ACCESSIBILITY IMPROVEMENT MODELS FOR TYPICAL FLATS: MASS-CUSTOMIZABLE DESIGN FOR INDIVIDUAL CIRCUMSTANCES

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Accessibility improvement models for typical flats: mass-customizable design for individual circumstances

ABSTRACT

Elderly housing policies in Finland emphasize ageing-in-place and pursue preparing the existing housing stock for the predicted increase of the aged population. Timely home modifications enhancing mobile accessibility are a focal target for these policies. This paper introduces the idea of mass-customizable architectural accessibility improvement models (AIMs) that have been developed for typical Finnish flats. The applicability and generalizability of an AIM designed for an archetypal two-room flat is tested by applying it to nine case buildings in the city of Tampere. The model was found to be beneficial for 42 of the 45 rooms in the research material.

KEYWORDS

Architectural design, home modifications, housing stock, interior spaces, refurbishment, universal design

INTRODUCTION

The populations of many developed countries are growing older (Giannakouris, 2010; Lanzieri, 2011; Suzman & Beard, 2011), but in Finland, the ageing is expected to be more rapid than in any other European country (Tuorila, 2014). This has made Finnish governments pay attention to the living conditions of the elderly and prepare for the increase of the aged population. Accessibility improvements were given a prominent position in the National Renovation Strategy for years 2007–17 (Ympäristöministeriö, 2007). Living at home was prioritized in legislation (Vanhuspalvelulaki, 980/2012) during the administration of the previous government, which also considered elevator retrofits, home modifications and increasing accessibility in the housing stock as focal housing policy targets for supporting the autonomy of aged Finns (Valtioneuvoston kanslia, 2011) and launched a Development Program for the Housing Conditions of the Elderly for the years 2013–17. The current, austerity-driven government is set to increase home care and services delivered at home, since they are considered to be more cost-efficient than assisted living facilities or institutional care (Valtioneuvoston kanslia, 2015).

Although the Finnish housing stock is one of the youngest in Europe (Hassler, 2009), a number of shortcomings have been detected with its age-friendliness (Sorri, 2006; Verma, Kilpelä & Hätönen, 2012; Kaasalainen, 2015). The first provisions on accessibility of buildings were issued in 1979, but they considered only public buildings. The regulation came to encompass residential buildings as late as in 1994, and at first, they only touched upon apartment buildings with four or more floors. The norms were extended to encompass low-rise housing in 2005. (Verma et al., 2012). Consequently, aged homebuyers have been found to prefer brand new homes due to bad previous experience from older dwellings (Hirvonen, Manninen & Hakaste, 2005). The Ministry of the Environment has estimated that only 10% of the existing housing stock is accessible (Väyrynen, 2014).

However, over 65-year-old Finns already make up 20% of the population, and the share is expected to grow to 28% by 2060. The increase will be especially significant in the oldest age classes. (Statistics Finland, 2015). The authorities' aim is that in future, 92% of over 75-year-olds would be able to live at home, while 89.5% of them do so at the moment (Ympäristöministeriö, 2012). In addition, permanent and temporary physical disabilities are estimated to affect 10% and 5% of the population, in a respective order (RTS, 2011). In all, circa one-third of the current population could, thus, benefit from a wider existence of accessible homes.

Therefore, the target is to increase the share of accessible dwellings from the current 10% to 30% by 2030. The plan is to meet 60% of this target with refurbishment, 60% of which would take place in blocks of flats. The goal is to refurbish 14 500 flats annually, *i.e.* 250 000 flats by 2030. Since the emphasis of accessibility renovations has long been on elevator retrofits, the interest is now shifting to internal accessibility improvements. (Ympäristöministeriö, 2012). These are expected to touch on 7500 flats annually or 135 000 flats in total (Ympäristöministeriö, 2012), which equals to 10% of the stock (Statistics Finland, 2015).

The expert group that prepared the Development Program for the Housing Conditions of the Elderly concluded that the focus of accessibility improvements is to be placed on the 1960–80s mass housing for a number of reasons (Ympäristöministeriö, 2012). First of all, these three decades represent the most notable era of Finnish housing construction in terms of volume, making up 56% of all Finnish flats (Statistics Finland, 2015). Secondly, this stock is acknowledged to be in need of repair due to erstwhile underdeveloped building techniques and materials (Kaasalainen & Huuhka, 2015a), and the authorities see the coincidence of the ageing of buildings and the ageing of population as an opportunity to slip home modifications into the usual facade and plumbing renovations (Ympäristöministeriö, 2012). Thirdly, improving accessibility in this stock is less complicated than in older stocks, due to more spacious dimensioning, existence of elevators in some of the buildings and the lesser extent of heritage values (Verma et al., 2012). Fourthly, the stock accommodates a significant share of the older population (Lankinen, 1998; Kivi & Nurmi-Koikkalainen, 2007).

Purpose and goals of the paper

This paper is a continuation for previous research on Finnish housing stock and studies related to accessibility and elderly housing. The current authors are set to create a link between the two branches of investigation. The paper introduces the idea of accessibility improvement models (AIMs) that are based on typical flats and intended to facilitate the initiation of home modifications. In studying Finnish multi-story housing from the late 1960s to the mid-1980s, Kaasalainen and Huuhka (2015a) recognized 18 recurring flat types, which were found to cover over 80% of the flats of the era – in all, circa 30% of Finnish flats. Taking advantage of these findings, Kaasalainen (2015) analyzed accessibility problems occurring in these homes and developed AIMs for the six most common flat types that altogether encompass circa two-thirds of the 1960–80s stock, or one-fourth of all Finnish flats. The goal of the AIMs was to be applicable to a large number of homes with as few modifications as possible. (Kaasalainen, 2015). The purpose of the current paper is to enlarge the knowledge by testing the applicability of an AIM on randomly selected homes from the respective era. Based on the results, discussion is presented about the usefulness of the concept and the development needs observed.

AGEING-IN-PLACE AND HOME MODIFICATIONS

Benefits of ageing-in-place

Although housing policies pursuing ageing-in-place are often driven by the desire to reduce institutional care in order to achieve cost savings, at the same time it should be noted that aged people in many countries, including Finland, prefer to continue living at home (AARP, 2005; Bayer & Harper, 2000; Ewen & Hahn, 2014; Fänge & Ivanoff, 2009; Haapola et al., 2009; JCHS, 2013; Turcotte & Schellenberg, 2007; van Hoof, Blom, Post and Bastein, 2013; Warnes, 1993). The home has been found to constitute an important part of one's identity at an older age (Aminzadeh, Dalziel, Molnar & Garcia, 2010; Fänge & Ivanoff, 2009; Kivi & Nurmi-Koikkalainen, 2007) and living at home has been shown to have positive implications for the wellbeing of older people (Aminzadeh et al., 2010; Heywood, 2001). Its benefits for physical, mental and cognitive health arise from, as Aminzadeh et al. (2010) sum up, 'autonomy, affinity and constancy of environment; participation in activities of daily living and home maintenance as a source of physical and mental exercise; connection with friends and family, entertainment and reciprocation of hospitality; and residence in a specific neighbourhood, including social network of neighbors and access to community services' as well as from modulating 'the experience of an illness or decline'.

The role of home modifications

While housing is only one aspect of ageing-in-place (Horner & Boldy, 2008; Verma & Huttunen, 2015), the tendency towards living at home has been found to require paying more attention to the age-friendliness of home environments (Afifi et al., 2014; Verma & Huttunen, 2015). In Finland, one of the main reasons for moving to an assisted living facility is a housing stock that does not provide the elderly with enough support (Verma & Huttunen, 2015). Home modifications, though, have been found to have a positive effect on ageing-in-place (Heywood, 2001; Hwang, Cummings, Sixsmith & Sixsmith, 2011; Kajanus-Kujala, 2008).

The elderly who have had architectural modifications done in their home are more independent in daily tasks than those who have not (Fox, 1995; Petersson, Kottorp, Bergström & Lilja, 2009) and are likely to continue living at home for longer (Hwang et al., 2011). The improved functional abilities reduce the burden of family caregivers and strengthen the persons' psyche by enabling experiences of security, safety, comfort, control, mastery and self-efficacy (Tanner, Tilse & de Jonge, 2008). Furthermore, modifications ease home care (Sipiläinen, 2011; Kim, Ahn, Steinhoff & Lee, 2014) and can even participate in delaying mortality (Gitlin et al., 2009). At best, ageing-in-place, supported by home modifications, benefits individuals, their families and the wider society.

Further considerations

It has been found that home modifications need to be done early enough in order to be beneficial (Petersson et al., 2009). This conclusion is supported by statements that emphasize the significance of the stability and familiarity of the home environment in the face of physical and cognitive decline (Aminzadeh et al., 2010; Horner & Boldy, 2008; Yeo & Heshmati, 2014). In this light, the Finnish governments' aim to prepare the housing stock for ageing in advance becomes more understandable.

The needs of the elderly are individual, and the variation in those needs has been found to increase as the number of older people increases (Bakker, 1999). Thus, although there are standards for accessibility, home modifications themselves must not be standardized. Therefore, the AIMs to be presented in the next chapter are based on multiple stages of improvements and alternative solutions.

In practice, a major consideration in engaging in home modifications is cost. Income has been shown to predict having home modifications and a conclusion has been drawn that modifications should be available at an affordable cost (Fox, 1995). Similar statements have been presented in several studies (Kajanus-Kujala, 2008; Marquardt et al., 2011; Verma & Huttunen, 2015). Therefore, the AIMs also consider residents' differing financial resources.

RESEARCH MATERIAL AND METHODS

Flat types

This study is based on the typology of flats (Figure 1) defined by Kaasalainen and Huuhka (2015a) for the buildings years 1968–85 and the AIMs that were developed for the most common of them by Kaasalainen (2015). As follows from the principles of typology (Argan, 1963), the types are not plans of any singular flats but fusions of typical properties of several flats (Figure 2). Kaasalainen and Huuhka (2015a) defined the flat types using plans of 320 apartment buildings with a total of 8745 flats. The most commonly occurring flat type, referred to with the code '2-1A', was chosen for the current study. It occurred in half (158) of the buildings. Figure 3 presents the type *i.e.* the theoretical flat in scale. According to Kaasalainen and Huuhka (2015b), this type covers 15.7% of all flats from years 1968–1985 and 35.0% of all the two-room flats built during those years. Furthermore, types 3-1A, 3-3 and 4-1A are similar apart for the additional rooms. This denotes that the AIM created for 2-1A can be useful for up to one-third of the era's flats. The present paper tests and evaluates the applicability of the AIM by applying it to a sample of nine randomly selected cases. Because the flat type is based on a large sample in which the variation of dimensions was very limited (see Figure 2), the hypothesis is that the AIM would be applicable to a clear majority of the cases.

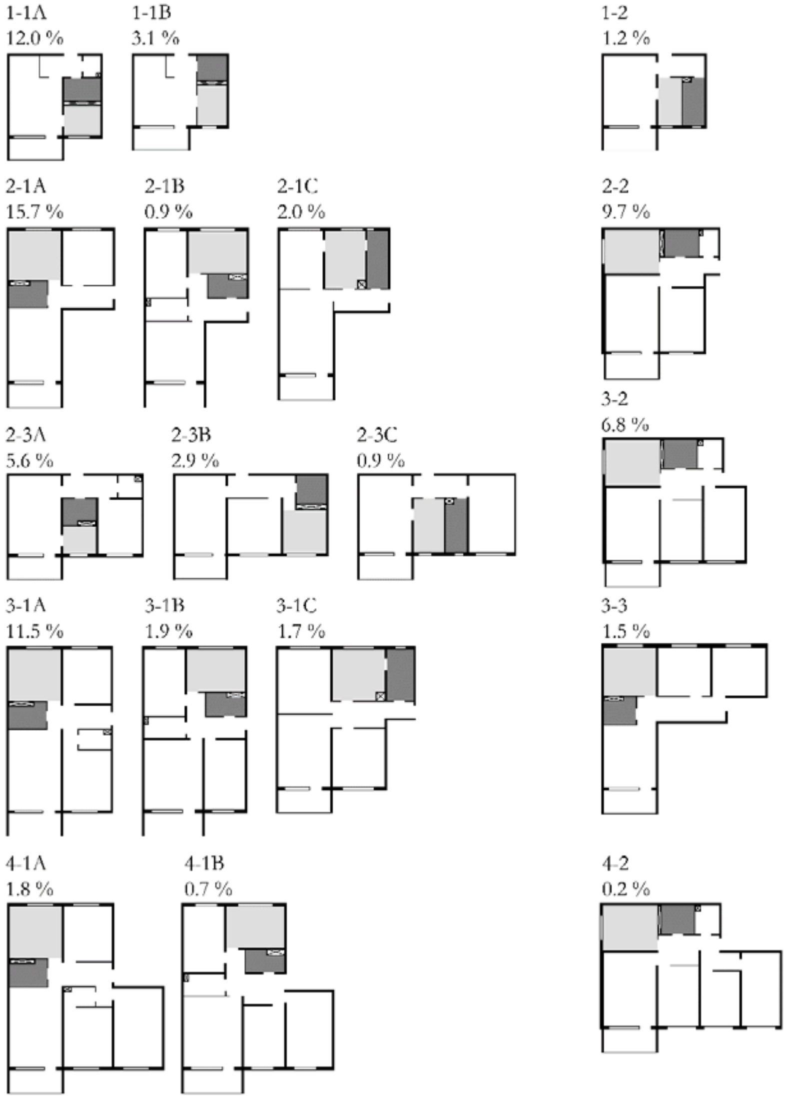

FIGURE 1 The typology of Finnish 1960–80s flats, scale 1:500. The codes of the types and their shares of the respective stock are given above the plans. Bathrooms are marked with dark grey and kitchens/kitchenettes with light grey. Types on the left are variations of the same main type, with the bathroom and a possible walk-in closet changing place but the main rooms staying put. The types on the right do not have subtypes. The figure is based on Kaasalainen and Huuhka (2015a; 2015b). In Kaasalainen (2015), AIMs were created for types 1-1A, 2-1A, 2-2, 2-3A, 3-1A and 3-2.

FIGURE 2 The method for creating the flat types in Kaasalainen and Huuhka (2015a) and the variation in the dimensions of the flats, scale 1:250. As the figure illustrates, the type plans (Figure 3) were the result of piling translucent line-weighted color-coded graphs that were made from the original plan drawings, aligned along the circled bathroom front wall, and by defining mean values for the dimensions of rooms and locations of windows and doors visually. (Kaasalainen & Huuhka, 2015a).

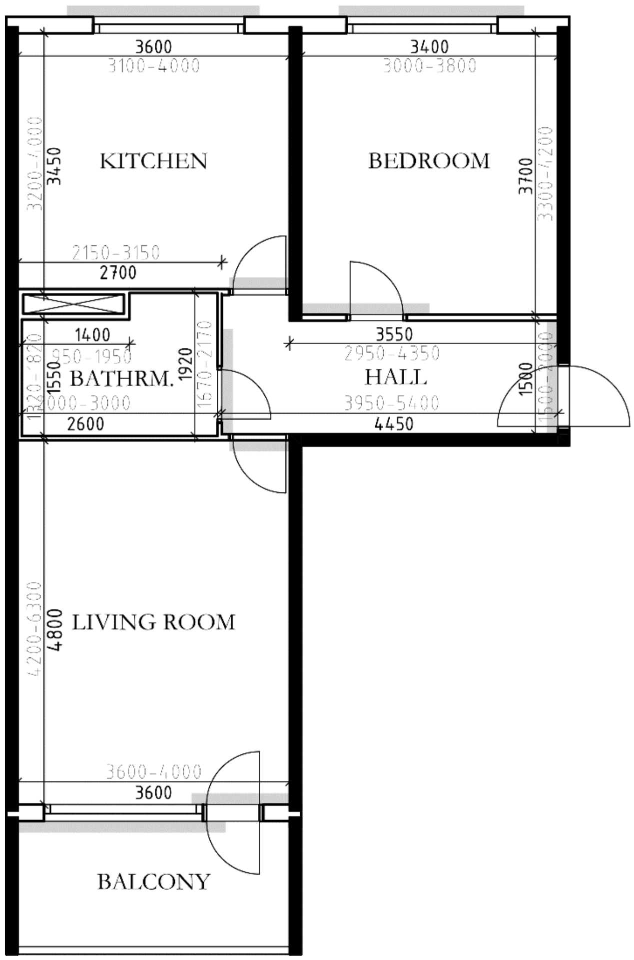

FIGURE 3 A theoretical flat representing a large two-room unit, typical dimensions, load-bearing structures and fixtures in scale 1:100. The room dimensions used in the drawing are given in black; they as well as the drawn locations of doors and windows are mean values. The dimensions given in grey as well as the grey bars next to doors and windows represent the usual ranges for these features. Load-bearing walls are drawn in black. The figure is based on Kaasalainen and Huuhka (2015a) and Kaasalainen (2015).

Accessibility improvement models (AIMs)

The starting point for the development of the AIMs was the Finnish regulation for accessible housing design (RTS, 2006). Alas, comprehensive studies comparing various national accessibility-related building regulations were not found in English or Finnish. The closest to this was a comparison of minimum accessible toilet dimensions by Dion (2005), which is presented in Table 1 along with the Finnish requirements. Based on the figures, Finnish standards appear to correspond fairly well to other countries' guidelines, the Finnish requirements being stricter in most cases. Although the table presents dimensions specifically for the bathroom, the minimum door opening is universal throughout the flat and the other figures are likely to reflect more general spatial requirements as well. Furthermore, the bathroom has been noted to be the most common object of renovation in elderly people's households in Finland (Verma, Aalto, Anttila, Aro & Åkerblom, 2006), so it is of special interest.

TABLE 1 Minimum accessible toilet dimensions according to various standards. *Sources:* Dion, 2005; RTS, 2008.

	Minimum floor dimensions, mm		Minimum door clear opening, mm
	Dimension 1	Dimension 2	
ACCESS (UNKNOWN)	1500	1500	850
ADA (U.S.)	1525	1420	815
ANSI (U.S.)	1525	1420	815
AUSTRALIA	2000	1600	800
BEIJING (CHINA)	1600	1400	900
CSA (CANADA)	1500	1500	810
ENGLAND	2000	1500	1000
FIJI	2300	1900	850
FINLAND	1900	1500	850
KENTUCKY (U.S.)	1600	1422	813
NBC (CANADA)	1700	1700	800
UFAS (U.S.)	1524	1422	813

The development of the AIMs began with analyzing the problems of the flat types with the help of norms, guidelines and research literature (Figure 4 and Table 2). The main focus was on mobile accessibility, although other issues such as cognitive problems were also considered. Since they largely encompass aspects that are not visible in the floor plan, such as colors and surface materials, which also have short service lives, it was not possible to analyze the current state of the stock or to portray the modifications in the plan format. Therefore, design guidance (on *e.g.*

clearly distinguishable floor and wall surfaces and contrasting trims) was given as text in the original publication (Kaasalainen, 2015), as were instructions on lighting, materials and alarm systems. Easy comprehensibility was also a key consideration in the changes made to the layout. Possible caregivers were taken into account where relevant, such as around the bed and the toilet, where the assisting space required by the Finnish regulation was ensured. In addition to these particular locations, the increased spaciousness in general makes it easier for the caregiver to assist the resident wherever necessary. Primarily, however, the solutions were designed for an independent occupant, therefore including, for example, a full kitchen. Specific choices of appliances were not considered, only the room needed to place and operate them.

TABLE 2 Accessibility problems in the flat type 2-1A, see Figure 4. Accessibility problems in other flat types are similar.

Number in Fig 4	Location or object	Problems	Implications	Risks	Sources
1	Hall	Narrowness, especially near the entrance when original fixtures are in place.	Lack of space for a wheelchair or a walking aid.	Reducing autonomy in daily tasks.	Sorri, 2006; Kaasalainen, 2015
2	Doors	Narrowness; opening angle < 180°; two leaves (entrance and balcony); high thresholds (especially balcony and bathroom).	Hinders use with reduced walking ability, especially when using a wheelchair or a walking aid.	Risk of falling; reducing autonomy in daily tasks.	Sorri, 2006; Verma et al., 2012; Kaasalainen, 2015
3	Floor	Level difference between the bathroom and the balcony and the rest of the flat.	Hinders use with reduced walking ability; prevents use with a wheelchair.	Risk of falling; reducing autonomy in daily tasks.	Neuvonen, 2006
4	Bathroom	Lack of space; high threshold to tub; slippery, materials that are difficult to clean.	No space for assistance; hinders use with reduced walking ability, especially when using a wheelchair or a walking aid.	Risk of falling; reducing autonomy in daily tasks.	Sorri, 2006; Verma et al., 2012; Kaasalainen, 2015
5	Kitchen	Low and shallow toe kicks, no knee space, deep and narrow cabinets and closet, no dishwasher, sink in the corner.	Hinders use with reduced mobility, limits use with a wheelchair.	Reducing autonomy in daily tasks; risk of sustaining burns; risk of injury when reaching.	Sorri, 2006; Kaasalainen, 2015
6	Bedroom	Deep and narrow closets with hinged doors	Hinders use with reduced mobility, limits use with a wheelchair.	Reducing autonomy in daily tasks; risk of injury when reaching.	Kaasalainen, 2015

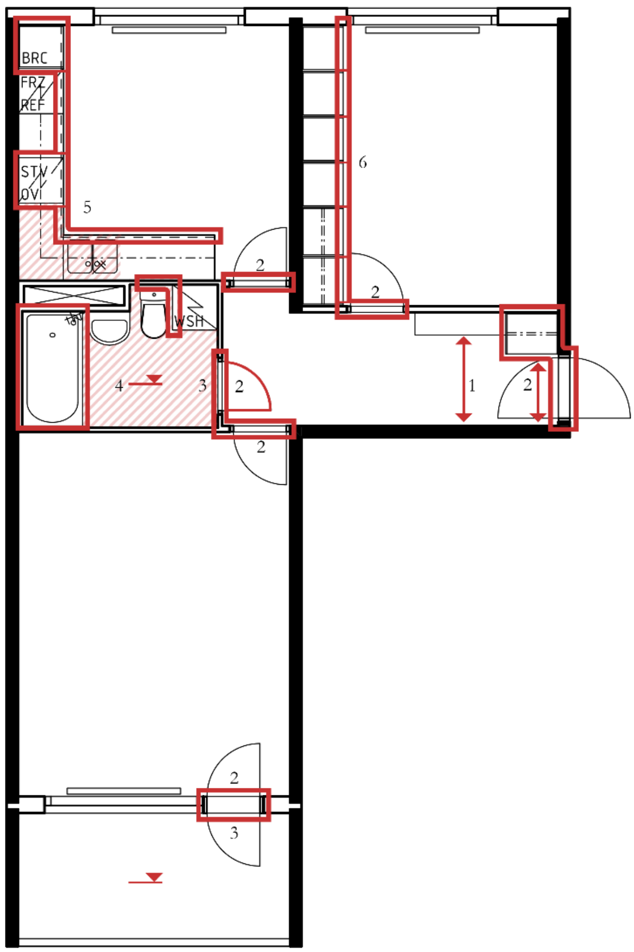

FIGURE 4 Accessibility problems in the flat type, scale 1:100. The key is given in Table 2. The figure is based on Kaasalainen (2015).

To account for individual conditions, such as accessibility needs and financial resources, and developments in them, the improvements were divided between four stages based on scope of action, level of cost and actorness (Figure 5 and Table 3). All the stages have been designed to aim at the same end result, allowing modifications to be staggered or individual measures to be picked without needing to implement all of those presented on that stage. Therefore, the stages are not a rigid progression as much as a set of categories for modifications—they can be implemented in the order of the stages, but this is not necessitated by the AIM.

When it comes to bathrooms and balconies, the lower levels' ability to result in fully accessible solutions depends on the favourability of the original properties of the flat. In some cases, only some of the lower-stage modifications might be required to achieve full physical accessibility, but as a rule, extensive structural work is needed. This is because bathrooms tend to have a level difference with the rest of the flat and they are usually not large enough to meet the current accessibility standards.

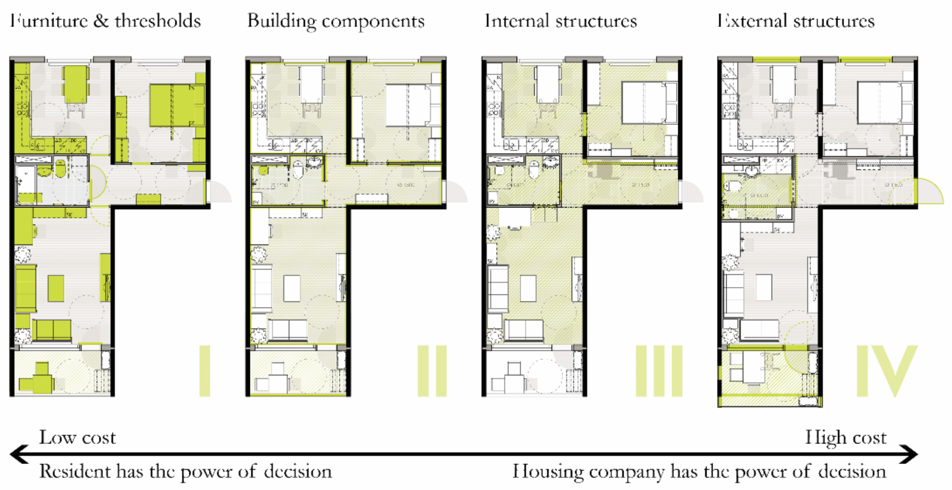

FIGURE 5 A four-stage AIM for a two-room unit, scale 1:250. The figure is based on Kaasalainen (2015). Rebuilding the bathroom is considered a part of 'external structures' because enlarging it and changes to drainage have implications for the flat below. See Table 3 for more detailed description of the modifications on different stages. The principle in developing the model has been that the changes made in the lower stages do not compromise the modifications suggested in the higher stages. The changes made are based on current Finnish accessibility regulations for housing design in conjunction with other literature on the subject (e.g. Bakker, 1999; Könkkölä, 2003; RTS, 2006; 2008; van Hoof et al., 2013). In addition to the material focused on the actual design part, a comprehensive literature review was conducted on the implications of ageing to gain an actual understanding the factors behind the design decisions (see the bibliography in Kaasalainen, 2015).

TABLE 3 Modifications on different stages of AIMs, see Figure 5.

Stage I	**Stage II**
Rearranging furniture; Changing fixtures not requiring structural changes; Adding grab bars and handles; Adding lifts and alarms; Removing or replacing thresholds; Removing or replacing interior doors.	Replacing hinged doors with sliding doors; Removing interior door frames; Replacing a non-fixed bathtub with a shower; Changing surface materials; Adding balcony glazing.
Stage III	**Stage IV**
Complete or partial dismantling of interior walls; Enlarging doorways and installing pocket doors; Replacing a fixed bathtub with a shower; Changes to floors and ceilings not limited to surface materials.	Structural work in the bathroom such as removing a level difference or moving the walls; Changes to the façade walls such as replacing and enlarging windows; Replacing or enlarging the balcony.

The 4th stages of the AIMs consist of three exemplar customization alternatives (Figure 6 and Table 4): the baseline is for an independent wheelchair user; the second alternative is for a visually impaired resident that uses a walker; and the third one is for a resident that receives care on a regular basis. The differences lie mostly in furnishing and lighting, all the alternatives solutions for which have been designed to be interchangeable between the variants without structural changes. The option of having two separate beds instead of a double bed was incorporated into the design for a visually impaired resident. One variant presents a situation in which a wheelchair for outdoor use must be stored inside the apartment, requiring space to be arranged in the hall. Studio flats excluded, the caregiver variant includes personal sleeping and storage space for the caregiver (a bedroom or a sleeping alcove). (Kaasalainen, 2015).

FIGURE 6 Customization alternatives for the 4th stage, scale 1:250. A is for a wheelchair user; B is for a visually impaired resident using a walker; and C is for a resident receiving care on a regular basis. Table 4 elaborates on the differences. The figure is based on Kaasalainen (2015).

All the AIMs were peer-reviewed by an architect and a researcher of accessible architecture Marta Bordas Eddy who is a wheelchair user and a specialist in universal design and, since the original publication (Kaasalainen, 2015) is a thesis, by a group of scholars consisting of professors and senior lecturers in the School of Architecture, Tampere University of Technology.

The current study utilizes the baseline version, *i.e.* the alternative customized for a wheelchair user, presented in detail in Figure 7 and Table 5. This is the AIM the applicability of which is evaluated to randomly selected flats of the corresponding type.

TABLE 4 Customization alternatives for the 4th stage of the AIM, see Figure 6.

Location	IV A (baseline): A wheelchair user and a fully functional resident	IV B: A wheelchair user and a visually impaired walking aid user	IV C: A wheelchair user staying mostly in bed and a temporarily residing caregiver
Whole flat	Accessibility, safety and usability for an independently functioning wheelchair user, room for basic assisting. Grab bars or provisions for them added where needed. Materials, though not visible in the plan, should be easy-to-clean, non-allergenic, non-slippery and colored appropriately for cognition.	Basic lighting plan, applicable to all variants. Includes both general illumination and specific lighting such as at work areas, inside closets and around mirrors. Color choices, though not visible in the plan, are important to help perceiving the environment, if some degree of vision remains.	Details of the layout are more compact than in other variants, since the fully functional caregiver performs the daily chores, such as cleaning and cooking.
Living room	Area slightly reduced to increase space in bathroom. Furniture arranged to ease use, have room for the wheelchair user and to provide a barrier-free access to the balcony door.	The number of furniture reduced to have more room for both residents using mobility aids.	The resident's bedroom moved to the living room for a more comfortable environment, more space for assisting and better access outside, either visual or to the balcony. Bed replaced with an adjustable bed with space on both sides; sliding door added for privacy.
Bedroom	Furniture changed and repositioned to ease access.	Two separate beds to provide access for ambulatory aid for both residents.	Original bedroom furnished as a private room for the temporarily residing caregiver.
Kitchen	Appliances and fixtures changed to ease access and use with reduced mobility.		Kitchen organized to be mainly used by the fully functional caregiver.
Hall	Increased space near furniture and for storing a wheelchair for outdoor use.	Storing the wheelchair for outdoor use is assumed to be possible outside the flat; if not, the hall should follow one of the other variants.	Wheelchair for outdoor use stored in the hall; storage is more compact as the use is infrequent and facilitated by the caregiver.
Bathroom	Increased space for use and basic assisting, added room for laundry.		More assisting room provided in the bathroom by moving the toilet seat further from the wall and extending the shower area; washer/dryer stacked to save space as they are used by the caregiver.
Balcony	Increased space through extension or replacement of balcony.	The number of furniture reduced to have more room for both residents using mobility aids.	

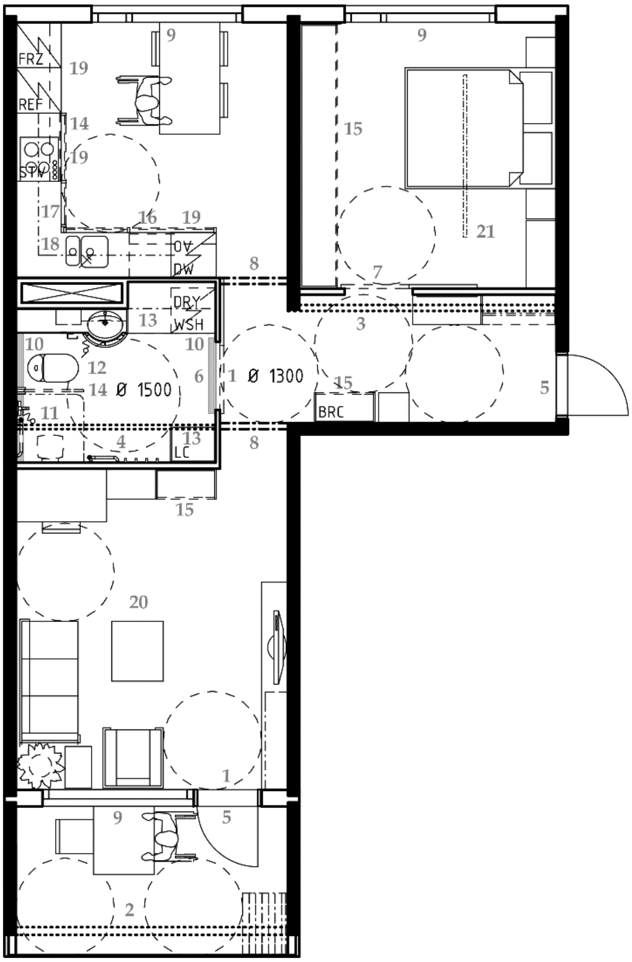

FIGURE 7 Accessibility improvement model, 4th stage plan customized for a wheelchair user in scale 1:100. The figure is based on Kaasalainen (2015). The key is given in Table 5.

TABLE 5 4th stage modifications in detail in flat type 2-1A, see Figure 7.

Number in Fig 7	Modification	Purpose	Stage of origin
1	Level difference removed between hall and bathroom as well as living room and balcony.	Ease moving; reduce risk of falling; enable use with a wheelchair.	IV
2	Balcony extended or replaced with a larger one and equipped with glazing.	Enhance use.	II / IV
3	Bedroom wall pulled back.	Increase spaciousness in the hall to enable wheelchair storage and ease moving.	III
4	Bathroom extended towards the living room.	Increase spaciousness in the bathroom to enable use with a wheelchair or a walking aid and to ease assistance.	IV
5	Old doors replaced with larger, single leaf doors with no thresholds.	Ease use and moving.	I
6	Larger entrance to the bathroom with a sliding door and without a threshold.	Ease use; enable use with a wheelchair.	IV
7	Sliding door to the bedroom.	Ease use.	II
8	Kitchen and living room doors and their frames removed.	Ease moving.	I / II
9	Windows changed to ones with lower sill.	Ease use of window mechanisms; increase visibility when seated.	IV
10	Trench drains added.	Drain the floor when the threshold has been removed.	IV
11	Bathtub replaced with an accessible shower.	Ease use; enable use with a wheelchair.	II / III
12	Toilet seat and sink moved.	Ease assistance and the transfer between a wheelchair and the toilet seat.	II / IV
13	Added a laundry closet and a washer/dryer combination with increased table space.	Ease use.	I/ II / IV
14	Grab bars added where needed, structural requirements for future installations considered in relevant places.	Ease use; reduce the risk of falling.	I
15	Closets replaced with shallower and wider models with sliding doors.	Ease use.	I
16	Kitchen cabinets replaced with drawers.	Ease use.	I
17	Lowered upper cabinets with ability to pull down if needed.	Ease use.	I
18	Knee space and deeper/taller toe kicks added.	Enable use with a wheelchair or when seated.	I
19	Dishwasher added; a stove/oven and a freezer/refrigerator replaced with separate appliances.	Ease use; reduce risk of sustaining burns.	I / IV
20	Furniture rearranged.	Ease moving and provide space for a wheelchair user.	I
21	Lift installed above the bed.	Ease transfer between the bed and a wheelchair.	I

Cases and evaluation criteria

The research material for testing the applicability was picked from the city of Tampere, Finland, since the authors had easy access to the archives. The sample is random apart from the facts that the buildings were taken 1) from neighborhoods known to have blocks of flats from the year range of interest (1968–85) to minimize unnecessary searching; and 2) as evenly throughout the year range as possible in order to cover the whole period. The material initially consisted of twelve buildings, nine of which exhibited flats of the studied type. All flats of the same type were identical within their respective building, making the number of plans that form the research material also nine. These plans (Figure 8) are later referred to as 'comparison flats'. An attempt to apply the baseline version of the 4th stage of the AIM was made to each of them. The applicability of the AIM was studied in ArchiCAD architectural design software on a room-by-room basis according to the criteria given in Table 6.

FIGURE 8 The research material, *i.e.* the plans of the nine comparison flats corresponding to the flat type in question, scale 1:250.

TABLE 6 Criteria of applicability of the AIM.

Applicable without changes	Applicable with changes to the layout	Applicable with additional structural changes	Not applicable
The room of the comparison flat is as large as or larger than in the theoretical flat and of a suitable (similar) shape.	The AIM can be implemented by moving fixtures or furniture, which can still be placed accessibly.	The AIM can be implemented by conducting structural changes that are not proposed in the AIM and that do not compromise the function of the adjacent room(s).	The AIM cannot be implemented without compromising the functionality of the current room or the adjacent room(s) even with structural changes.

Limitations of the study

The sample behind the flat type on which the applied AIM is based on covered 51 cities from different parts of the country (Kaasalainen & Huuhka, 2015a), whereas the sample of the current study encompasses buildings from only one city. However, Kaasalainen and Huuhka (2015a) detected no difference in the design between different locations, which is also supported by many other studies noting the uniformity of the Finnish building stock of the researched era (Mäkiö et al., 1994; Neuvonen, 2006; Huuhka, Kaasalainen, Hakanen & Lahdensivu, 2015). The flat production from the 1960s to the early 1980s was contractor-driven and accordingly focused heavily on minimizing construction costs by keeping variation to the minimum (Neuvonen, 2006). This also meant that the regulations for various minimum dimensions also became the maximum, leading to further homogenization in design, along with reusing the same plans again and again. Figures 1 and 2 manifest the results of this development. Therefore, the limited geographical coverage of the sample should not have a significant effect on the results of the study.

Although the AIMs have been developed for six flat types, this paper investigates only one of them. Based on the observations on the other flat types made by Kaasalainen and Huuhka (2015a), the majority of the contemporary Finnish dwelling stock in blocks of flats should be comparable to the flat type examined in this study when considering the applicability of mass-customizable models. In all, 9 of the 18 flat types identified by Kaasalainen and Huuhka (2015a) can be considered variations or extensions of the layout presented herein and the rest follow similar design principles; various functions are clearly separated into their own rooms, each of which is directly accessible from the hall—with the exception of the kitchenette in the smallest flats. As the dimensioning of flats is based on prefabricated construction technology and guidelines that were shared by all contractors (Kaasalainen & Huuhka, 2015a), room sizes do not differ notably between different flat types or buildings. Flats with more rooms obviously provide more options for case-by-case problem solving by rearranging functions. As this rearrangement is more of a matter of individual customization after establishing the baseline with the help of the AIM, evaluating the concept in the chosen flat type should be a reasonably reliable indicator of its applicability on a broader scale.

Lastly, the AIMs have four stages, but this study only examines applying the most comprehensive stage. However, over half of those modifications originate from previous stages and the 4th stage encompasses the majority of lower-stage changes (see Tables 3 and 5). Therefore, applying the 4th stage should give a good indication of the applicability of the lower stages as well. The bathroom makes an exception to this rule, since the 4th stage encompasses an extension of this space. Therefore, the applicability of the lower-level changes to the bathroom is evaluated separately. The 4th stage also encompasses three customization alternatives, only one of which is tested. However, the differences lie mostly in interchangeable furnishing variants, of which the chosen one requires the most space, since it has a double bed and is intended for complete wheelchair accessibility. Therefore, the two other alternatives are definitely implementable if the chosen version is, but not necessarily vice versa.

RESULTS

Table 7 presents the results of applying the 4th stage of the AIM (Figure 7) to each of the nine comparison flats (Figure 8). In previous literature, the hall and the bathroom have been stated to be the most problematic spaces in this building stock, primarily due to the lack of space (Sorri, 2006; Verma et al., 2006). This was also evident in many of the comparison flats. Even so, only one of the halls in the comparison flats required more structural changes than the repositioning the non-load-bearing wall next to the bedroom suggested in the AIM. Three of the halls could accommodate the proposed new layout without the partition wall changes inbuilt into the AIM.

Enlarging the bathroom is also a feature inbuilt into the 4th stage of the AIM. As expected, all the bathrooms of the comparison flats needed to be increased in size to accommodate the fully accessible, wheelchair-usable layout. The initial dimensions of the bathrooms varied considerably, but only one of them required more structural changes than moving one wall and the accompanying floor work. As the dimensions of the bathrooms stayed within the ranges of the flat type (Figure 3), the lower stages of the AIM, *i.e.* modifications that increase but cannot guarantee accessibility, can also be deemed applicable insofar as the interior of the room is considered. In flats 2, 3, 7 and 9 applying the third or the fourth stage of the AIM required removing the adjacent walk-in closet (the sauna in flat 9).

TABLE 7 Applicability of the AIM to the flats of the research material (Figure 8).

	Living room	Hall	Bathroom	Bedroom	Kitchen
Flat 1	□	■	■	□	□
Flat 2	□	■	■	■	□
Flat 3	□	■	■	■	–
Flat 4	□	■	□	–	□
Flat 5	□	□	■	■	–
Flat 6	□	■	□	□	■
Flat 7	□	□	□	■	■
Flat 8	□	□	□	□	□
Flat 9	□	□	■	□	□

□	Applicable without changes
■	Applicable with changes to layout
■	Applicable with additional structural changes
–	Not applicable

As expected due to its lack of fixtures and general spaciousness noted by Kaasalainen (2015), the living room presented the least problems for the application. Even after expanding the bathroom, all studied living rooms could easily accommodate the layout proposed in the AIM. Unexpectedly, bedrooms and kitchens proved to be the most challenging rooms for the application of the AIM.

Most of the difficulty in applying the model to the bedrooms was caused by the need for a two-person bed and the closet space required for two people. All of the bedrooms—even the one marked 'not applicable'—could easily fit a one person bed with a bedside table and closets. As the circa 60m² one-bedroom flat is considered as a home that should be able to house a couple, the AIM had to be deemed inapplicable if the bedroom could not fit a queen bed with enough space on both sides for one wheelchair user and one fully functional senior. In parallel, a conclusion can be drawn from observing the research material that these flats simply cannot accommodate an accessible queen bed in the room intended to act as the bedroom. If a small living room can be accepted, the problem may be solved by switching the functions of the bedroom and the living room, but that is a solution the AIMs do not encompass. However, architects designing home modifications can apply the principles presented in the AIM for the living room and the bedroom even in cases where their functions need to be switched.

As for the kitchen, its size and the location of the entrance are generally fixed in the flat type due to both structural and spatial reasons. Therefore, the AIM was mostly either applicable as such or not at all. The main problem was the amount of free counter space and room for drawers after placing all the necessary appliances. Singular improvements (such as replacing the stove with a hob and an oven; or replacing the refrigerator-freezer with separate appliances; but not both) could be performed at the expense of storage space. The dining table, on the other hand, fit reasonably well even in the two kitchens where the overall design was not deemed applicable due to the aforementioned factors.

Expectedly, by far the most common problem among all the flats was the lack of space. Since the flats are strictly partitioned to individual rooms by function, often bound by load-bearing walls, the opportunities for changing the area distribution without major renovations are limited. However, the rooms that have been noted to be the most problematic in terms of accessibility, *i.e.* the hall and the bathroom (Sorri, 2006; Verma et al., 2006), were also the ones that could be enlarged the most in the comparison flats. On the other hand, in the kitchen and the bedroom, which had the least potential for spatial change, it is easier to make compromises based on individual needs simply by changing the furniture and fixtures. Swapping the locations of the living room and bedroom is also simple due to all of the rooms being directly accessible from the hall.

The connections between rooms did not vary much set against what was presented for the flat type by Kaasalainen and Huuhka (2015a). One of the bedrooms was accessed through the kitchen and the precise location of the doors varied but not enough to affect the application of the AIM. The location of load-bearing walls also matched the flat type acting as the basis of the AIM in all but one flat, where the wall between the kitchen and the bedroom was non-load-bearing, easing relocation. The vertical drain was located as expected, next to the bathroom, in every flat, although its size and shape varied. Again, this variation was not major enough to affect the refurbishment plan.

On the level of the entire dwelling, the AIM was fully applicable to six of the nine flats. In five of these, no additional structural work was required. In the flats where the model was not fully applicable, the problem was restricted to a single room. On the level of individual rooms, the AIM was suitable for 38 of the 45 rooms studied without structural changes. In 26 of them, applying the model required no changes at all. In four rooms, structural changes were needed. In all, the AIM was applicable with or without modifications to 42 of the 45 rooms.

CONCLUSION

This multi-case study introduced the idea of architectural accessibility improvement models (AIMs) developed by Kaasalainen (2015). The four-stage AIMs have been designed to support older adults' functional abilities and, thus, to help them maintain autonomy in daily life. The changes to flat layouts also ease assistance in home care. Therefore, the repertoire of modifications presented in the AIMs can enable the elderly to continue living at home for longer, which has previously been shown to have positive implications for their health. Since encouraging ageing-in-place by increasing the accessibility in the 1960–80s housing stock is also a focal goal in the Finnish elderly housing policy, the work presented herein may participate in meeting that target.

The purpose of the current paper was to test the applicability of an AIM created for a prevalent two-room flat type in nine case buildings in order to evaluate the usefulness and development needs of the concept. The experiment showed that without customization procedures, a straightforward flat-wide design (*e.g.* an accessibility improvement plan based on a singular case study) would not be widely applicable enough to work as a generalizable model. The degree of variation in the amount and distribution of space available means that unless the plan is designed for a severely restricting situation, parts of it will likely be unsuitable for a specific target flat. Therefore, it is important that the AIMs cater for customization in the application phase. Based on the results, the design of the AIMs was successful in spaces recognized as problematic in previous literature, *i.e.* bathrooms and halls. However, the experiment revealed that kitchens and bedrooms, which the literature does not highlight, can also be problematic with regard to accessibility and therefore deserve more attention.

Essentially, the results showed that the AIM was fully applicable to two-thirds of the studied cases, which is a clear majority and corresponds, thus, to the hypothesis. The coverage was even more significant on the level of individual rooms (42/45 rooms *i.e.* over 93% of rooms). Even if a flat-wide model isn't always applicable, even partial home modifications can be sufficient in many cases due to the variation in individual needs. The AIMs cannot be expected to reach the coverage of their respective flat types in the housing stock, since the dimensions of these 'theoretical flats' are mean values. Ultimately, the overall applicability of the concept of AIMs is more reliant on the repetitiveness of the flat designs than the specific layouts exhibited. The applicability of a specific AIM, on the other hand, is mainly determined by the similarity of the physical dimensions between the AIM and the targeted dwelling—especially when it comes to load-bearing structures and the location of vertical drainpipes.

Improving the direct applicability of a flat-wide AIM calls for supplemental plans for individual rooms to account for more notable variation in dimensions. This is especially true for rooms that are difficult to expand—for example the kitchen in the flats of this study, which was in all but one case practically unexpandable due to being bordered by a façade, a load-bearing wall and the bathroom with a wide drain. In practice, this would mean defining the smallest room size that can still be renovated to be accessible while retaining its functionality and using that as a basis for the supplemental plan. Although the use of supplemental partial plans would somewhat decrease the simplicity of the concept, the result should still enable a more tailored and communicative approach than a written set of universal guidelines. The number of supplemental plans required, at least in the Finnish stock of flats, is also likely to be rather small considering the extent of regulation for dimensions and the proclivity of contractors for sticking to the legal minimum recognized by Neuvonen (2006). Even with the addition of partial plans for more specific situations, the concept of AIMs, based on a verifiably representative typology of flats, seems suited for creating an easily understandable, widely applicable 'catalogue' of modification possibilities.

It should be noted that the degree of accessibility achieved with the help of an AIM can only be as good as the degree of accessibility in the AIM itself. The development of the tested AIM was based on peer-reviewed expert work in which the current best practices were applied in the context of typical Finnish flats, that is, translated into plan drawings. It can be argued that this was a just choice, as it has been found that when it comes to accessibility improvements, the residents usually settle for less than what professionals would do (Heywood, 2011; Verma et al., 2006). Furthermore, the Finnish accessibility standards appear to be on a fairly good level in international comparison, if the minimums for door and toilet dimensions given in Dion (2005) (see Table 1) are taken as its evidence.

In addition, it should be acknowledged that the current study tested the customization of the AIM for different flats, not different needs. As the latter is also an essential part of the concept, in future it should be studied how the AIMs support achieving this target. Here, the architect's capability to understand the resident's condition and to apply the AIMs to meet their needs is likely to have a significant role. Future studies should also investigate if the models are communicative enough towards the client in their current form, or if the presentation should be taken to 3D, for instance. Such a representation could not only help the users engage more in the design of the modifications but also encompass modifications for supporting cognitive health, such as color and material choices, which cannot be easily portrayed in the current plan format.

Although the AIMs already encompass a rough progression of effort and cost, embarking on modifications could be less daunting for homeowners if, in future, the AIMs could be combined with cost estimates. Furthermore, AIMs could also act as a basis for developing commercial mass-tailored home modification concepts that are more affordable to the resident than individual projects. For productization to be able to provide customers with more satisfying outcomes for affordable prices, enterprises must be able to define the content and price of the service in detail (Jaakkola, Orava & Varjonen, 2009). Mass-customizable AIMs designed for typical flats would seem to meet this criterion.

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