What is preventing the practical development of shipping containers as mobile dwelling units in the U.S.?

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Working Paper 430

This paper was written during the author's enrollment at Harvard University, and was intended for an academic audience with a certain level of subject familiarity. The author wishes to thank Max Hirsh, a scholar of mobility and urban design.

It is the author's desire that the information contained herein be publically available and accessible as an educational aid. Every reasonable effort has been made to conduct scholarly research and present relevant findings in a meaningful and unbiased way.

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Introduction

Shipping containers have often been the focus of architectural explorations since their inception in 1955. They have been posited as solutions to affordable housing, disaster relief housing, and portable housing. Architectural images of container cities and skyscrapers filled with hundreds of high-tech, mass-produced plug-in homes can be found in many magazines—but where are they in real life? Though on a theoretical level container housing is promising, there are many practical barriers and unresolved design issues that prevent the development of mobile plug-in dwellings in the United States. There are a number of companies selling "instant offices" and portable storage spaces made from modified containers. But the idea of shipping containers as mass-produced, mobile dwelling units that can be "plugged-in" to towers and communities around the world is still far from realization.

In order to account for the continued absence of such transportable units in the United States, this paper is divided into two lines of arguments. First, it argues that the shipping container is not as advantageous as it is generally thought to be, and that its theoretical benefits are quickly eroded as it is adapted into housing. Secondly, it brings to light the major practical frustrations which prevent transportable plug-in units from being developed. Financial constraints, markets, infrastructure, intended users, and urban politics are all critical in determining what gets developed in the U.S.—yet these issues are almost always inadequately addressed by architects' dreamy proposals. As one begins to understand the practical frustrations, it becomes evident why proposals for transportable plug-in dwellings have never materialized, though they have been attempted for decades.

The Appeal of the Shipping Container and the Mobile Dwelling Unit

Architects and innovators have long been fascinated by ideas of mobility and portability, but why are they so intrigued by shipping containers? There are many reasons, but the most common ones are listed below. It is important to understand the appeal of containers as dwellings, in order to be able to measure the benefits against the costs (i.e., barriers) which will be discussed later.

1) True Transportability: Unlike so-called mobile homes—which are fragile and extremely expensive to move repeatedly[1]—shipping containers are easy to ship locally or internationally. They can be shipped by truck, rail, or barge. Because shipping containers conform to the modules of international transport, container dwellings have the promise of universal transportability at minimal cost.

2) Watertight Enclosure: It is no small thing that containers come as hermetically-sealed, watertight steel enclosures. Many (if not most) lawsuits against architects rise from problems related to leaks/water penetration. The fact that the initial "building block" is already watertight reduces risk enormously.

3) Structure and Stack-ability: Industrial shipping containers are designed for extreme loads and stresses involved in lifting, stacking, and hauling the units at high speeds during transit. These steel containers are stronger and more durable than standard homes built of wood, and are designed to support live loads of over 200 pounds per square foot—five times that of most residences. Containers can be stacked five high without reinforcement[2], which makes "instant multi-story buildings" imaginable. They are also designed as beams/box trusses to span the full length (typically 40') of the container, so that if supported on each end, they do not require intermediate supports.

4) Affordability and Availability: There are over 7 million[3] shipping containers around the world today, and because it costs half as much to ship back an empty container as it does to buy a new one, hundreds of thousands of used containers are lying unused in ports around the world. Though prices vary, a used 40' container typically costs no more than $4,000. At less than $13/s.f. (unfinished), this is extremely affordable compared to the price of constructing a livable enclosure from scratch.

5) Sustainability and Society: With increasing concerns about global warming and the shortage of natural resources, the thought of "recycling" these byproducts of our global consumer culture adds a measure of social responsibility to container architecture.

Theoretically, it is much more sustainable to reuse a container as a home than it is to make a new home from scratch. The idea that these used containers had a previous life—a previous global identity—adds to the intrigue of living in a shell with a unique individual history. For a young generation with growing resentment for ticky-tacky houses and faceless mass-production, this certainly adds to the appeal of container houses.

There have been many attempts[4] over the last fifty years to design mobile dwellings from shipping containers, but this paper focuses primarily on one recent attempt: the modular dwelling unit[5] (MDU) developed by LOT-EK. However, the findings and criticisms are meant to apply broadly to the idea of using containers as transportable plug-in dwellings, not exclusively to LOT-EK or their MDU. The goal is not to criticize or discourage mobile dwellings, but to explore why such ideas—as compelling as they seem—have failed to materialize in the United States.

The idea of the modular dwelling unit as proposed by LOT-EK is to create a living unit from a single 40' shipping container that could follow its owner around the world, giving true freedom of mobility to mobile 21st century subjects. So that the unit could have more space but still fit within a single container during transport, a series of "extruded subvolumes" (each encapsulating a different function) were designed which tuck in during transport and slide out during use. Around the world, conceivably in every metropolitan area, there would be vertical MDU Harbors for the units to plug-in to[6]. Instead of having an "anonymous room" in an international hotel, a traveler could live in her own sumptuous home—with all her belongings—wherever she went[7]. LOT-EK intended that these units would not be exclusive to elite globetrotters, but would be affordable to normal travelers[8]. They could be sold online, by catalogue, or in stores such as The Home Depot[9].

Shipping Containers: Theory vs. Reality

Conceptually, MDUs sound like a great idea, and shipping containers seem like a perfect fit. Transportability, water-tightness, stack-ability, affordability, and sustainability are important characteristics, but unfortunately, using containers is not as beneficial as it sounds. At the most basic level, in the case of LOT-EK's MDU, there is so much addition to and subtraction from the container that one wonders why the container was used in the first place, except as a theoretical point of departure (see Figures 7 through 10). In order to make the 8' x 40' (exterior) footprint livable and still include all the necessary functions, telescoping appendages (i.e., extruded subvolumes) were a necessity. However, these sliding appendages required the removal of large sections of the container. The MDU has eight appendages, which require approximately three-quarters of the surface area on each side of the container to be removed. This creates two problems. First, it punctures the watertight steel skin, breaking the hermetic seal and encouraging leaks. Because the appendages must be able to slide in and out, it is difficult to prevent water penetration. Furthermore, these cuts compromise the structural integrity of the container, which performs as a beam/box truss. Just as one would destroy the structural integrity of a beam by drilling large holes through it, so one destroys the spanning capability of the container by cutting large holes through the rigid siding. This would prevent the container from being able to be lifted by a crane, and from being held in the vertical harbor without intermediate supports. The functionality and efficiency of the vertical harbors depends on the beam-like rigidity of the container, and could never perform as designed (see Figures 5 and 6). Thus water-tightness and structural integrity—two important benefits of containers—are lost.

Stack-ability of containers is also a misnomer. Even though from a structural standpoint shipping containers can be stacked five high, one must remember that units which are stacked underneath one another cannot be moved. If five containers are stacked, it is impossible to move any of the containers except the top one without moving the others. In order to allow for individual mobility, it is necessary to create a "shelf" for each container to rest on. However, this represents a costly redundancy of structure. On the one hand, there is an expensive building frame (i.e., series of

"shelves") which must be built to support the weight of all the units. At the same time, because the individual units must support themselves in transit, the units must also be structurally self-sufficient. The fact that structurally sufficient units are placed on structural "shelves" within a tower means that twice the material necessary for a normal unit is used. It is also worth noting that the amount of structure required for a typical house to resist gravity, wind, and other loads is significantly less than the amount of structure required for a mobile unit which must also withstand forces encountered in highway transport and loading/unloading. Developers are always looking to minimize structural costs; MDUs and their harbors knock the budget out of the ballpark.

Structural redundancy is not the only reason transportable container units are so expensive. Because containers are so small and awkwardly shaped for use as housing (only 7'6" wide and 39' long on the inside), designers are forced to either use multiple containers for one dwelling unit, or "borrow space" via appendages as LOT-EK does. Using multiple containers means automatically doubling or tripling the transport costs and docking costs. It also raises the issue of how the containers will be repeatedly connected and disconnected for transit, and somewhat defeats the purpose of using a shipping container as a module in the first place. Thus, the only option is to "borrow space" through appendages and creatively utilize every inch.

Creative utilization of space often involves high-tech gadgetry, automated components, flat screen TVs, etc. While these appendages and high-tech gadgets may work, the space they create is exponentially more expensive than standard floor space. I have learned from personal experience building a house with many extrusions, that framing the five extrusions took more time than framing the entire rest of the house. The extrusions were the Achilles heel of the entire project. If one looks at how much effort (not to mention material) LOT-EK expended to frame each extruded volume, to carve the voids in the container, to weld all of the siding together, and to restructure the floor to allow for the extrusions to slide, one can only imagine the cost and complexity of this borrowed space (see Figures 7 through 11). Moveable appendages also necessitate flexible plumbing and wiring, as well as mechanisms for gliding. All of this adds up to make a unit which sounded cheap—$4,000 for the

entire shell—prohibitively expensive, and only minimally comfortable. From a marketing standpoint, because extrusions/appendages typically do not contribute to the unit's legal square footage, it is difficult to sell a unit so heavily dependent on appendages for space. Not only does this make the unit less marketable; it also makes the cost per square foot appear much higher since there are fewer square feet over which to amortize the total unit cost—not to mention the fact that the borrowed space from the appendages came at an exponentially higher cost than the rest of the space.

Finally, two elements which greatly affect livability but which are often left out in container houses are storage space and thermal insulation. Steel is not a good insulator, but with insulation and paneling, the interior width of a container (7'-6") might become unlivable (< 7'). Thus insulation is often non-existent in architects' drawings. In an architectural drawing, this might go unnoticed; but in a built prototype, this would surely present a problem. The situation is much the same with storage space. Compared to a kitchen, or bathroom, or bed, storage space is easy to leave out of drawings. Yet without storage space—a place to put one's belongings—the MDU becomes simply a shell, much like the "anonymous" hotel room it was meant to replace. Without clear cost benefits *or* comfort benefits, it is difficult to imagine who might purchase a MDU, and why.

Major Frustrations to the Practical Development of Mobile Dwelling Units

Unclear Market/Clientele: One of the first things a designer must address when creating a product is "who is the intended user?" Who would benefit from a MDU, and what niche does it serve? Is it intended for the business elites, or for lower-class laborers and migrants? Is it meant to add convenience, or to save costs? Is it meant to replace a permanent residence, or to supplement one? In the past, many designers have proposed transportable dwelling units as a solution to affordable, convenient mobility. They envisioned mass-customized, prefabricated units which could be produced cheaply like Fords by virtue of their small size and economy of scale. But the problem is that it is extremely difficult to design mobile dwelling units that are truly affordable or even economically

feasible. Even units which are designed to be cheap turn out expensive when they are actually built. Though they do not mention costs, this seems to be the case with LOT-EK.

In an interview, Ada Tolla (LOT-EK) mentioned: "Now that we're in the development phase of MDU, we are thinking of it as some sort of housing that is neither low-income nor high-income. It's just housing.[10]" Her choice of words ("*some sort* of housing") is not very reassuring. The phrase "Now that we're in the *development* phase" makes one wonder if LOT-EK had originally expected the MDUs to be low-income housing, but found out how prohibitively expensive it was when they started constructing it. Ada's partner, Giuseppe Lignano, made it clear earlier in the interview that the MDUs were not intended for wealthy elites, but for normal people traveling for "mundane and normal reasons[11]." But why not target the elites? Are they not the most frequent travelers? Perhaps it is because Giuseppe fears that wealthy elites would never choose to live in such conditions when they can afford to live in the best international accommodations? It seems that LOT-EK's choice to target middle-income buyers may not have been the original intention, but was the only viable choice in the end. The unit was too expensive to be low-income and too "mediocre" to be high-income, so it became middle-income. Whether or not this was the case with LOT-EK, it seems to be a common phenomenon among designers of mobile dwelling units. Needless to say, this is not the way to develop/market a product.

Infrastructure and Industry Fragmentation: One of the reasons that marketing is so critical to the success of mobile dwelling units is that the idea cannot work without economy of scale. Even if a company were able to produce beautifully designed, affordable, transportable units, there would still be the problem of infrastructure. Innovators such as LOT-EK often compare the mobile dwelling units to automobiles, mentioning how the dwellings could be mass-produced and used around the world to enable mobile lifestyles. But such a comparison is somewhat naïve. It overlooks the fact that so much infrastructure already exists for automobiles which does not exist for plug-in dwellings. There are roads and highways, parking structures, gas stations, motels and restaurants to serve drivers, mechanics to repair vehicles—so many things without which the automobile would be relatively

useless. This is not to say that the plug-in units could not develop all of this in time. After all, the U.S. did not become the auto-oriented nation it is over night; it took years for the automobile to work itself into everyday American life, so that services could develop for it. But widespread acceptance and infrastructure takes a lot of time and a lot of money. Architects rarely advertise prices for their mobile unit designs, but even when they do, they never include the cost of constructing/maintaining the "harbors" and other necessary infrastructure.

One of the difficulties in implementing expensive infrastructure for plug-in units is the fragmentation of the building industry in the U.S. For most of the country's history, the public sector (typically the Federal government) has developed the nation's major infrastructure, including roads, highways, bridges—even some housing. But to coordinate the fragmented, capitalist *private* sector in order to develop infrastructure for mobile dwelling units is no simple task. Who would make the rules? Who would set design standards and module sizes? What cities would get the harbors first? How would the costs and benefits be distributed? If there were tens of thousands of MDUs already in use in the U.S., independent private developers might rise up to build "harbors" for the sake of making a profit. But until the MDUs are in popular demand and attain a certain presence, it is difficult to imagine how infrastructure will be developed and financed. And until the infrastructure is in place to allow the units to be mobile, the MDU is just small, expensive unit which makes little financial sense.

There is an even greater problem related to fragmentation. The U.S. is broken up into tens of thousands of local governments and jurisdictions, with powers divided between state, federal, and local governments. The building industry is also extremely fragmented. What prefab housing manufacturers in the last century discovered is that it was impossible to create a universally acceptable American house. These companies—who planned to mass-produce homes from a single high-tech central factory and ship them across the entire U.S. (like automobiles)—found that the multiplicity of building codes and labor interests across the U.S. made their dreams impossible. One city would require copper pipe while another required plastic; one would specify 1/2" diameter pipe, and another 5/8". Local codes often contained requirements that could only be met by purchasing locally-

manufactured materials, and which contradicted codes in other localities. Every state, county, city—even some neighborhoods—had different requirements for houses. This was not accidental, but was designed to protect local jobs and union laborers, and to prevent houses from being imported. If LOT-EK were to attempt to build vertical harbors across the U.S., and to dock identical units regardless of local regulations, they would meet the same frustrations that the prefab home-builders met time and time again. Their units would be banned by local officials, and would probably be resisted by organized labor as well. As long as the U.S. remains fragmented and allows contradictory codes to exist from city to city, it is difficult to imagine how MDUs could ever materialize. According to the letter of the law, one would have to reconfigure her unit every time it changed locations. Reconfigurations could include anything from replacing plumbing and electrical wiring to replacing windows and wall finishes, even sometimes furnishings! Obviously, such changes are not feasible, and would dampen the idea of unlimited mobility. If it were possible to design to "the strictest standards" in order to make a universally acceptable house, that would be nice, though it would also be unnecessarily expensive. But this is not possible, because the city codes are purposely contradictory for the sake of protecting local interests and preventing such a "universal" house.

All of this seems so backwards and out-of-date—so anti-capitalism and globalization—but it is not an accident and is not likely to change. Fragmentation is a protection from global takeover of the American housing industry. Since the rise of prefabricated housing in the early- to mid-1900s, the U.S. home-building industry has realized that if it does not protect itself from foreign competition, it will not survive. Critics often lambaste the inefficient, outdated construction methods used to build homes in the U.S. Other countries are much more efficient, and could beat us if given the chance. Both Japan and Switzerland—experts in high-end prefabricated housing—have at times considered exporting houses to the U.S. They probably would have done so except that they realized that they would never be able to achieve economies of scale because of the high degree of fragmentation and conflicting standards across the U.S. While this intervention may have improved the quality and lowered the cost of housing in America, it would have been detrimental to the building industry. It is critical for

designers to understand that any housing scheme that threatens American jobs will be resisted and ultimately overthrown. Many brilliant housing innovations have failed not because they were bad ideas, or because the public refused to accept them, but because they threatened the power structure in the building industry.

Outsourcing and Financing Woes: Unfortunately—codes and foreign competition aside—even the fundamental concept of transportable housing is a threat to the home-building industry. The fact that a home conforms to the universal module for transport by truck, rail, and boat means that it can be built anywhere in the world and shipped to its site. Because container-based units can be shipped internationally for only a few thousands dollars, it makes no sense to fabricate the units in the U.S. Mobile home manufacturers will frequently claim that the only difference between a site-built house and a modern[12] manufactured house is the cost of labor. They argue that the building materials are the same, and that the savings come from using factory laborers ($7 – $15/hr) instead of traditional builders/carpenters on site ($25 – $40/hr)[13]. If savings of up to 40 percent[14] of the total home price can be achieved by simply using cheaper labor, one can only imagine how great the incentive would be to fabricate MDUs abroad. If mobile homes were truly mobile[15] and were not limited to a feasible travel distance of 300 miles, one can be sure they would be produced abroad. Sadly, the idea of unlimited unit mobility which sounds so appealing on paper does not sound so good for American jobs.

Mobility is also a problem for mortgage lenders and home financiers. No lender wants to lend on a home if their collateral might disappear in the night. This used to be a real problem for mobile homes, when they were smaller (8’ wide, instead of 14’ today), and could be easily loaded onto a truck and hauled away. Because of the risk premium, banks charged significantly higher interest rates, often 2 to 3 percent above standard home loan rates. But as mobile homes have become bigger and more complex, the high cost of moving a home (and the limited number of trucking companies who can do this) has largely eradicated the problem. Nevertheless, this would still be a concern for lenders with mobile dwelling units, since they are truly mobile.

Another thing that lenders fear is obsolescence. With traditional houses, this is usually not an issue. But with any prefabricated or high-tech home, banks fear that newer models will be introduced every few years, making previous models obsolete[16] and causing significant reductions in their value. If a buyer defaults or walks from the obsolete model, the bank will be unable to recapture its loan and will suffer loss.

Conclusion

There are surely many other unresolved design issues and industry frustrations which erode the feasibility of mobile dwelling units—issues such as how to keep personal items from sliding/breaking in transit, or where (and how much it costs) to dock units when they are not in use. But rather than go on talking about problems, I would like to briefly discuss mobile dwelling units in the context of two similar but successful precedents: recreational vehicles (RVs) and mobile homes.

RVs (i.e., Class A Motorhomes) are in many ways the closest existing housing typology to MDUs. LOT-EK may or may not specifically mention RVs as a source of inspiration, but they include several photos of high-end RVs with telescoping extrusions in their published conceptual work (see Figures 1 and 2 in Appendix). These RV extrusions likely inspired LOT-EK's "extruded subvolumes," which are the defining characteristic of LOT-EK's MDU as compared to other architects' mobile dwelling concepts. In many ways, RVs are simply MDUs with wheels and self-propulsion. They can be independent or plugged-in. RVs are limited to a width of 8.5' in the U.S., and range in length from 25' to 45'. Shipping containers are similar in size: 8' wide and 40' long. Though RVs are slightly more bulky than shipping containers, owners have found that they can ship their full-size RVs internationally for as little as $5,000[17]. In some ways, RVs enjoy even greater mobility than MDUs because they can drive and park practically anywhere. And because all the necessary infrastructure is already in place (thanks the automobile), RVs require no major investment in infrastructure[18]. This is very different from the situation with MDUs. The main shortcoming related to RVs is that they may be difficult to park in dense urban cores, and "vertical harbors" for RVs do not yet exist (thought they

have been conceptualized). This may be a significant shortcoming, but is it enough to justify the introduction of a radical new mobile typology?

In the end, it might be easier to build towers for docking RVs in urban cores than to build vertical harbors and MDUs. Though it may seem like a small difference—the fact that RVs have wheels and MDUs do not—this has severe implications when it comes to product classification and taxation. Because they have wheels and evolved from autos/trailers, RVs are not classified as houses. Thus RVs are not considered real estate, and owners are not required to pay property taxes[19]. (This is the same in many cases for mobile homes, unless they are situated on permanent foundations.) Anyone who owns a home can testify that this is no small advantage for RVs! But because the MDU would presumably be classified as a home, property taxes would be levied against it. How these taxes would be levied on a unit which is here one month and abroad the next is another question.

If one focuses on all the odds against mobile dwellings as this paper has, the situation may seem hopeless. It seems that any innovate idea in housing is doomed to failure. But this does not have to be the case. It is encouraging to know that amidst the countless failures and frustrations, there have been a few successes.

Though overlooked and scoffed at by many, the mobile home industry (now the "manufactured housing" industry) succeeded against all the previously discussed frustrations to become a major provider of alternative housing in the U.S. Whether one appreciates these homes or not, one has to appreciate how they were able to shake the industry stronghold and introduce something new. Where hundreds of prefab companies and visionaries failed, the mobile home industry overcame union resistance, fragmented/contradictory codes, tax structures, financing difficulties, and deep-seated power structures in the building industry. One of the most important keys that allowed them to sneak in the back door and revolutionize the housing industry was how they classified and marketed their product. Because the mobile home was classified as a vehicle—a logical extension of the auto-trailer—it was not considered a "home" for decades following its inception. Not only did this spare the industry from a property tax standpoint; it also spared the industry from being considered a

threat to traditional homes and home-builders. This allowed the industry to gain popular support and momentum for many years, so that by the time traditional home-builders acknowledged mobile homes as a serious threat, the industry was too powerful to be shut-down[20]. Mobile home manufacturers did not come in waving flags and promising radical change overnight. They simply created a product that met a real demand, allowed it to grow and evolve, and stayed under the radar long enough to gain an unshakeable foothold. If visionaries who dream of mobile dwellings for 21st century lifestyles can learn from lessons like this, then no matter what the obstacles—innovation is possible.

[1] typically $4,000 to $5,000 for a 14' single-wide, and more for double- or triple-wides.

[2] though containers can (and often are) stacked up to five high without reinforcement, when used as occupiable spaces (which require greater safety and trigger stricter building codes), lateral and seismic reinforcing is necessary. However, no reinforcement for vertical (gravity) loads is necessary.

[3] Scoates, p. 88

[4] ibid., p. 95

[5] "MDU" refers specifically to LOT-EK's development, and stands for "modular dwelling unit." I also frequently mention "*mobile* dwelling units" as a phrase for generic mobile housing proposals, which includes, but is not exclusive to LOT-EK's MDUs.

[6] ibid., p. 57

[7] ibid., p. 81. Ada and Giuseppe also mention the following advantages of the MDUs/MDU harbors: 1) being in a community of like-minded individuals; 2) having anonymity on the outside of the unit, and a sumptuous/personalized interior; and 3) a change of scenes without moving, since neighbors would be changing all the time.

[8] quoted by Giuseppe Lignano (LOT-EK) in Scoates, p. 109

[9] Giuseppe Lignano: "Maybe Home Depot could carry the MDU very soon, who knows, right?….Maybe in the parking lot? MDU-Model I, MDU-Model II, and MDU-Model III. Why not?" Scoates, p. 112

[10] ibid., p. 110

[11] ibid., p. 109

[12] i.e., contemporary manufactured housing (as opposed to older models, which have been proven inferior in quality)

[13] this is an average based on several sources from different locations and different dates, which required interpolation.

[14] comparative prices vary widely, because the cost of land, transport, local permits, on-site installations, foundations, etc., vary from house to house. But the typical price differential between a site-built home and a manufactured home is in the range of 30 to 40 percent.

[15] Mobile homes may be mobile in name, but are stationary in reality. Once delivered to a site, 98 out of 100 mobile homes never move again. This is due to the high cost of secondary transport and the fact that the majority of mobile homes are double- or triple-wides, which are joined on-site and require significant effort to separate and move to another location. It is also due to the fact that from a structural standpoint, older homes would likely collapse if subjected to the stresses of highway transport. In essence, the mobility of the mobile home is solely to make off-site prefabrication feasible, so that the home can be built in a factory and shipped (a single time) to a site. International transport is unheard of, because the high cost of transporting these homes limits the feasible transport radius to 300 miles.

[16] this has been a recurring issue with mobile/manufactured homes, and in order to lessen the detrimental effect, manufacturers will generally refrain from putting model (or year) numbers on the mobile homes themselves. This helps to keep secondary buyers less aware that a home may in fact be "out-of-date."

[17] An exact, current cost is difficult to find, but there are recent examples of RVs being shipped abroad for between $2,500 (for a small, Class C motor home) and $5,000 (for a full-size Class A motor home).

[18] Over time, independent companies have developed community camp-sites and social services to support RVs and enhance the RV lifestyle, but this was done for profit, not of necessity.

[19] Though RVs are not liable for *real estate* property taxes, some states do levy *personal* property taxes. RVs also pay a vehicle tax, but this is significantly less than standard property taxes.

[20] This is a summary of Margaret Drury's explanation for the success of mobile homes given in her book Mobile Homes: The Unrecognized Revolution in American Housing (Revised Edition), 1972.

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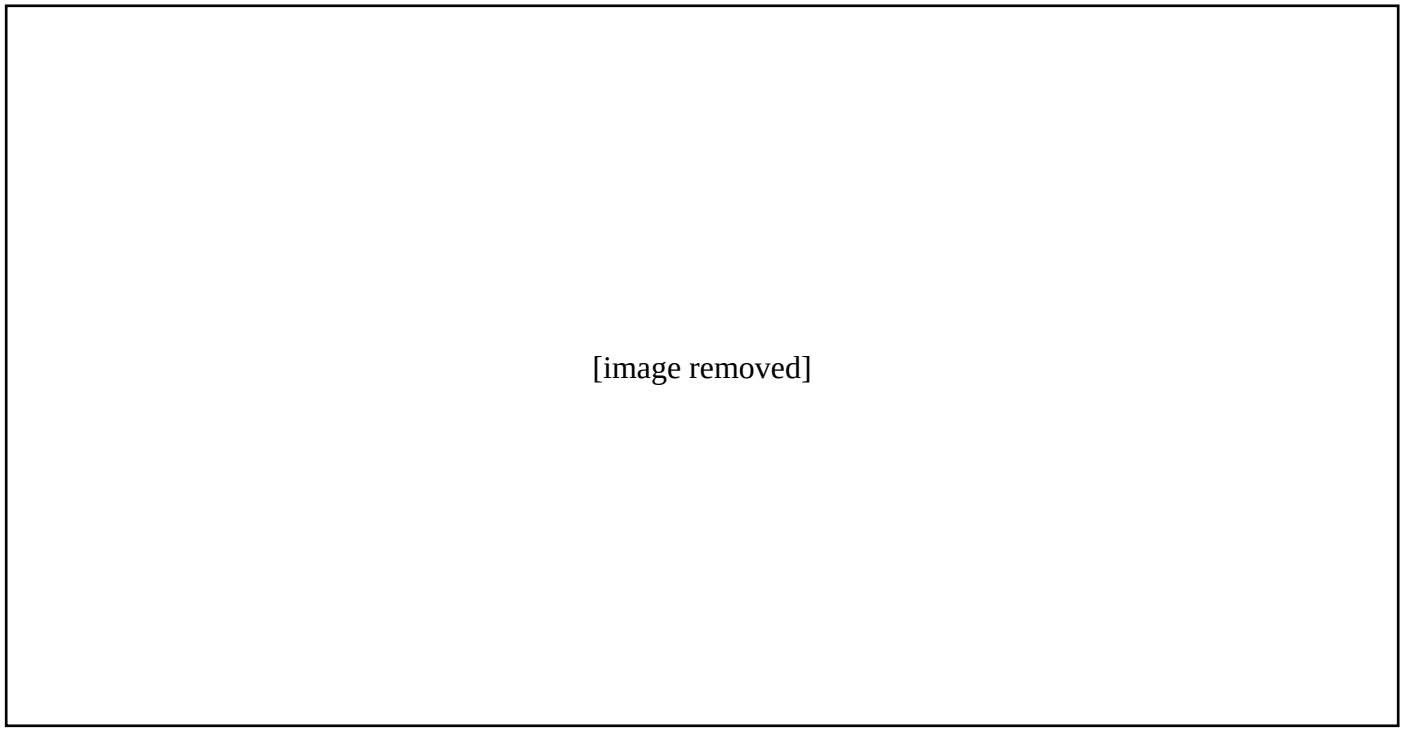
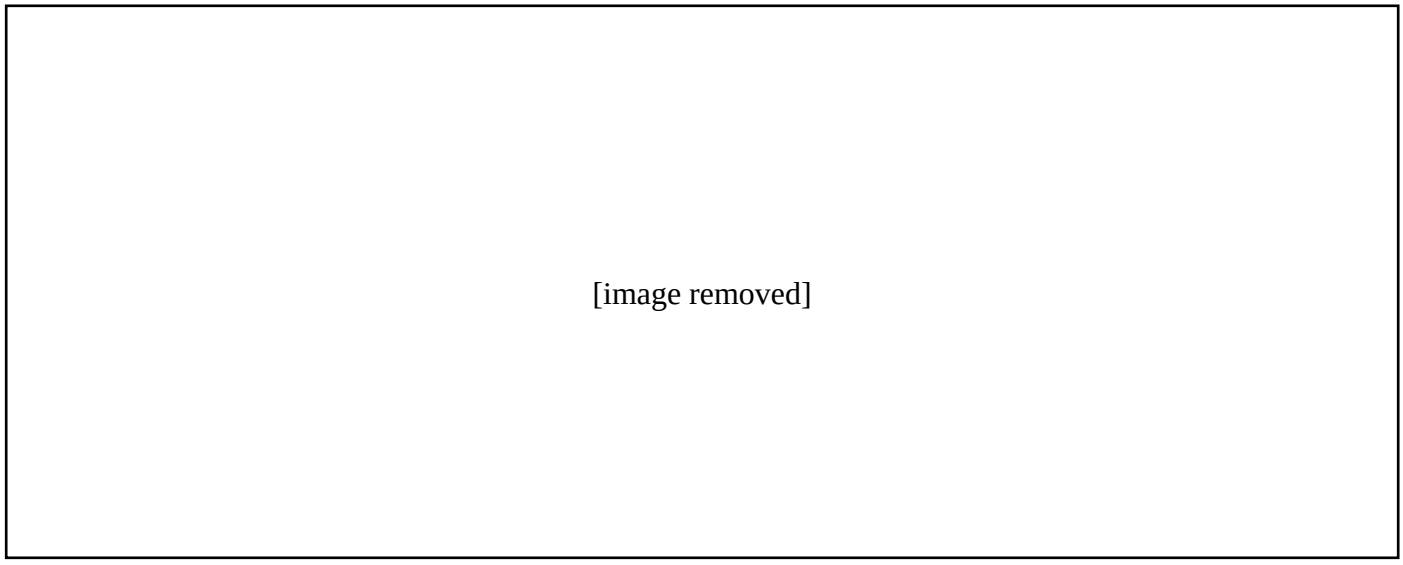
Appendix

NOTE: All images included in the original paper and appendices have been removed for legal (copyright) reasons. However, the image sources (including website urls, where applicable) have been retained for the benefit of those who would care to search for them.





Figures 1 and 2: Images of RVs with telescoping extrusions, recorded in (and likely the inspiration for) LOT-EK's heavy reliance on extruded subvolumes for "borrowing space." Source: Scoates, 24-25 (above); 26-27 (below)

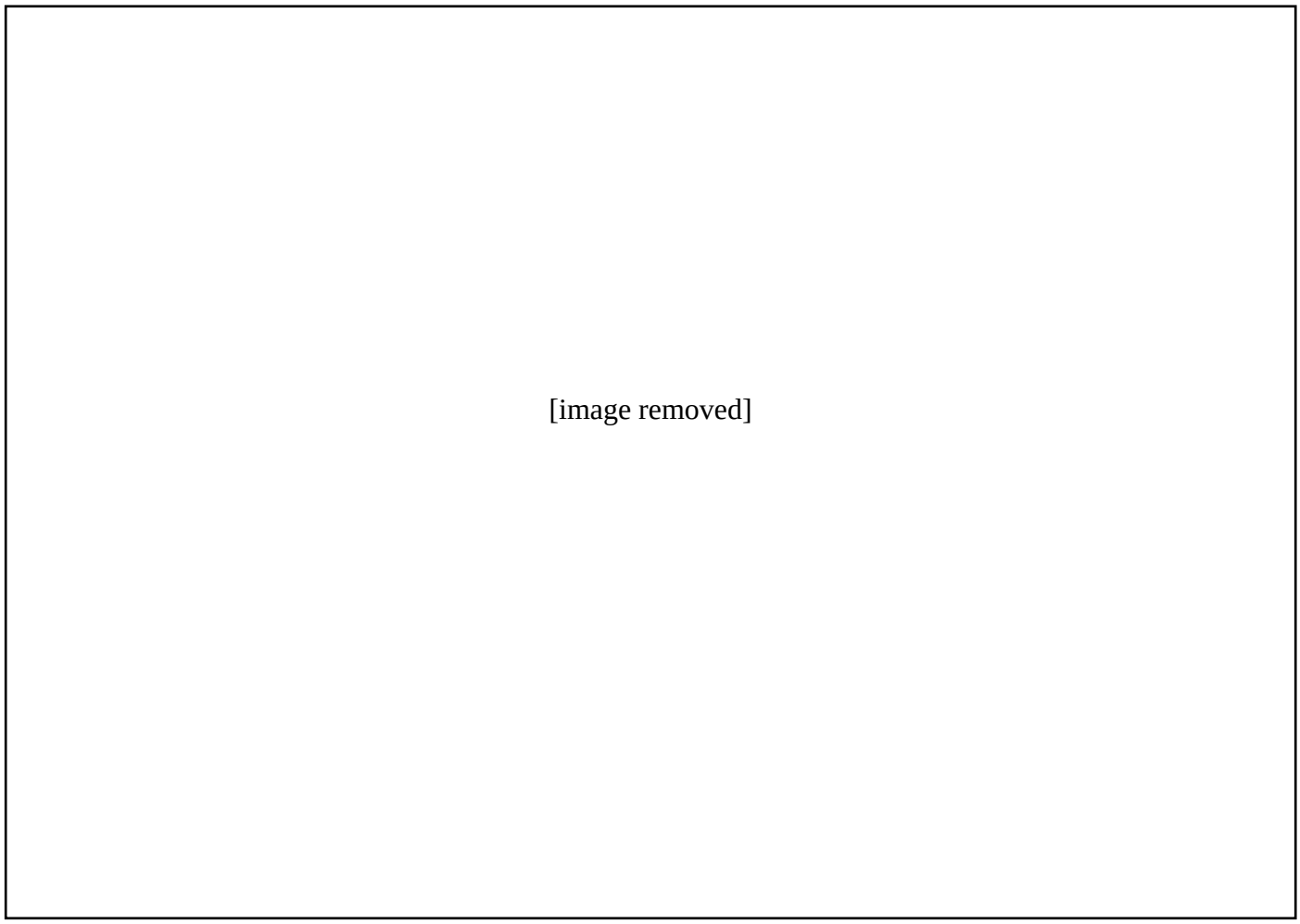


Figure 3: Floorplans of Marathon Coach Luxury Bus Conversions, illustrating their conceptual similarity to LOT-EK's MDU with extruded subvolumes. Source: <http://www.marathoncoach.com/corporatecoaches/08_floorplans.pdf>

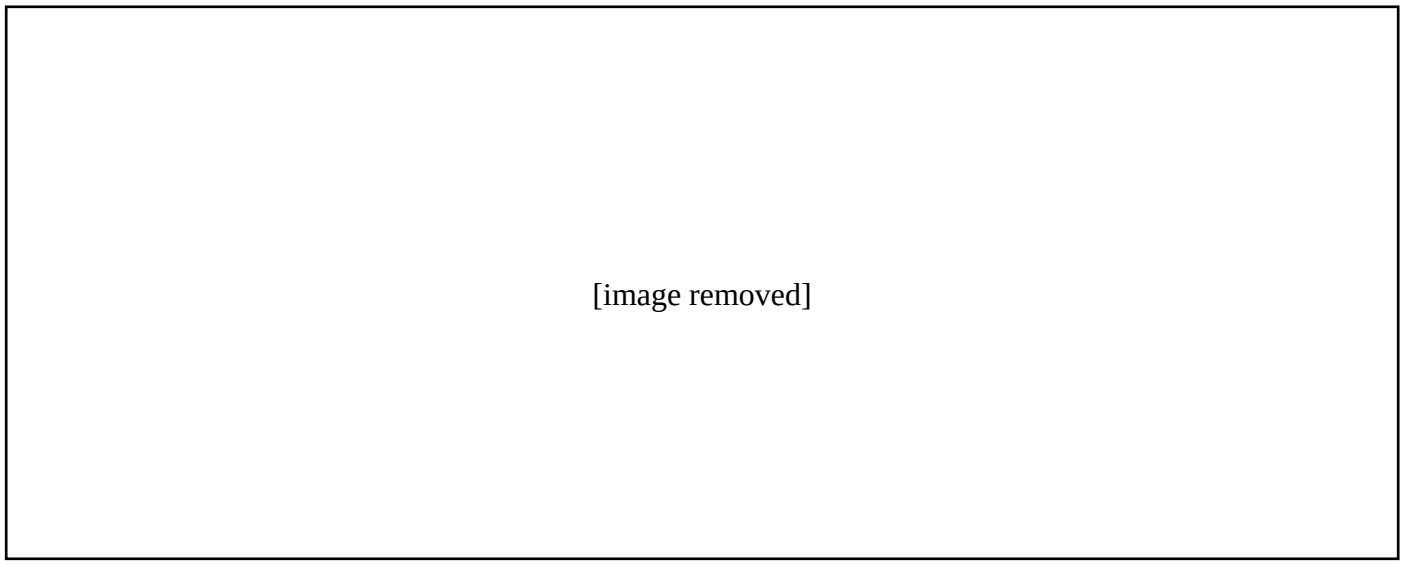
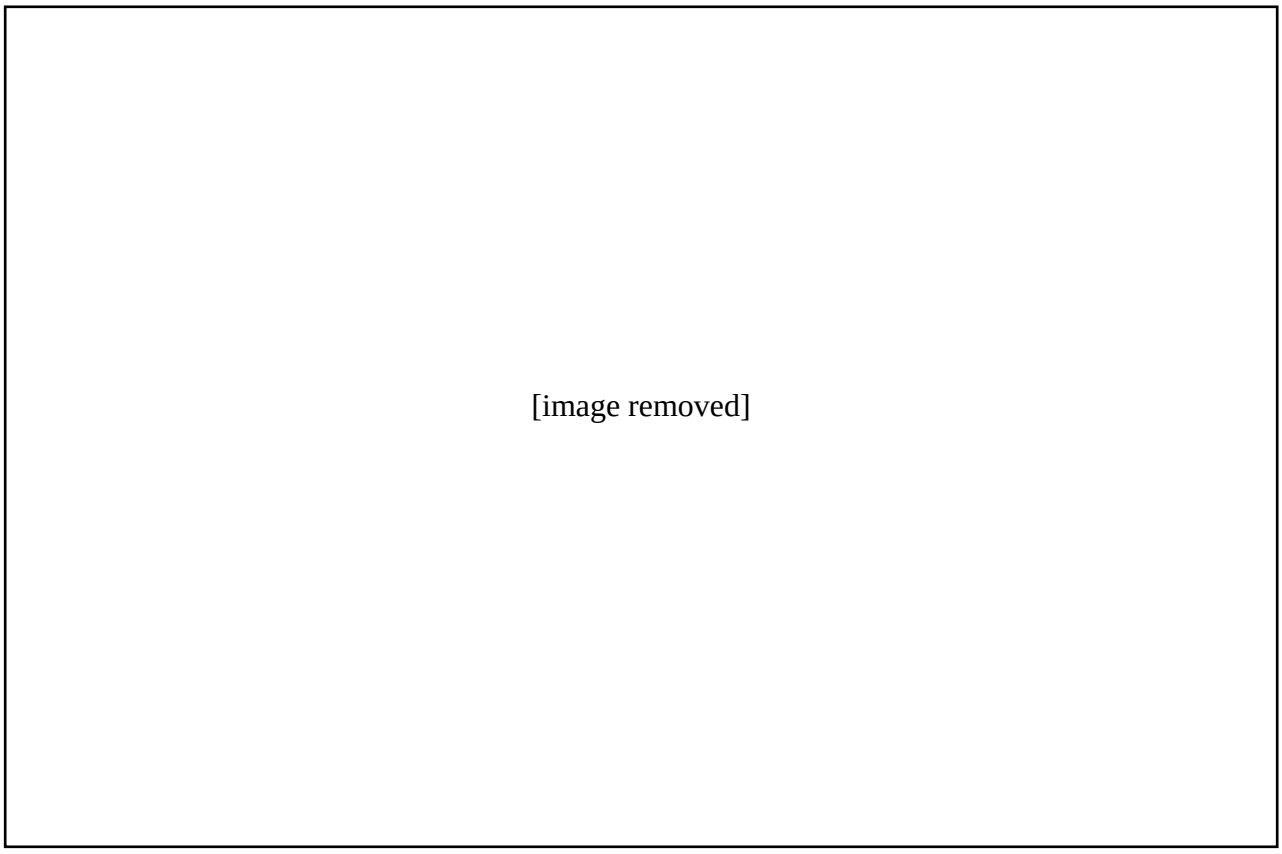
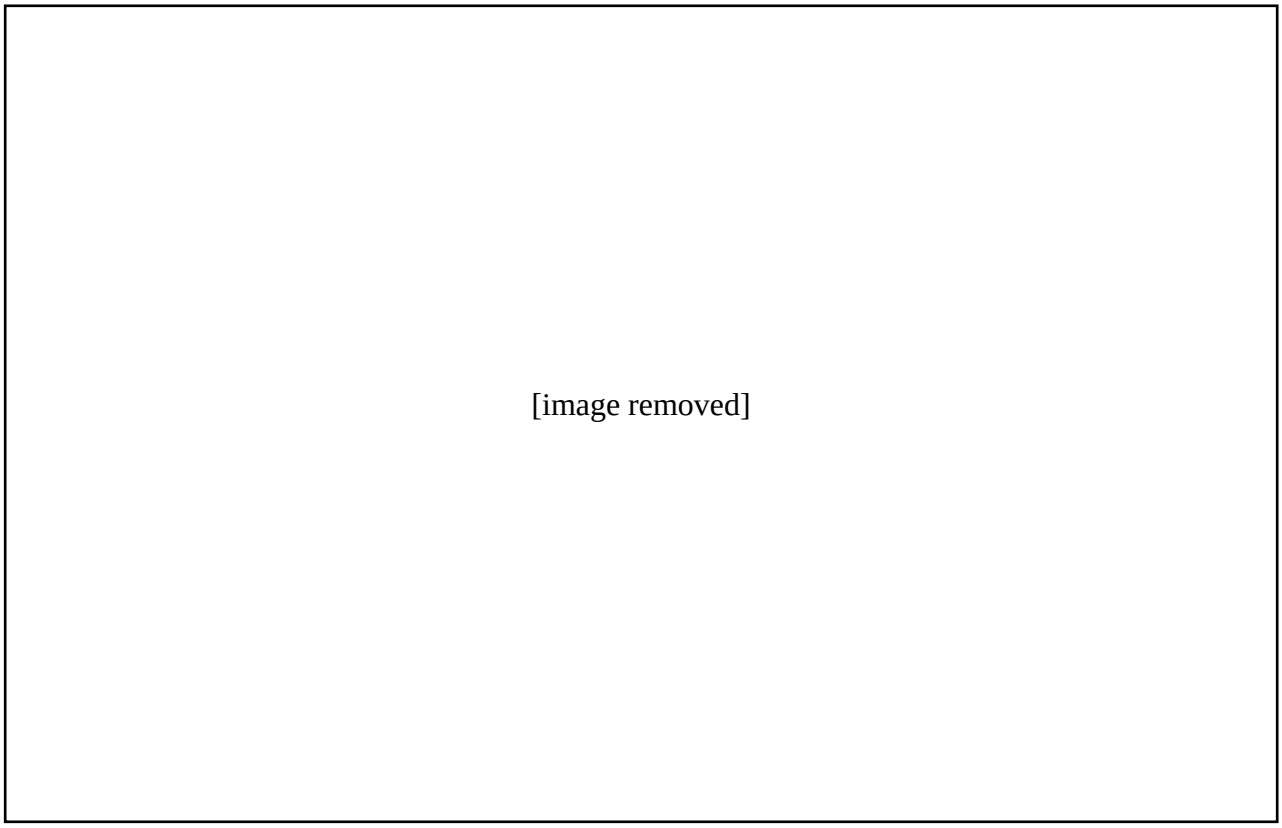
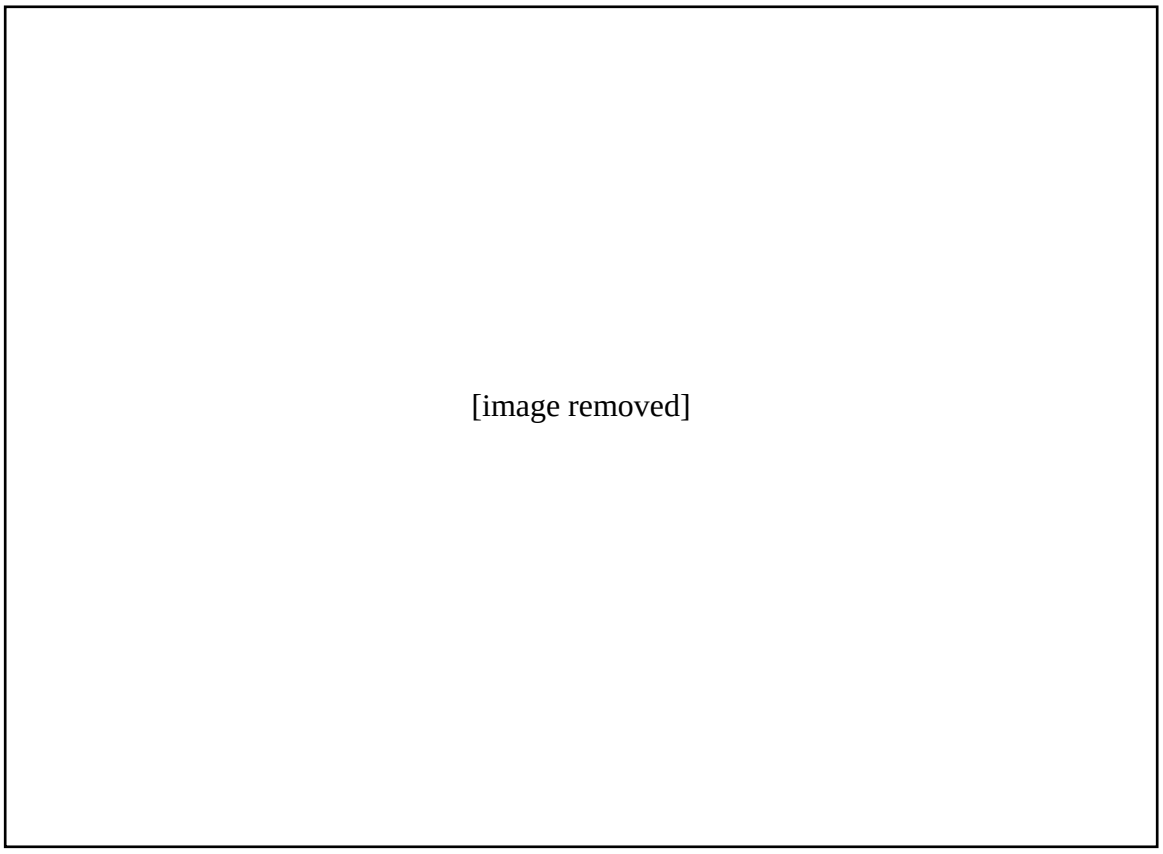


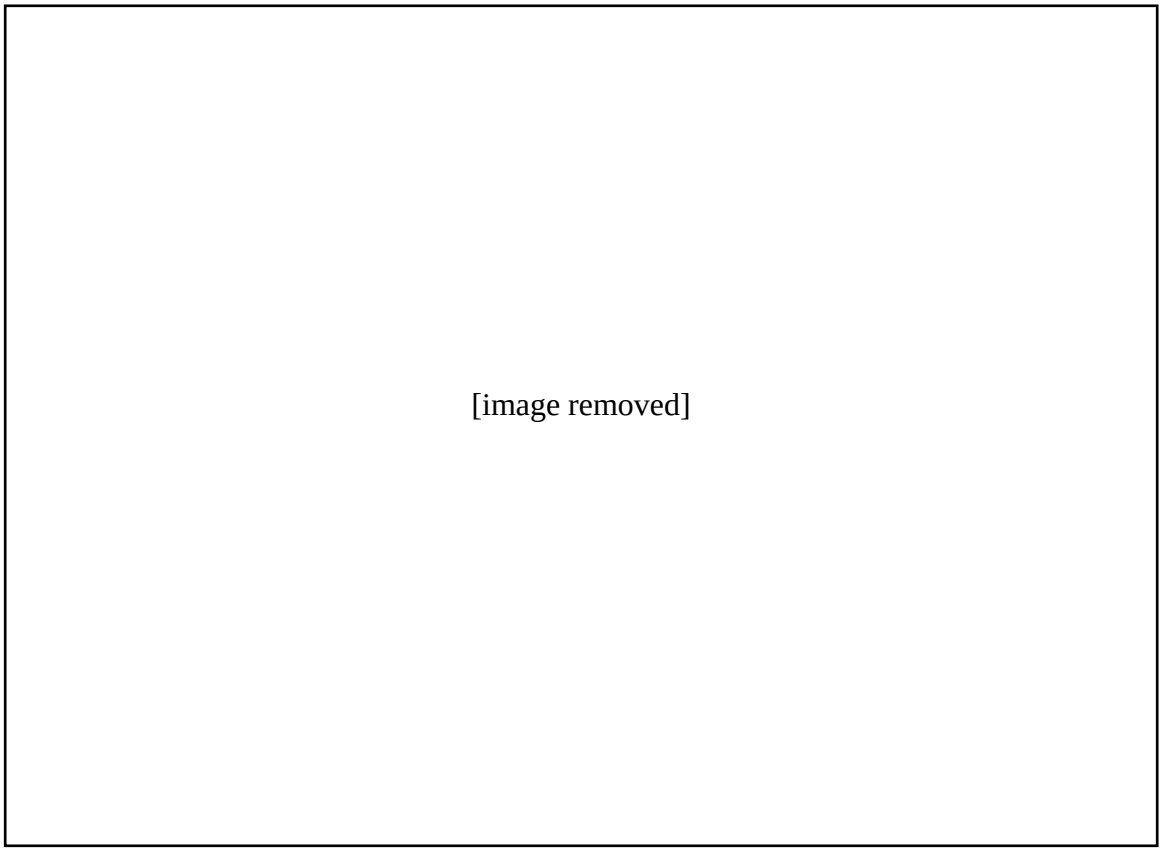
Figure 4: Floorplan of LOT-EK's MDU with extruded subvolumes, showing similarity to RV floorplans (above). Source: Scoates, 114-115



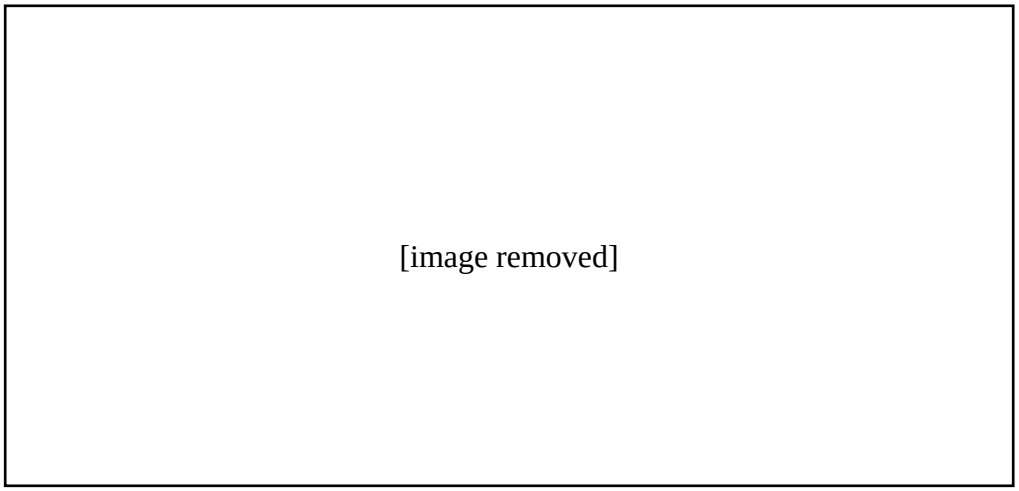


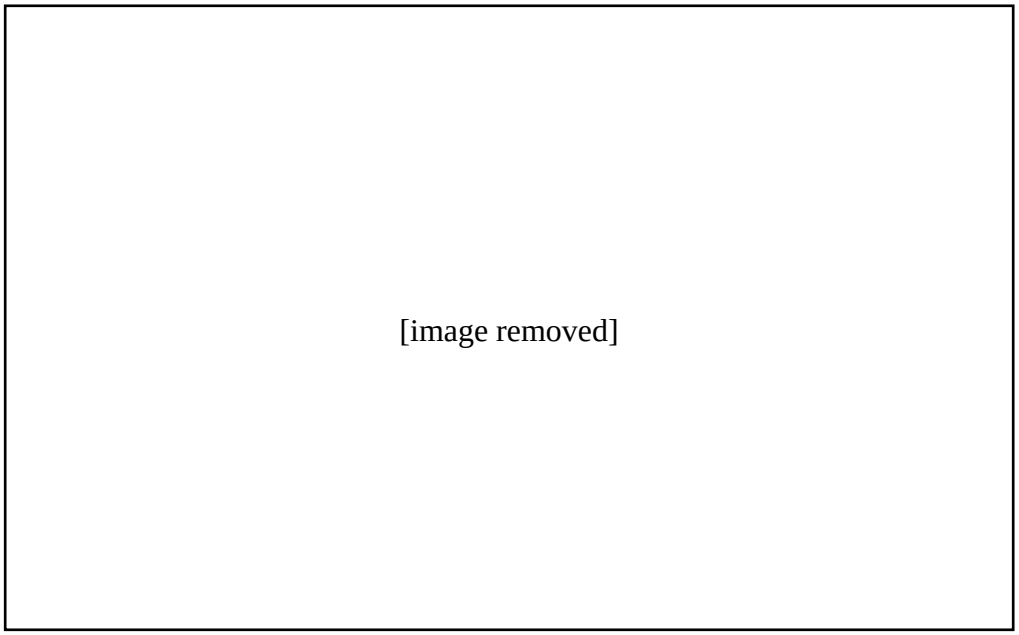
Figures 5 and 6: Rendering of LOT-EK's vertical harbor with MDUs (above); Diagram illustrating the structural deficiencies which result from puncturing the container's siding to allow for extrusions, and which make the vertical harbors unworkable as designed. Source: Scoates, 58-59 (above); diagram by author (below)





Figures 7 and 8: Photos of LOT-EK's MDU during construction, illustrating the high degree of subtraction from the original container (above) and addition to the container (below), as well as the large amount of steel and labor required to retrofit the container for the extruded subvolumes. Source: Scoates, 140 (above), 144 (below)





Figures 9 and 10 (above): Photos of LOT-EK's MDU during construction, showing the removal of the original container's steel flooring and the addition of steel to accommodate the sliding extruded subvolumes. Source: Scoates, 138 (above), 139 (below)

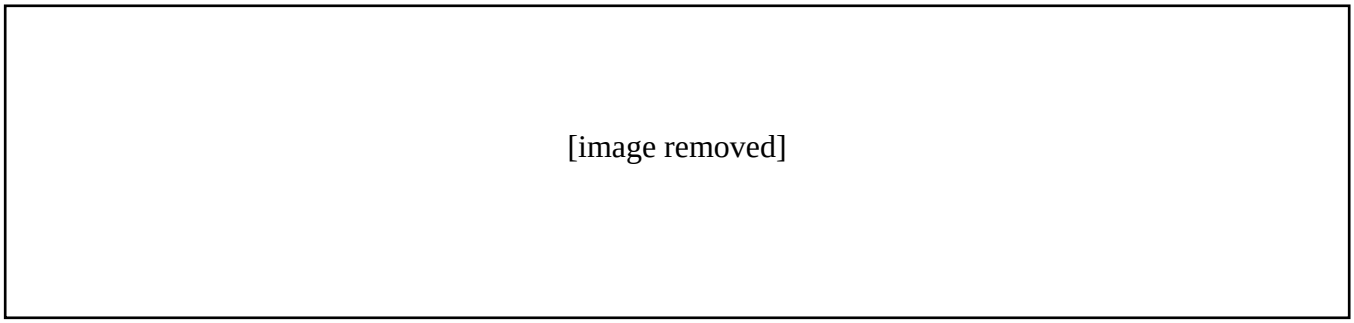
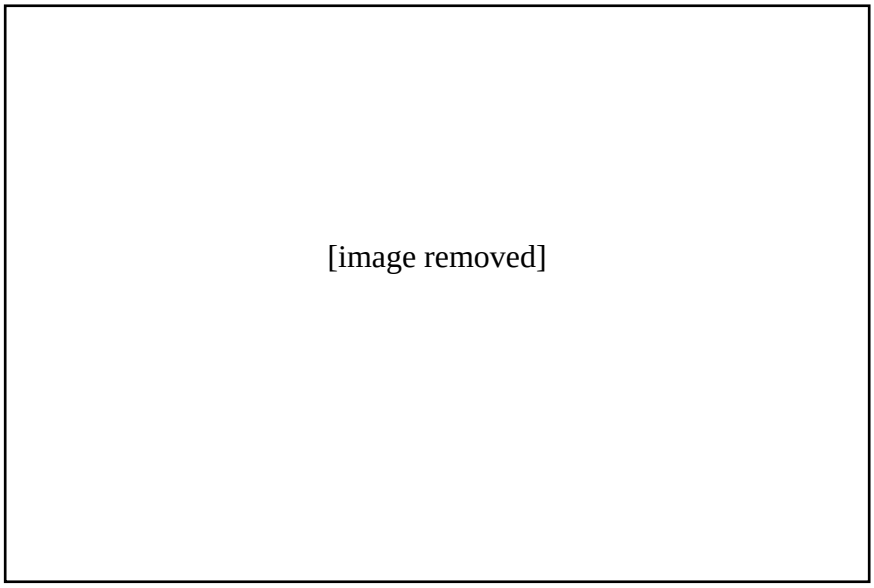
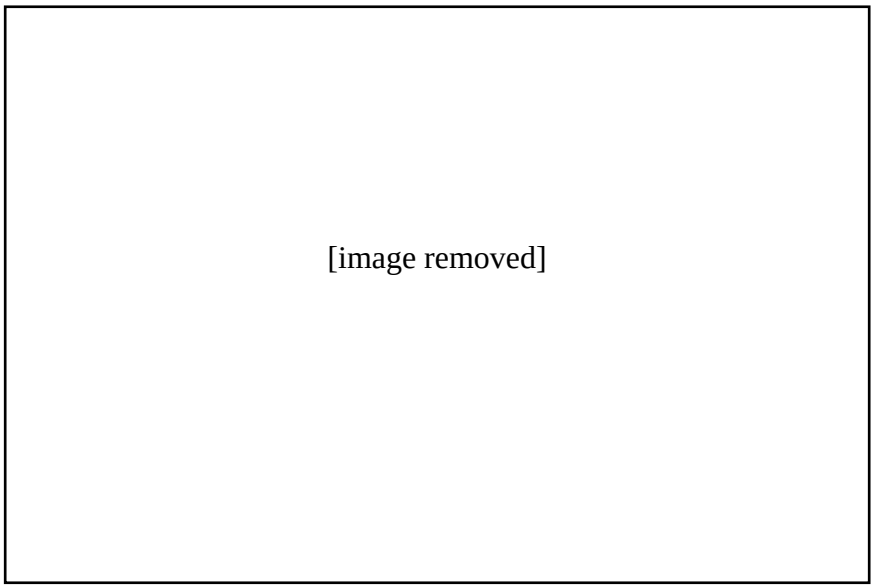
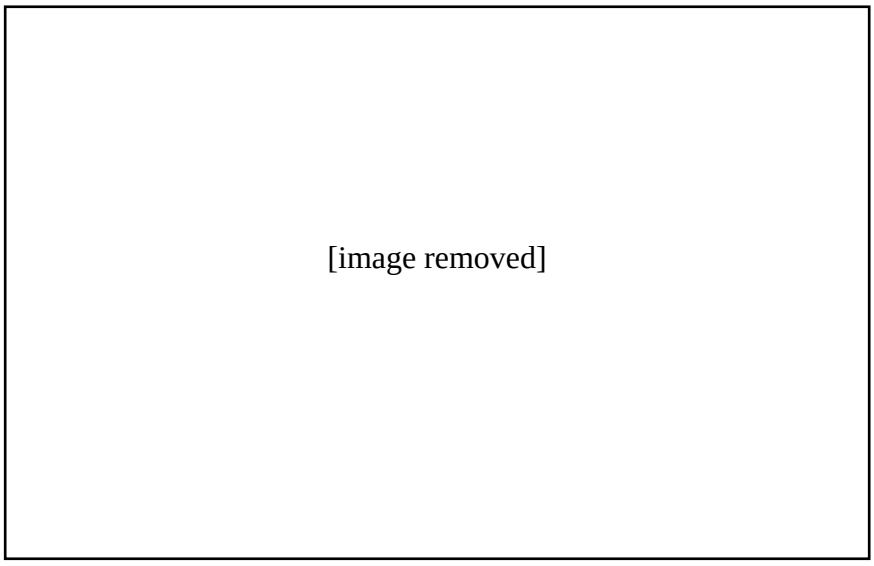


Figure 11: Longitudinal section of LOT-EK's MDU, showing the interior height lost by adding the new steel flooring and space for the extruded subvolumes to glide in and out. The interior height of a standard shipping container is 7'6". The finished interior height of the MDU appears to be no more than 6'8", which is arguably unlivable. Source: Scoates, 118-119







Figures 12-14: Terra Wind RV (the world's first luxury amphibious motor coach), illustrating the extreme mobility and innovative potential for RVs. Source: <http://www.camillc.com/terrawind.htm>

[image removed]

Figure 15: 2009 Winnebago Motor Homes with Prices, illustrating the range of prices and overall relative affordability of the motor home. Source: <http://www.winnebagoind.com/products/winnebago/2009/>

[image removed]

Figure 16: Fleetwood Gas Motor Homes in the $100,000 range. Affordable mobility.
Source: <http://www.fleetwoodrv.com/gas-motorhomes/>