the field of study, on the basis of which certain contemporary housing trends were identified (case studies).

The changes that have taken place in society have had a significant effect on life styles and the structure of family housing. The main changes that have taken place in the structure of domestic units over the last 40 years are the reduction in average family size, the increase in the number of single people, the fall in the most typical format for the nuclear family i.e. the couple with children, and the reduction in complex units (containing various nuclear families and non-kinship relations) (Aboim, 2003).

The consequences of the mass entry of women into the employment market are the higher age at which the first marriage takes place, the higher age at which the first child is born, reduced fertility rates and therefore smaller families. In addition, this situation has led to a greater role sharing within the family, together with a more equal use of domestic areas. The fact that both partners work, combined with longer periods of time spent outside the home (working, travelling, other activities) are the consequences of a reduced or less continuous use of the dwelling by the family.

The increase in the divorce rate and average life expectancy, and the mobility of young people for the purposes of studying outside their usual place of residence together with the new, more individualistic, culture amongst the younger sections of the population, have led to a rise in the number of people living alone.

In addition to these changes, the emergence of new types of personal relationships between household members is also an important factor and includes recomposed families with children from different marriages, whose length of residence varies. Parallel to this, relationships between adults and young people within households has also changed, both in terms of autonomy and in the different ways in which parental authority is expressed. This change in basic family values has influenced the use of space, which is now used more informally and shared more amongst the different family members.

Parallel to the spread of ICTs and mobile equipment, new habits associated with individual privacy and, within households, the need for autonomy amongst family members have emerged (Pereira, 2006). In this context, the functions carried out in dwellings are changing, e.g. the inclusion of recreational activities and communications with the outside world in bedrooms, in addition to relaxing/sleeping.

In another context, it can be seen that standards for health, hygiene and environmental comfort requirements are much higher nowadays, with obvious consequences for the structure of housing, both in terms of planning buildings and housing infrastructures.

These and other social changes have had impacts on housing requirements that have been cited by various researchers, including those previously mentioned, namely: larger spaces; fully installed sanitation facilities; specific areas for the care of clothes; a private area for each adult in the household; a large living room offering facilities for new kinds of recreational equipment, in addition to serving as a reception room; a kitchen large enough to eat everyday meals in and for the family to gather in whilst meals are being prepared; divisions allocated no specific function, reserved for future use (e.g. as an office), for occasional use (e.g. as a guest room), or as a support zone for the rest of the house; areas for working from home, specifically for e-work; extra storage space; greater flexibility in functional organisation to allow for multiple uses of the same space.

In this context, the organisation of living space must be considered in terms of improving the way in which areas are adapted to contemporary life styles. In addition to specifically social matters such as families with smaller numbers of children, other issues have led to changes in the structure of housing. Within the context of this research, the most important are the impact of ICT, domotics and other technologies that have invaded our homes and are responsible for many of the changes in organisation, use and ways of living in these spaces. The existence of technological items in the home aims to establish interactivity between the space, the equipment and the user through intelligent performance involving regulation, monitoring and surveillance, amongst other facilities, in addition to establishing a link between physical and digital space. The diffusion of technological equipment across all the divisions in the household, often creating functional redundancies, provides areas with greater autonomy and personalisation, encouraging alternative uses of areas previously dedicated to one single function. For this reason, the traditional spatial hierarchies within housing are compromised and the nerve centres of the traditional household are changing.

Once we are aware of this new situation, the great question we face is that of being able to envisage a habitat, as a quality residence that is durable, will evolve slowly and can adapt to technologies or ephemeral elements and sees obsolescence as a major factor in its existence (Eleb et al, 1989: 97).

Case study "rabo-de-bacalhau buildings"

The housing stock built in the 50's and 70's of the last century was chosen to be the case study of this research on account of what it represents (circa 36% of Lisbon's buildings were constructed between 1946 and 1970) and its expectancy of rehabilitation in a short term. Although the existing housing stock in Lisbon has the potential to draw more population to the city, the truth is that 55% of dwellings built in the studied period require construction rehabilitation (INE 2002) and 24% was considered to be in medium to highly deteriorated conditions.

The large amount of buildings built at that period led us to select a case study that would allow a more specific and objective analysis and characterization (functional, constructional and social).

The type of building that was chosen is commonly labelled "tenement building" and among these buildings we selected the type "rabo-de-bacalhau" (Figure 2) mainly because their topology is very representative of the period and its presence in the city is large. These buildings present a "right and left" displacement, variable heights with a six-flour average, and a preponderance of reticulate concrete structure filled with masonry walls. In the two decades that this study concerns, it was observed a slow increase in the height of buildings, as well as the employment of new construction techniques and the increasing use of concrete. These dwellings are essentially very similar to each other, and present mainly two and three bedroom layouts, with relatively small, highly split areas.
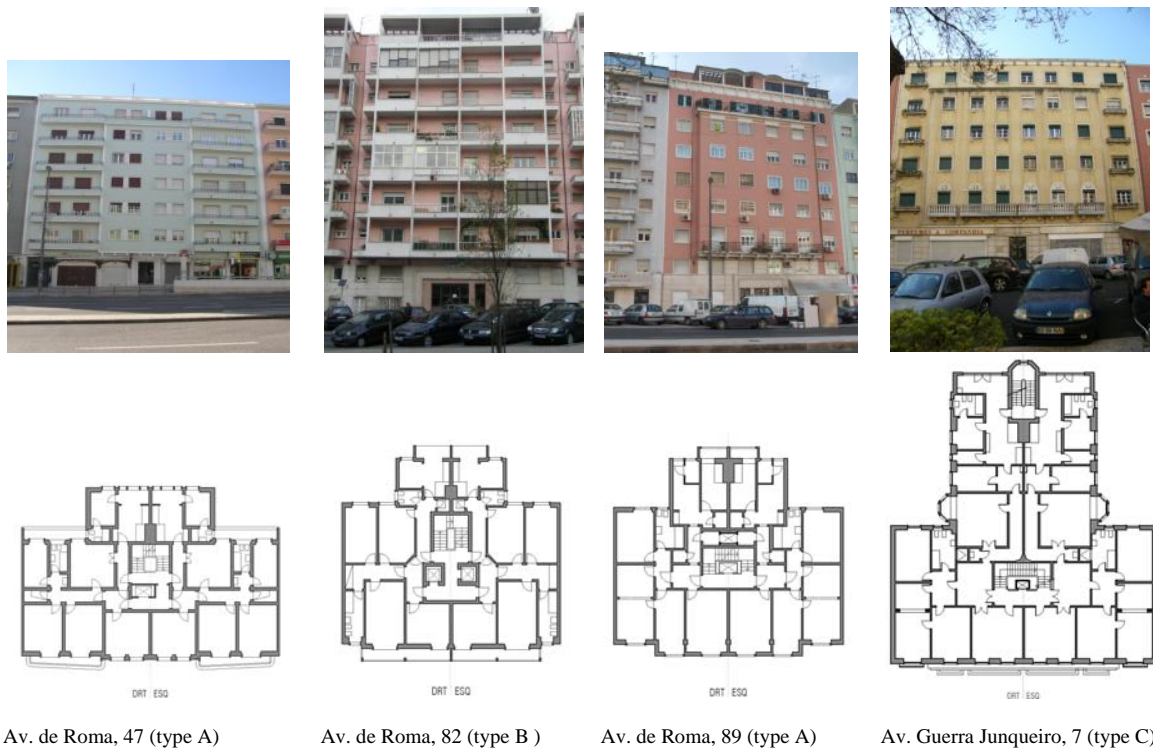

| Av. de Roma, 47 (type A) | Av. de Roma, 82 (type B) | Av. de Roma, 89 (type A) | Av. Guerra Junqueiro, 7 (type C) |

Figure 2 – Examples of "Rabo-de-bacalhau" buildings, photo and typical floor plan.

The need to rehabilitate these dwellings from a functional perspective is also vital, but perhaps not as easy to quantify as it is to understand.
The existing housing stock does not fulfill the present lifestyle's needs, both function wise and comfort standards wise. The selected housing stock, now a few decades old, present several problems that

jeopardize its functional and constructive performance, particularly in terms of comfort. This situation is the result of a set of factors, of which we underline the following: lifestyle changes that demand new needs and requirements; and the inexistence of regular repair works, which cause deterioration of materials, components and utilities.

"Rabo-de bacalhau" buildings constitute a specific type of building with similar functional, constructive, social and stylistic characteristics. The typification enable the definition of a base type of dwelling and four sub-types A, B, C and D (Figure 3). The base type includes features that are common to all sub-types:

–   2 dwellings on each floor with a left-right symmetrical layout;

–   Front wing with the facade facing the street. This facade is mainly occupied with rooms from the social and private areas;

–   Rear wing occupied by the services accommodations;

–   Vertical circulation in the core of the building without connections to the building facades;

–   Buildings with 4 to 8 floors with the mentioned floor arrangement repeated on all floors.
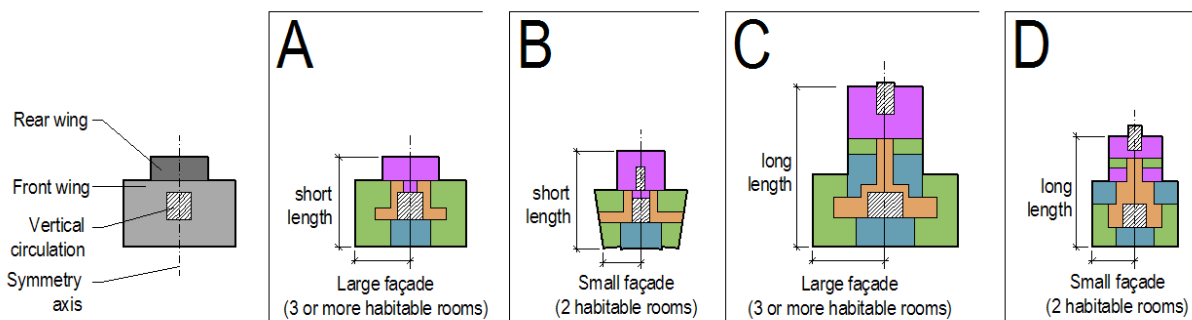

Figure 3 – Types of "rabo-de-bacalhau" dwellings

Results of the survey applied to the field of study shows that 43% of the dwellings have 2 residents and 19% are single people which demonstrate that there is excess available area within these dwellings.

Methodology for the rehabilitation

As previously stated ongoing research intends to define a rehabilitation methodology for Lisbon's existing housing stock so that it responds to new technology requirements and new ways of living. The fundamental goal of rehabilitation is to upgrade houses with the incorporation and actualization of ICAT and domotic infrastructures, while solving emergent conflicts in the use of spaces prompted by the introduction of new functions associated with such technologies. To tackle the problem of developing a general methodology for housing rehabilitation, we used a case study, the "rabo-de-bacalhau" building type. This allowed us to apply the methodology to concrete buildings with a specific morphology so that principles of transformation could be inferred and then tested. With these building we tested different hypothesis for functional rehabilitation.

It was then hypothesized that a rehabilitation methodology should encompass four steps, as shown in Figure 4. The first step consists in gathering the data needed for the rehabilitation process: the profile of the future dwellers and a description of the existing dwelling. The second step consists in using the family

profile to elaborate the ideal functional program of the dwelling – following Pedro's and Duarte's work on the housing program mentioned above – as well as the ideal pack of ICAT functions. The functional program in this case, is a description of an ideal housing solution for that family, not bound to any existing morphological structure or design language. In the third step, because the solution will be conditioned by the existing morphological structure, the existing dwelling, the ideal functional program, and the ideal pack of ICAT are used to derive a description of a compromised or adapted solution based on the existing dwelling. Finally, from the description of the adapted dwelling is obtained the layout of a design solution for that family in that dwelling, which includes the ICAT components needed in the dwelling.
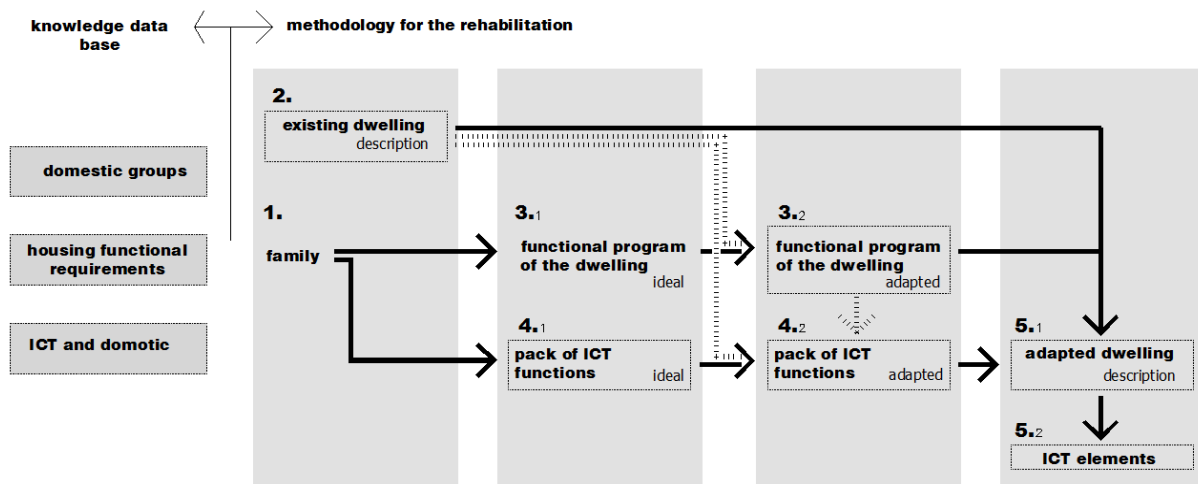

Figure 4 – Basic steps in the envisioned rehabilitation methodology.

Transformation grammar

The use of a specific case study allows the methodology defined above to be extended further. By using a specific type of building, a transformation grammar can be developed for this particular building type, therefore producing a specific methodology for "rabo-de-bacalhau" rehabilitation.

A transformation grammar is based on the theories of shape grammar. The initial investigations on shape grammars occurred more than thirty years ago with Stiny and Gips. (1972) Shape grammars are "*algorithmic systems for creating and understanding designs directly through computations with shapes, rather than indirectly through computations with text or symbols.*" (Knight 2000) A shape grammar is a set of rules that apply to shapes in a step-by-step way to generate a language of designs.

In the current research, we are using what we called a transformation grammar that enables existing houses to be transformed in a very precise and systematic way. This process was used to manage shape transformation within dwellings to create a systematic and methical process that could encompass all the valid transformation rules for a given dwelling. The transformations respond to functional and technical requirements as well as constructional requirements.

In order to evaluate functional conditions of the case study dwellings (original and rehabilitation's proposals) it was essential to define a reference structure to analyze spatial configurations. This task implies the definition of the fundamental performance criteria that allow housing spaces to fulfil their requirements. For this evaluation of spatial layouts and their influence on shaping patterns of human behaviour, we used space syntax to analyze the case study dwellings. Space syntax was conceived by Bill

Hillier and Julienne Hanson in the late 1970s as a tool to help architects simulate the likely social effects of their designs. In their theory, real space is represented by its parts which form a network of components related to each other. Following space syntax methodology, space is represented by maps with convex surfaces that describes spaces contiguity, adjacency, and proximity or by graphs with nodes and arcs that describe the accessibility and permeability of those spaces.

In the present research we use shape grammar as a tool do define the methodology for rehabilitating existing types and we use space syntax as a tool to evaluate the spatial properties of the existing and proposed dwellings designs.

Three rehabilitation strategies: in the search for diversity

In the beginning of the study two possible methods of transforming the dwellings were identified. In addition, a third method of transforming the dwellings was explored in order to create smaller dwellings for households consisting of one or two people.

Each of these three rehabilitation strategies has its own advantages and disadvantages in terms of functional and constructional aspects, and they can be combined within the same building to generate a wider market offer. The differences in the resulting transformations lie in the number of dwellings on each floor and the position of the kitchen in each dwelling.

The three strategies are as follows:

1. Maintaining two dwellings on each floor and moving the kitchen from its original position in the rear wing of the building to the front of the building.

    The aim is to strengthen the relationship between the social and service areas and to segregate the private area from the rest of the dwelling.

2. Maintaining two dwellings on each floor and the position of the kitchen.

    The aim is to keep construction transformations to a minimum without compromising the use requirements established in the functional programme. This strategy can be used to rehabilitate just one dwelling in the entire building.

3. Dividing one dwelling into two smaller ones and creating a kitchen in one of the new dwellings.

    The aim is to obtain smaller dwellings and a variety of dwelling types within the building.

Figure 5 shows the simplified derivation and decision tree for the three rehabilitation strategies described above, which is reflected in the structure of the transformation grammar.

For reasons of space and clarity of information, the decision tree shows only some of the transformation options for each strategy. The first transformation step shown is the choice of strategy, according to the resident/developer's objectives. It then shows the option of defining the social area for strategies 1 and 2 and their basic variations. For strategy 3, the second step consists of choosing between the three methods of dividing up the dwelling to create different types of housing. The third step shows the definition of private space, which may have various configurations. The tree aims only to simulate the derivation by considering the main functional areas and not the specific divisions, with the exception of the kitchen, which is the major defining space in the service area. Figure 5 is accompanied with graphs which provide a general view of the situations illustrated.

Figure 5 – Simplified derivation tree for the different rehabilitation strategies (Eloy, Duarte, 2011).

Strategy 1

In the first rehabilitation hypothesis the aim was to functionally reorganise the dwelling so that it would respond better to present day lifestyles. The kitchen is therefore situated next to the main façade so that it is conveniently linked to the main entrance and social areas, in particular the dining room. In this solution, the private areas are essentially located in the rear wing and are well segregated in relation to the remaining areas of the dwelling. In this proposal the circulation areas in the rear wing are maintained, since they provide access to the bedrooms and bathrooms.

The advantages and disadvantages of this strategy in terms of rehabilitating the dwelling and/or building are presented in Table 1.

Advantages	Disadvantages	
– Good location for social area, with direct access to the main entrance and connection to kitchen	– Changing the location of the kitchen has a major constructional impact, requiring new infrastructures	
– Location of kitchen/ social area improved, with direct access to the main entrance and connection to social area	– As it is located in the rear façade of the building, the drying area for laundry is included in the private area rather than the service area	Table 1 – Advantages and disadvantages of Strategy 1.
– Private area better segregated, offering greater privacy	– This strategy in isolation does not increase the range of typologies within the building	

Strategy 2

The second hypothesis was developed with the intention of producing a less intrusive proposal in both functional and constructional terms. From this perspective, the aim was to maintain the wet zones as far as possible and only add one or two bathrooms when necessary.

The option of keeping the kitchen in its original location led to three options for the social area:

- Relocating the entire social area (or its main divisions) to the rear, providing a link between the service and social areas with the frequent disadvantage that the rooms were not very large and had a linear arrangement;
- Keeping the social area in the front wing, linked to the main façade of the building and, consequently, away from the service area;
- Dividing the social area between the dining area (in the rear, near the kitchen) and the living room area in the front wing, linked to the main façade of the building, which has the disadvantage of separating the living/dining room areas.

In this rehabilitation hypothesis, the premise of keeping the kitchen in its original position made it unfeasible, in most cases, to comply with all the functional requirements for connections between the different functional areas. The advantages and disadvantages of this strategy are presented in Table 2.

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Advantages	Disadvantages	
– Few constructional impacts – Few changes to the original morphology of the dwelling	– Poor results in terms of relationship between social and service areas – Private area generally very exposed – This strategy in isolation does not increase the range of typologies within the building	Table 2 – Advantages and disadvantages of strategy 2.

Strategy 3

The third rehabilitation strategy was explored with the aim of creating a more diverse offer within the building. The possibility of combining T0, T1 and T2 dwellings with other larger types such as T3s or T4s within the same building allows for greater social diversity and increases the real estate value of the building.

In addition, certain studies show that the demand for rehabilitated dwellings comes mainly from young families consisting of 1 or 2 individuals and that the desired types are T0, T1 and T2 (Caria, 2004: 163). "Rabo-de-bacalhau" buildings can therefore only be adapted to meet this demand by dividing one dwelling into two smaller ones.

It is interesting to note that, although divided, one of the new dwellings (the one in the rear) will always have areas with greater depth or segregation, given that the building is organised in terms of a long passage from the front wing to the rear. This occurs essentially in types C and D. In types A and B, in which the main nucleus for vertical access within the building offers two possible entrances to the dwellings, this can be inverted.

The advantages and disadvantages of this strategy are presented in Table 3.

Advantages	Disadvantages	
– Creates a range of typologies within the building – Offer meets demand – Makes building more profitable by providing accommodation for a larger number of families	– The addition of a kitchen has major constructional impacts, requiring new infrastructures – The dwelling which only opens onto the main façade has no outdoor area for drying laundry – In some cases dividing the dwelling involves removing space from the original hall to accommodate the two new entrances.	Table 3 – Advantages and disadvantages of strategy 3.

The dwellings can be divided in three different ways: by dividing the dwelling in half; by dividing the dwelling in half but ensuring that the rear dwelling has one habitable division at the front of the building; by dividing the dwelling in half but ensuring that the front dwelling has one habitable division in the rear (Figure 5). The combination of different types of divisions on floors creates different typologies within

the same building, thus creating greater diversity. In each of the new dwellings, the aim was to ensure that the new infrastructures required for the bathrooms and kitchen were planned around the same duct.

Combining the three rehabilitation strategies

It is possible to combine all three rehabilitation strategies within the same building. Strategies 1 and 3 have a greater constructional impact and require new infrastructures for the position of the new kitchen. These include a new vertical drainpipe as well as a chimney. The new bathrooms proposed in all three strategies need new vertical infrastructures or macerating pumping systems units. The combination of Strategies 1 and 2 would have a major constructional impact because of Strategy 1 and would not generate new dwelling types within the building, thereby leading to a narrower market offer. The combination of Strategies 1 and 3 would also have a major construction impact but would generate new dwelling types.

If only one or a small number of dwellings in the same building are rehabilitated, the second strategy is recommended, since this does not require new vertical ducts for the infrastructures. If the decision is made later to rehabilitate the entire building, Strategy 2 can be combined with the other two strategies.

Using space syntax indexes we reach to the conclusion that dwelling characteristics as depth integration and control differ according to the rehabilitation strategy chosen. These properties also differ according to the original dwelling types. These results suggest that the "rabo-de-bacalhau" dwelling types A to D have particular characteristics which enable specific rehabilitation strategies to be carried out. This observation leads to the conclusion that a combination of rehabilitation strategies and dwelling types enables designs to be produced for various life-styles, therefore meeting current market demands.

Conclusion

Over the last decades, social and technological changes have affected the ways of living and the requirements and functions of housing. These have changed the families' lifestyle, thereby making traditional house types inadequate to the contemporary society's demands. Although the concept of family unit still represents the majority of homes, the crescent number of other forms of cohabitation and new ways of grouping individuals cannot be ignored.

These new emerging forms of cohabitation need to be satisfied by the housing sector through the renovation of urban areas and the rehabilitation of dwellings.

One premise of the current research is that the functional adaptation of houses to new ways of living and to the diversity of current needs and requirements can be facilitated by the incorporation of ICT and domotic. However, the emergency of new functions in homes calls for new approaches to the design of domestic spaces, in which it is necessary to incorporate the diversity of conventional spaces to the multiplicity of new-functions created by the emergence of activities like telework.

The development of a methodology that encompass several strategies to implement functional and construction rehabilitation as well as to create diversity within the housing sector was presented and demonstrate to be viable. The use of shape grammar to generate the housing solutions and space syntax to evaluate them will allow for customized dwelling solutions based on common rules to all the "rabo-de-bacalhu" buildings.

This strategy of housing rehabilitation will enable more lively neighbourhoods populated by mixed generations and family types.

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