MOVING PARTS

MODULAR ARCHITECTURE IN A FLAT WORLD

FXFOWLE

Podium ›

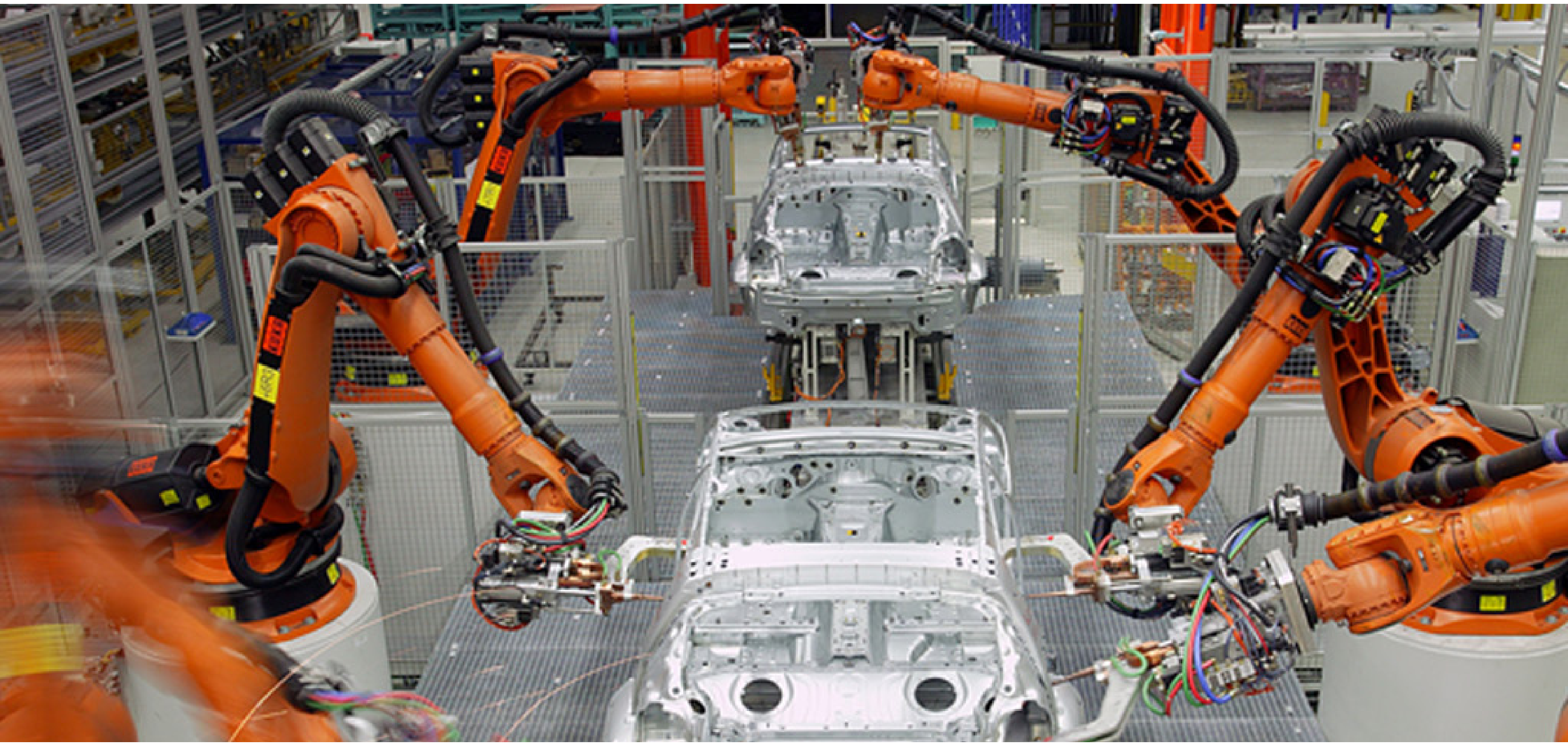
Figure 1:
The building site contrasted with an automotive assembly line. Despite modern materials and methods, the building site in its essential aspects has not changed for thousands of years.
Image: KARIM SAHIB/AFP/Getty Images

1 http://www.citymayors.com/society/urban_growth.html

2 United Nations Department of Economic and Social Affairs, July 10, 2014

3 Bongaarts, John. 2001. *Household Size and Composition in the Developing World*. Policy Research Division, Population Council, p.8

An edited version of this paper was presented at the 2015 NYC New York Conference Proceedings, Council on Tall Buildings and Urban Habitat (CTBUH).



MOVING PARTS
MODULAR ARCHITECTURE IN A FLAT WORLD

David Wallance, AIA, NCARB, LEED AP BD+C,
Sr. Associate, FXFOWLE

By the time you finish reading this sentence, the world's urban population will have grown by one new household. And as you pause for a moment to consider that, another household will have been added. Then another... pause... and another...

The world's population is urbanizing—rapidly. New urban households are forming eighteen times faster than rural households. In 2010, for the first time, the proportion of the world's population living in a city passed the 50 percent mark, and urban population will continue grow into the foreseeable future, with the figure rising to 60 percent by 2030[1]. By 2050, the world's urban population is expected to increase by 2.5 billion inhabitants, according to a United Nations report[2]. At roughly five persons per household[3], that's a total of 500 million new households. In order to keep pace, 275,000 new dwelling units will be needed every week, on average, for the next 35 years. Equally staggering, estimates predict that in ten years, by 2025, there will be 440 million existing urban dwellings that are substandard, not fit for a healthy, dignified

Figure 2:
American-style suburban subdivision, as pioneered by William J. Levitt. Low-cost production stick-frame housing developed on inexpensive tracts. Image: Christoph Gielen: UNTITLED XI Nevada, from CIPHERS courtesy of Jovis Verlag, Berlin

existence[4]. Virtually every breath you take marks the need to add one urban dwelling unit somewhere on the face of the globe, most likely in a developing country.

The wherewithal to purchase a car is considered the benchmark of entry into the middle class, and roughly seventy developing countries, altogether containing about four billion people, are poised to see rapid increases in car ownership in the years ahead[5]. The global rise in car ownership, while marking economic improvement for tens of millions of people a year, is at the same time an ominous trend, because with widespread automobile ownership comes the tendency towards American-style suburban sprawl (Figure 2). Land use patterns in the developing world increasingly resemble our own, with urban surface area worldwide increasing at twice the rate of urban populations[6]. On a global scale a growing and urbanizing middle class is buying cars and using them to live on the outskirts of cities, away from dense metropolitan cores (Figure 3), a trend that can be reversed only with planning policies that encourage density. Such policies include investment in civic improvements: convenient mass transit; compact land

4 Woetzel, Jonathan, Mischke, Jan and Ram, Sangeeth, *The World's Housing Crisis Doesn't Need a Revolutionary Solution*, Harvard Business Review, December 25, 2014

5 Ali, Shimelse and Dadush, Uri, *The Global Middle Class is Bigger Than We Thought*, Foreign Policy, May 16, 2012

6 Seto, Karen C. & Güneralp, Burak, *Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools*, Proceedings of the National Academy of Sciences, August 16, 2012

Figure 3:
Traffic congestion. In the ten most congested American cities drivers spent an average of 42 hours a year sitting in traffic.

use/density tied to transit; public safety; water, sanitation, electrification, and other infrastructure. But without safe, economical, high-quality multi-story dwellings that can be built at a rate that keeps pace with urban population growth, the trend towards sprawl will continue unabated. The land use problem is inextricable from the problem of construction economics.

DRAWING THE ENERGY BOUNDARY

Research has shown that energy consumption from automobile use associated with suburban development is the single largest contributor to greenhouse gas emissions. While the display of technology like solar panels can make a statement about sustainability, the resulting energy savings represent a fraction of what can be achieved by employing site-specific passive design and thermally efficient construction. But all of these strategies combined aren't nearly as effective as one that should be considered first and foremost: effective land use. Regardless of how energy efficiently you build, you get the greatest energy savings and greenhouse gas reductions simply by building cities.

The Jonathan Rose Company, a real-estate firm that specializes in environmentally responsible development, did a study in 2011 that compared household energy consumption between urban and suburban patterns of land use. They discovered that when you step back and consider housing density, housing type (single family versus multi-family), and proximity to energy efficient public transportation, the gains in energy efficiency that are achieved by building dense, multi-story development with access to mass transit outshine the gains from all other energy-saving technologies. For example, according to Rose, a family living in a conventional multi-story apartment building *without* energy efficient features, but *with* access to transit consumes 40 percent less energy than a suburban house built with high efficiency heating systems, low wattage light fixtures, and airtight and well insulated walls. Energy efficient construction still matters: by bringing that urban multi-story apartment building up to stringent energy standards, an additional 16 percent gain can be achieved, for a 56 percent reduction in total compared to an equally efficient house in the suburbs[7] (Table 1).

In contrast, consider the unintended consequences when energy savings are first sought from technological fixes rather than from changes in land use patterns. In a 2012 study, the NRDC[8] showed how energy efficiency could be perversely undermined by policies that promote solar panels. The sloped roof of a suburban house standing by itself on a plot of land is the perfect mounting position (assuming it faces more or less south) for solar panels. The land use patterns that are ideal for rooftop photovoltaics, the NRDC found, resemble nothing other than Sunbelt sprawl!

The economist Edward L. Glaeser has studied the comparative energy use of U.S. cities and suburbs, tallying the impacts of heating fuel, electrical consumption, driving, and public transportation, and finds convincing evidence—supporting Rose and the NRDC—that dense, vertical cities are far more energy efficient than their suburban counterparts. Glaeser's findings also take into account that much of the housing stock in cities is old, with poor insulation, drafty windows, and inefficient heating systems, whereas suburban housing stock tends to be newer and better insulated. Glaeser shows that even with those very inefficient buildings in the mix, for example, "an average New York City resident emits 4,462 pounds less CO_2 [annually] than an average New York suburbanite"[9].

No doubt about it: Dense development in city cores is energy efficient. Now imagine how an economical high-rise modular system, as an urban building block, could be far more effective in reducing greenhouse gas emissions than a landscape of suburban rooftops covered with solar panels.

7 Jonathan Rose Companies, "Location Efficiency and Housing Type: Boiling it Down to BTUs," March 2011

8 Goldstein, David B. & Bacchus, Jamy. *A New Net Zero Definition: Thinking outside the Box*, Natural Resources Defense Council, 2012

9 Glaeser, Edward L., *Green Cities, Brown Suburbs*, City Journal, Winter 2009

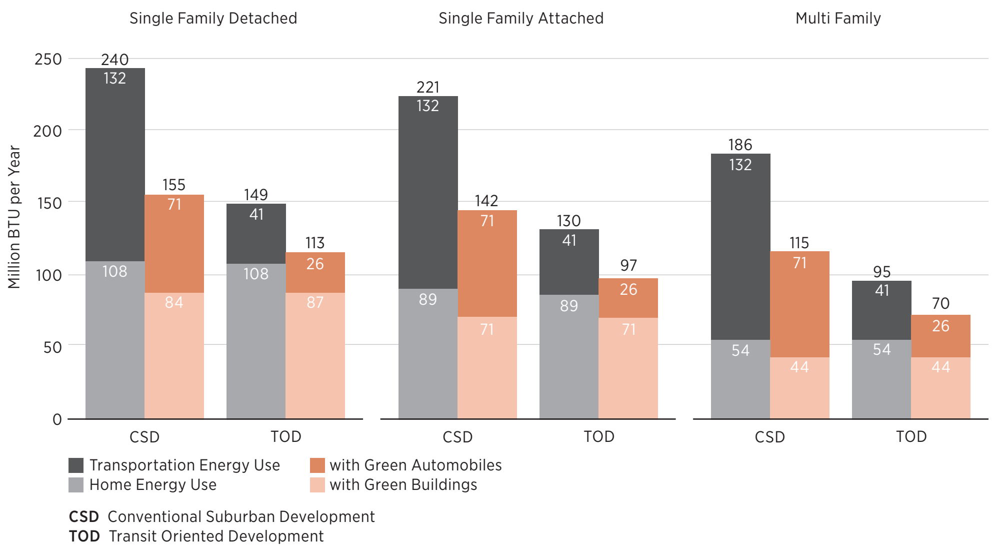


Table 1:
Location Efficiency matters more than energy efficiency. An ordinary multi-story apartment house with access to mass transit is actually 40% more efficient than a car-dependent suburban community of energy efficient houses and green automobiles.

MOVING PARTS

Prefabrication and modular construction have seen a recent resurgence of interest as a means to "crack the code" of construction costs for multi-story urban housing. However, the long-standing theory that modular construction will solve our housing problems has yet to be proven in practice. There remains an urgent and unmet need for a solution that can achieve both quantity and affordable quality to provide for a growing urban population.

The global market for prefabricated housing is forecast to reach 829,000 units by 2017. At an annually compounded 4.4 percent growth rate the global market will reach about 3.4 million units[10]. While this may sound like a lot of units, it is in fact a meager output—a fractional percent of the anticipated need for more than a billion new and replacement urban housing units worldwide (Table 2). The existing modular industry is simply not equipped to respond in any meaningful way.

10 DRM Investments Ltd., 2014

11 Kieran, Stephen & Timberlake, James. *Re-fabricating Architecture*, McGraw-Hill, New York, NY, 2004

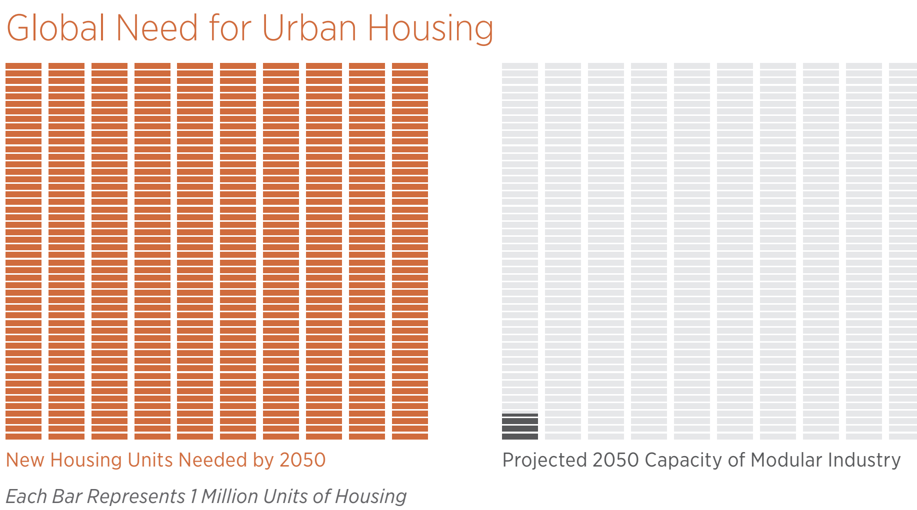


Table 2:
The anticipated demand for urban housing over the next thirty-five years contrasted with the projected capacity of the modular industry as presently organized. (Note that the projected capacity is predominantly single-family manufactured housing, or trailers in common parlance.)

The search for a better way to organize building construction, on a par with the automotive, aerospace, and shipbuilding industries, is one of the mythic quests of modern architecture. The modernist pioneers of the early 20th century fervently believed that new industrial technologies in the hands of architects would solve the housing problems of their era. Since that time, there have been innumerable attempts to marry architecture and manufacturing. Some have succeeded as polemic, and some have succeeded as prototype, but none to date has succeeded to any great degree in transforming building culture (Figures 4, 5 & 6).

In the modernist spirit, architects Stephen Kieran and James Timberlake make a cogent and compelling case for transforming the way we build in their book "Re-fabricating Architecture"[11], drawing a sharp contrast between the architect and the process engineer, in which the former is wedded to anachronistic notions about art, and the latter dedicated to efficiency and "commodity." Architecture is fragmented, where industry is integrated. The industrial process engineer designs the relationships among the many parts and participants so that they merge seamlessly in a complex endeavor. The architect, on the other hand, is relegated to the comparatively narrow task of designing a building.

Kieran and Timberlake study modern supply chain manufacturing methods, and compare those methods with building construction. Today, OEMs (Original Equipment Manufacturers) source myriad components and subcomponents from a global network

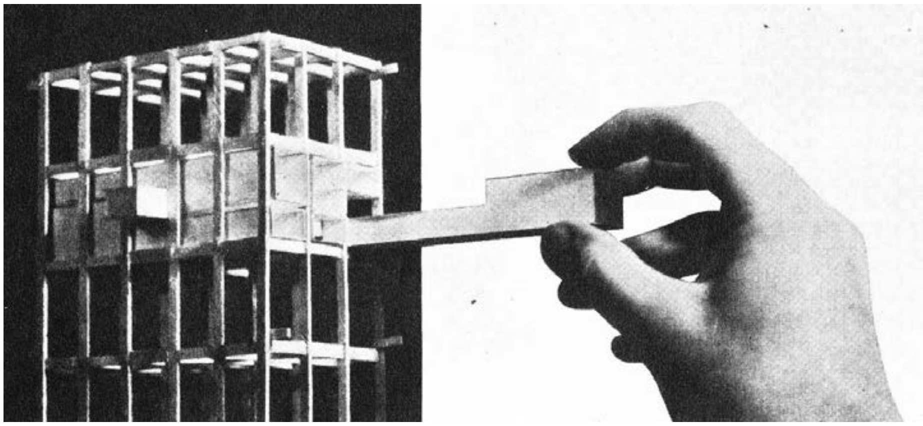


Figure 4:

The original "plug-in" modular idea, as proposed by Le Corbusier for the Unite d'Habitation in Marseilles. (The Unite was ultimately built using conventional techniques.) Others, most notably Archigram, have proposed similar approaches. None have been successful due to the cost of a redundant structural frame and difficult construction logistics.

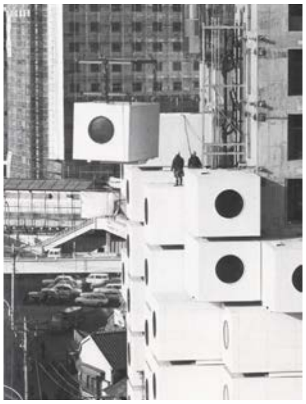


Figure 5:

A pre-cast concrete module for Moshe Safdie's Habitat being hoisted into position. The heavy modules, many weighing over 50 tons, required that a temporary factory be constructed on site in order to solve the transportation problem. Safdie subsequently proposed a series of modular projects, none of which were built. Image courtesy of Safdie Architects/Jerry Spearman.

Figure 6:

Kisho Kurokawa's Nakagin Capsule Tower. Pods hung off of a central concrete core were intended to be replaced after 25 years. They never were, due to the near impossibility of removing them, and the building became increasingly shabby.

of suppliers. Very large objects, like jumbo jets and ships, are assembled in prefabricated "chunks" fitted out with systems and finishes. Only at the final assembly stage are the chunks, which may be entire sections of fuselage, joined together and systems stitched into a complete whole.

However, Kieran and Timberlake don't follow their logic all the way through when it comes to industrializing the building process. The domain of process control stops at the factory or shipyard gate. Process engineering provides a method to control the manufacture of a large, discreet object assembled under one roof. So far, so good, but the vexing problem of assembling *buildings* from modules, as opposed to a jetliner is that, once assembled the jet flies away. In contrast, the building, which may be hundreds if not thousands of miles away from the factory, has not yet been assembled. Once the building module exits the factory *it is no longer under the control of the process engineer*, and the slow, cumbersome, and expensive way in which modules are traditionally moved from factory to building site remains the weak link in the chain (Figure 7).

Here is the crux of the matter: The problem of transportation logistics in modular building construction *is* the problem of modular building construction. Questions of factory capacity, growth potential, innovation, and R&D, all stem from transportation.

Supply chains in a global economy are dependent on global transportation. The incumbent modular manufacturers—which are without exception relatively small companies—have imprisoned themselves in what we might call the *transportation fallacy*. They strive to build the largest possible modules, in the belief that that economy comes from having the fewest units to roll down the highway and crane onto a foundation, and the fewest number of joints to close up and finish in the field. As an unintended consequence of this commitment to super-size modules, the incumbents have burdened themselves with high transportation costs owing to the need for escort cars, planned routes, overnight accommodations, fuel, special permits and insurance, as well as regulatory limitations on hours when modules can be transported into urban areas. As a further consequence the incumbents are unable to compete with conventional construction beyond about a 200-mile radius[12] (Figure 8), and even within that limited range they rarely compete on cost savings. Instead, they compete on time savings alone. The combination of high overhead, high local labor rates, and limited market opportunity makes these companies vulnerable to the ups and downs of the business cycle, and reluctant to invest in plant, equipment, and R&D. Like stunted trees on an exposed mountainside, they expend all their resources on survival and cannot grow.

Even the time-saving argument starts to unravel when it comes to a large-scale building like an urban high-rise. Part of the idea behind saving time in modular construction is that modules are manufactured while foundations are being poured, so that modules start arriving at the site for craning as soon as the foundation is ready. Once foundations are done, however, the rate at which modules can be produced in the factory has to match the speed with which the crane can operate, or those time-savings will quickly evaporate. The incumbent

12 Smith, R.E., Prefab Architecture: A Guide to Modular Design and Construction. Hoboken: John Wiley & Sons, 2011

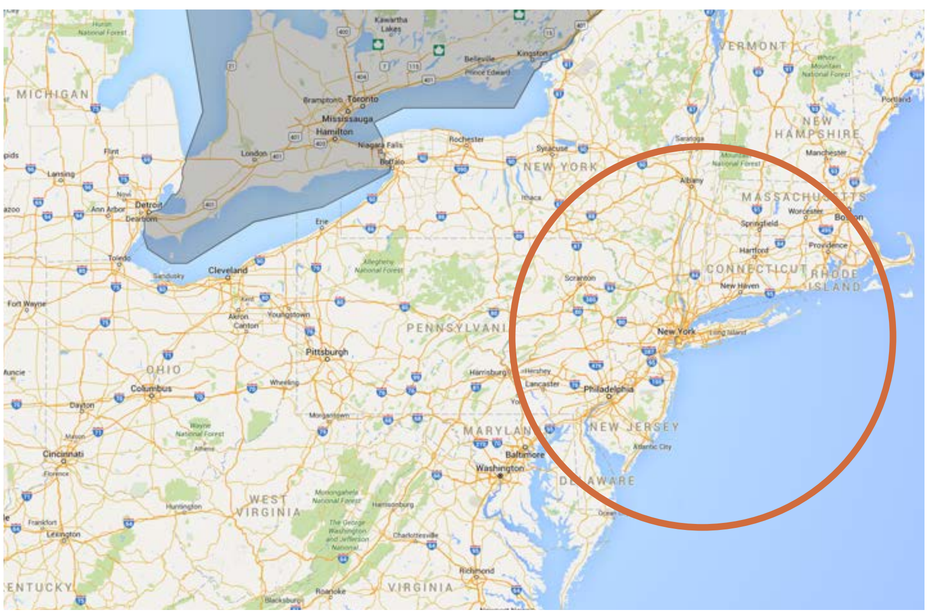
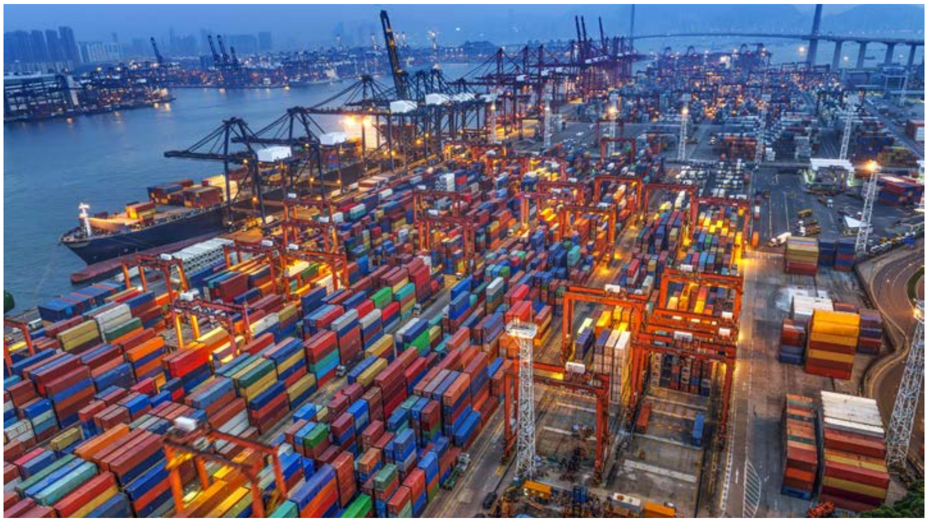


Figure 7:

A typical oversize modular load being trucked on the highway. In addition to being costly to transport these loads have difficulty navigating tight urban streets.

Figure 8:

A two-hundred mile radius centered on New York City, illustrating the transportation range for conventional oversized modules. Map data ©2015 Google



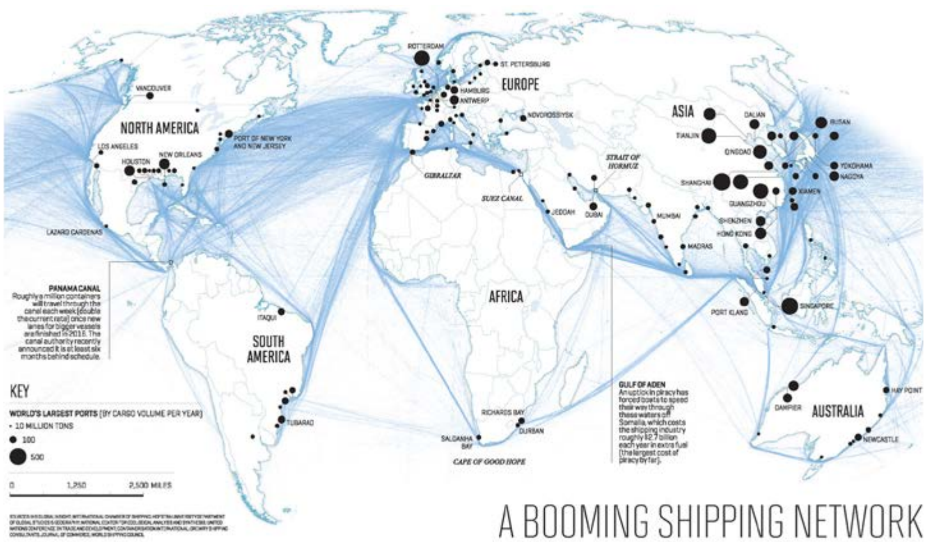


Figure 9:

An intermodal container port. Shipping containers are equipped with standard corner fittings designed for automated crane operation. Containers are transferred seamlessly from ship to truck or railroad flatcar. RFID technology monitors container locations anywhere in the world in real time.

Figure 10:

Intermodal shipping lanes. Every year, roughly 25 million containers are moved on the intermodal transportation system.

manufacturers, with small facilities that don't exceed a couple of hundred thousand square feet, cannot produce at a rate much faster than three modules a day, mainly because production is modeled on the traditional division of building trades rather than on supply chains. As the following example will demonstrate, this rate of production places a natural limit on time-savings for larger scale buildings.

A single crane hoisting large, heavy modules weighing as much as 80,000 pounds can stack up to twelve modules a day, or four times the factory production rate. What happens if a large building—let's say a tower on the order of 500,000 square feet—is being manufactured? At one-quarter the rate of crane capacity, production capacity starts falling behind as soon as foundations are completed. Let's assume a fairly typical 12-by-40-foot module, comprising 480 square feet. Allowing six months for foundations, at the upper rate of three modules a day 396 modules or about 190,000 square feet are in storage ready to start stacking when foundations are done (requiring about eight acres of storage space). The 645 modules comprising the remaining 310,000 square feet will take another ten months to manufacture, during which that costly crane and operating engineer, rented by the day, is working at 30 to 40 percent efficiency. Add another four to six months of hook-ups and final finishing after craning is finally done and the construction time comes to a total of twenty to twenty-two months, a timeframe comparable to a conventionally constructed building. Although the potential to shorten that time by seven to eight months was there, the limiting factor turns out to be the rate of factory production.

Now consider this situation from a business point of view. The factory that undertakes a 500,000-square-foot building will be tied up for a year and a half on that one project. All other sales opportunities must be passed up. By the time the manufacturer is finally ready to accept a new order, customers will have been driven to the competition. To maintain marketing and sales momentum, project turnaround time cannot be much more than just a few months. This suggests that large-scale projects require enterprises that operate in large-scale markets.

Transportation is not only the problem that must be solved, but it is the problem that must be solved *first*, before a scalable system for manufacturing modular buildings capable of mass-production (and ideally of mass customization) will come to fruition. And the solution, which has been right in front of us for more than half-century, derives from the standard ISO (International Standards Organization) shipping container. The shipping container, a cheaply transported modular structure, is the basis of our modern global supply chain, moving seamlessly by ship, rail and highway, as if carried along on a giant globe-strapping conveyor belt (Figures 9 & 10).

• • •

While it may seem ambitious in the context of the present modular industry's capacity, a manufacturing rate of twelve modules a day (i.e. the daily crane rate) is far too limited a goal. More than sixty years ago there was an enterprise that set the bar for modular manufacturing. In 1948, the Lustron Corporation launched the last serious effort at industrial-scale housing production, building a fully engineered and tooled-up

13 Kerr, Douglas, *Suburban Steel: The Magnificent Failure of the Lustron Corporation*, 1945-1951, Ohio State University Press, 2004

Figure 11:
The Lustron Corporation took over a 3 million-square-foot former aircraft factory and re-tooled it to produce steel-framed prefabricated housing.

Figure 12:
The specially designed Lustron tractor-trailer. Lustron's plant was laid out so that the trailer could move along the factory assembly line for loading in the reverse order of installation at the site—in other words, components that were manufactured and loaded last were installed first.

assembly plant in a 3 million-square-foot former aircraft factory. With a vertically integrated production line designed for 3,000 houses a month[13] (Figures 11 & 12), Lustron would have had the capacity to produce the modular equivalent of a 1 million-square-foot residential tower a week.

SHIPPING CONTAINERS TRANSFORMED

Recycled shipping container architecture has been trending for several years, but when it comes to scale, containers turn out to have significant technical limitations. A realistic look at the problem of obtaining used shipping containers will make evident how unfeasible it is to use them for any but the smallest buildings. To get to a significant scale of operations would entail the recovery of hundreds of thousands of containers a year. In this scenario, the ability to recover and reprocess used shipping containers quickly becomes a scale-limiting factor. Even if there were a way to recycle in quantity there are problems with structural soundness, contaminants such as bituminous waterproofing and pesticides, and combustible plywood floors that will not meet code for fireproof construction.

Further, much of the value-added material in a shipping container must be thrown away. The freight doors on one end of the container are of no use in building construction.

The catalog, fueled by Internet-based commerce and social media, would become a globally connected platform for collaborative design.

Large portions of the corrugated steel siding must be cut away and sent to the scrap yard in order to make a modular system that can be expanded spatially (we don't want rooms to be limited to an 8-foot width) so the frame of a standard shipping container then becomes too weak and has to have steel reinforcement welded to it. Costs add up, steel is wasted, and the slow process of converting a shipping container to a building module further limits the scale of operations (Figure 13).

If scale is the objective, then what's needed is a module that can be cheaply transported like a shipping container but which is engineered from the get-go to be optimized for mid- and high-rise building construction. Such a module would meet ISO's dimension standards, and would be fitted out with the eight steel corner nodes, that enable automated intermodal handling.

We'll call that new type of building module a Volumetric Unit of Construction, or VUC, to clearly distinguish it from a shipping container (Figure 14).

With such a system fully engineered and proven, a continual stream of variations, accessories, and add-ons can be developed to fit on the basic VUC chassis, enabling untold design flexibility and choice. This system is analogous to an iPhone, in which hundreds of thousands of apps have been developed to work on Apple's operating system. Like apps, the plug-and-play accessories for the VUC—balconies, shading systems, secondary facades, kitchens, etc.—could be developed by third parties . These "modular app" developers would be architectural product manufacturers, architects and industrial designers, or anyone, for that matter, who has an idea and the technical wherewithal to work it out and coordinate details with the VUC manufacturer. The catalog, fueled by Internet-based commerce and social media, would become a globally connected platform for collaborative design. With the modular industry for the first time operating with economies of scale, regional variations responsive to climates and cultures would flourish.

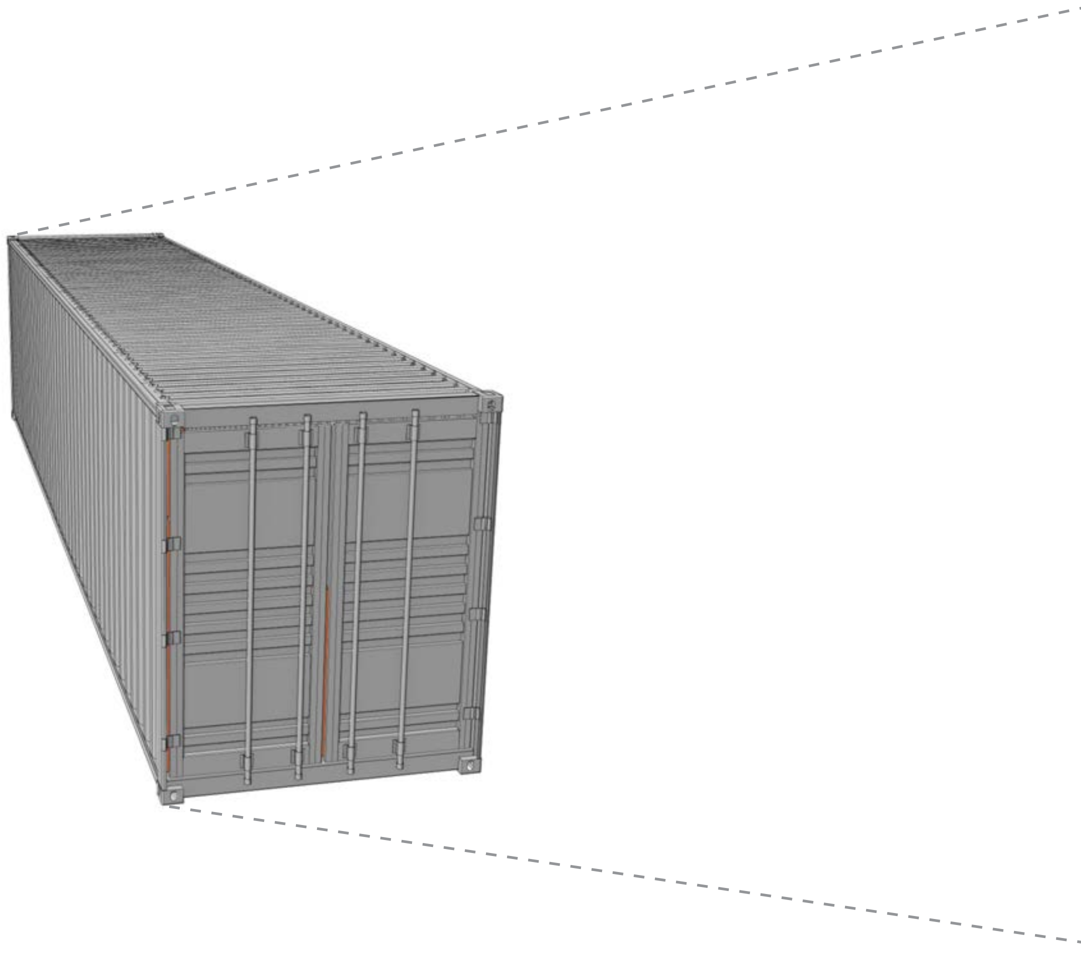
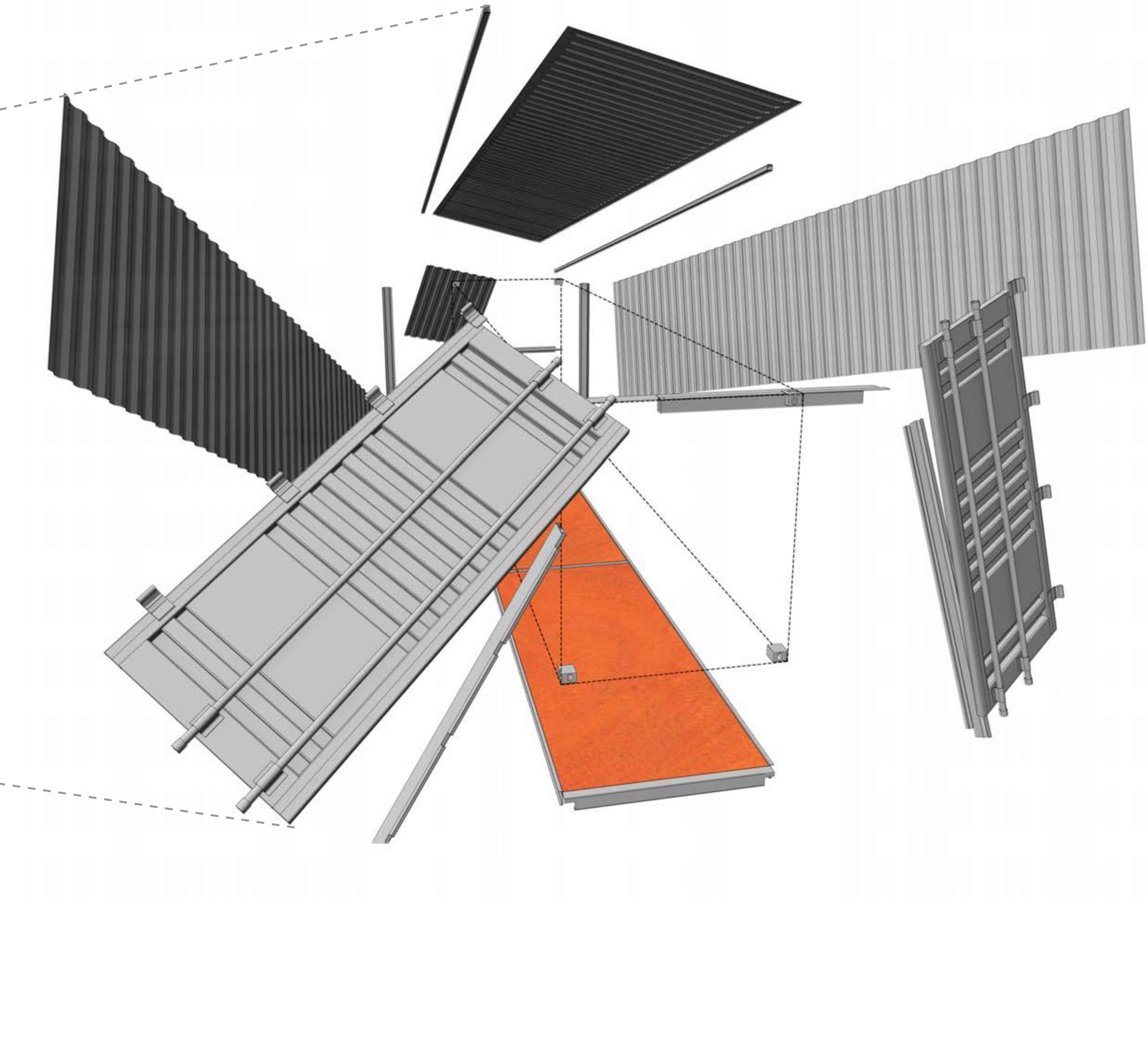


Figure 13:
The shipping container is encumbered by numerous features that are disadvantageous for building construction. Stripped down to its essentials—standard ISO conforming dimensions and corner nodes—it can be re-engineered to be optimized as a building module. Image courtesy of Global Building Modules, Inc. (GBM).



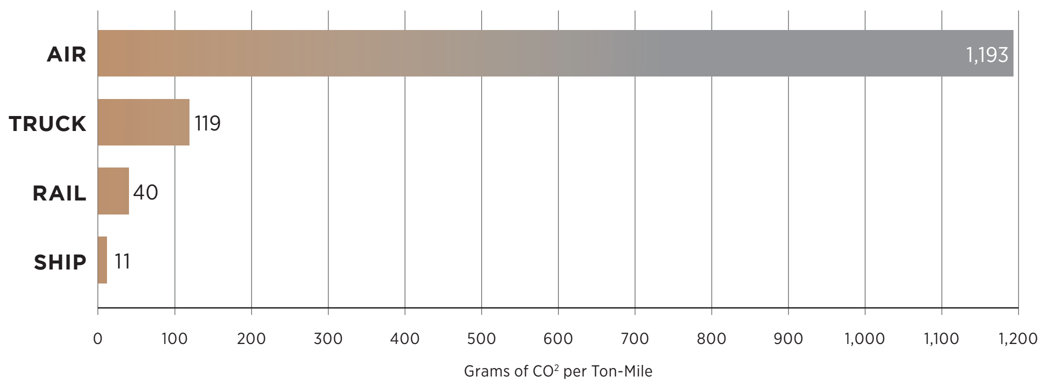


Table 3:
Comparison of CO^2 emissions per ton-mile for various forms of containerized freight transport.

BLUE IS THE NEW GREEN

A proposal to base a modular building system on intermodal transportation and global supply chain procurement raises a question: Does shipping building modules halfway around the world make environmental sense? The answer, which will come as a surprise is "Yes, and…". First, maritime transportation is many times more fuel-efficient than trucking, so the shipping distance across oceans translates into a fraction of the fuel consumed if that distance were traveled by a tractor-trailer over the highway. Overseas shipping is roughly ten times as efficient as truck transport[14] (Table 3). Via the Panama Canal, the trip from Shanghai to New York is 12,000 miles, or the equivalent of 1,200 miles on the highway. Let's call this "Equivalent Trucking Miles," or ETM.

The second part of the answer has to do with weight. The quantity of fuel used to move materials, no matter what mode of transport, is proportional to weight. The all-steel VUC, having no concrete, at 41 pounds per square-foot is approximately one-third the weight of a conventional steel-and-concrete building. Energy expended per square-foot of building area to transport a VUC is one-third of what it would take to transport the materials required to build 1 square foot of a conventional building. That 1,200 ETM becomes, in effect, the equivalent of 400 ETM per square-foot (ETM/SF). Remember that under LEED, a Regional Priority credit is achieved by obtaining materials within 500 miles. A building comprised of VUCs would be 20 percent more efficient than a conventional building in which all of the materials met the requirement for Regional Priority.

SCALE, SCALE, SCALE

Why, one might ask, do global supply chains matter? The answer has to do with the difference between simply moving the construction trades indoors, which is what the incumbents do, and transforming the modular industry along the lines of other advanced manufacturing sectors, as in, for example, the flourishing technology sector. With supply chains, myriad components are manufactured simultaneously by specialized suppliers. Components converge at an

14 http://www.nrdc.org/international/cleanbydesign/transportation.asp#footnote3, February 5, 2012

assembly facility, where building modules are rapidly put together on a moving line. Supply chains require economies of scale and standardization. The hide-bound incumbent manufacturers will never achieve scale, and don't (can't) think in terms of standardization. If there is to be a response to the need for multi-story urban housing on a meaningful scale, then modular needs to go global. A globalized modular industry can meet the demand of a burgeoning urban population for mid- and high-rise housing, at a cost and level of quality that will encourage living in densely populated environments.

Scale matters above all else. Scale drives industrialization, advanced manufacturing technology, supply chain procurement, and modern quality-control techniques. But scale in modular construction has proven elusive. To achieve scale in a contemporary enterprise global markets are required, and conventional modular manufacturing is locked in a regional cage of a 200-mile trucking radius.

Breaking the chains of regional manufacturing means adopting intermodal transportation, the system by which standard shipping containers are moved inexpensively around the world by the millions each year. The introduction of containerized shipping fifty years ago revolutionized global trade, but until now a shipping container was a metal box stuffed with products—it was not the product itself.

A new type of building module—the Volumetric Unit of Construction—based on the shipping container but purpose-engineered to meet the specific and stringent requirements of mid- and high-rise building construction (Figure 15), retains the advantages of intermodal logistics and automated handling. Such a module would be the basis for a completely integrated building system that will spawn a new industrial ecology, an interdependent network of architects, industrial designers, process engineers, entrepreneurs, and building product manufacturers that will flourish within a global market, leveraging the power of distributed intelligence. Dimensional standards and rules that govern the arrangement of components (an architectural operating system) will provide a behind-the-scenes backbone for a growing open-source catalog of apps. An expanding web of connections among stakeholders and start-up enterprises will ignite a global architectural conversation from which a new kind of architectural vernacular will emerge. Here, regional differences, whether they are cultural, environmental, or historical, will find expression within a system of broadly accepted technical standards.

The challenge, then, is how to achieve scale with diversity, differentiation, and local adaptation, in the context of a global shift to encourage density and discourage sprawl. A shift in land use of this magnitude requires a concerted effort on multiple fronts, which must include a solution that reduces the cost while increasing the quality of multi-story housing for the emergent global middle class. The key is within reach: an industrialized system of modular construction borne on the conveyor belt of intermodal shipping.

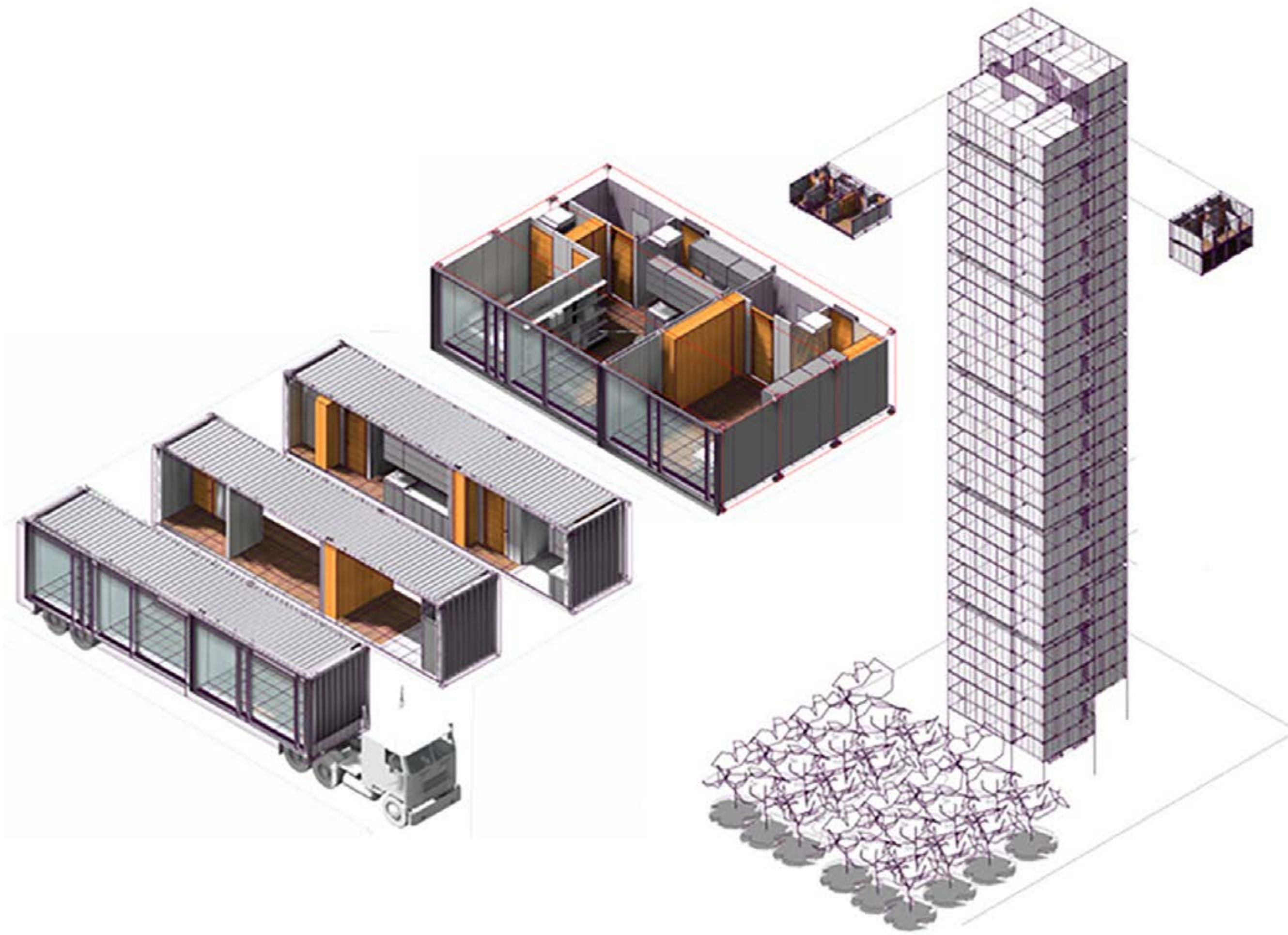


Figure 14:
VUCs can be arranged to create varied unit layouts and can be stacked into high-rise buildings. Elevators, fire stairs, corridors, interconnections and vertical services are integrated into VUCs as a “plug-and-play” system. Image courtesy of Global Building Modules, Inc. (GBM).

Figure 15:
A study by FXFOWLE for a 536,000-square-foot residential development over a conventional retail base, comprised of 1,621 standard VUCs arranged into high-rise, mid-rise, and townhouse typologies.

David Wallance is a Senior Associate at FXFOWLE Architects in New York City. He has practiced architecture for over thirty years, with wide-ranging experience in the design of residential, commercial, cultural, and institutional buildings. David pursues an approach to design characterized by a synthesis of form and building technology. He believes that we intuitively respond to buildings that are well-made, in which an architectural intention is legible at every scale down to the details. At the Polshek Partnership from 1993 to 2005, David was senior designer on the Rose Center for Earth and Space at the American Museum of Natural History in New York. In 2005, David joined Global Building Modules, Inc. (GBM), a start-up venture, to pioneer a system of modular construction based on the transformation of the standard shipping container into a purpose-engineered module for mid- to high-rise buildings. He has designed several buildings using the system and has filed 38 patents, the first four of which are now approved. David is currently working on a book about modular architecture and the transformative potential of the GBM system. He received a Bachelor of Architecture degree from the Cooper Union, and has been an Adjunct Associate Professor of Architecture at the Columbia University Graduate School of Architecture, Planning and Preservation since 1997.

FXFOWLE Architects is working with Global Building Modules, Inc. on the continued development of the GBM system.

FXFOWLE Podium develops white paper content that reflects the firm's core values of design excellence, technical innovation, and sustainability.

FXFOWLE ARCHITECTS

22 WEST 19 STREET
NEW YORK, NY 10011
MAIN +1.212.627.1700
FAX +1.212.463.8716

NEW YORK
WASHINGTON DC
INFO@FXFOWLE.COM
WWW.FXFOWLE.COM