



# ReFAB PreFAB: The Practice and Science of Prefabrication at the Cutting Edge

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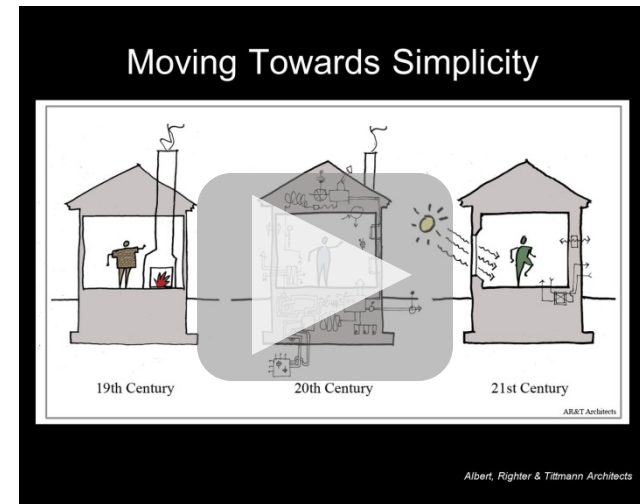
Form Follows Energy

Research, Building Science and Architecture

Detailing for Durability

Healthy Homes Research

Researching Resiliency



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# Course Description 1 of 2

Although prefabrication is not new to the practice of architecture, its full potential, particularly in residential design and construction, has yet to be realized. The time for architects to take the lead in realizing this potential is now. New concepts and technologies in prefabrication are creating exciting new architecture and opening the opportunity for architects to influence a larger segment of the construction industry. Not only will prefabrication expand architects' influence, it will also help revitalize residential neighborhoods, influence sustainable design, and provide lower-cost home-ownership alternatives.



# Course Description 2 of 2

In an effort to realize this ambition, Andrew Daley, Jason Fleming, and Peter Muessig (all recent M.Arch. graduates of the Rice School of Architecture in Houston, TX) set out to design and build a pre-fabricated, consolidated kitchen/bath/mechanical “core” tailored specifically for renovation of existing homes. Having just successfully installed their first fully working prototype, the three will present their project as a case study of the opportunities and challenges inherent to pre-fabrication.



# Learning Objectives

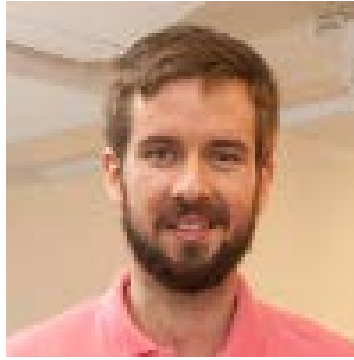
1. Recognize the potential of prefabricated residential architecture in new construction and in renovation of existing residential structures.
2. Understand the potential of sustainable design, computer modeling in the factory process, and new architectural avenues based on mass production.
3. Identify the benefits of prefabricated architecture, including cost savings, reduced material consumption and waste, reduced exposure to regional labor shortages, expedited delivery, and increased quality of design and construction.
4. Recognize the limitations of prefabrication (specifically what can be completed in the factory, what must be completed on site, and when and how to make concessions) and develop strategies that permit design flexibility.





**Peter Muessig, Assoc. AIA**

Designer  
Interloop Architecture  
Houston, TX  
Speaker



**Jason Fleming, Assoc. AIA**

Designer  
Morris Architects  
Houston, TX  
Speaker



**Stephen Schreiber, FAIA**

University of Massachusetts Amherst  
Moderator

Submit a question to the moderator via the Chat box. They will be answered as time allows.



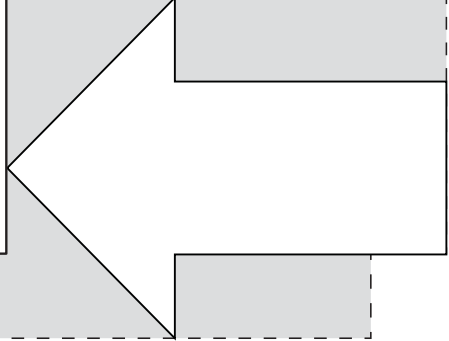




INHOUSE OUTHOUSE

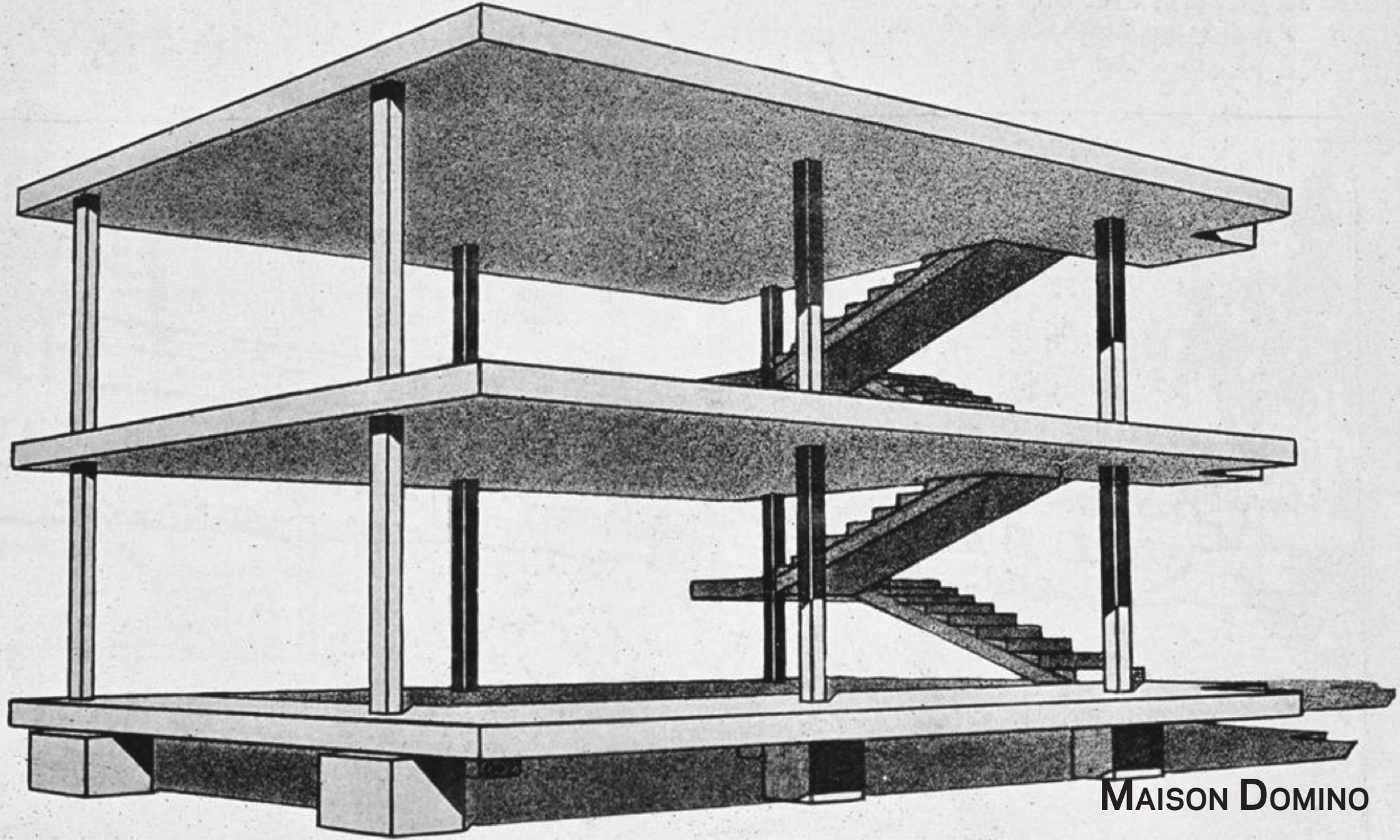


OFFICE  
MECH  
BATH  
KITCHEN



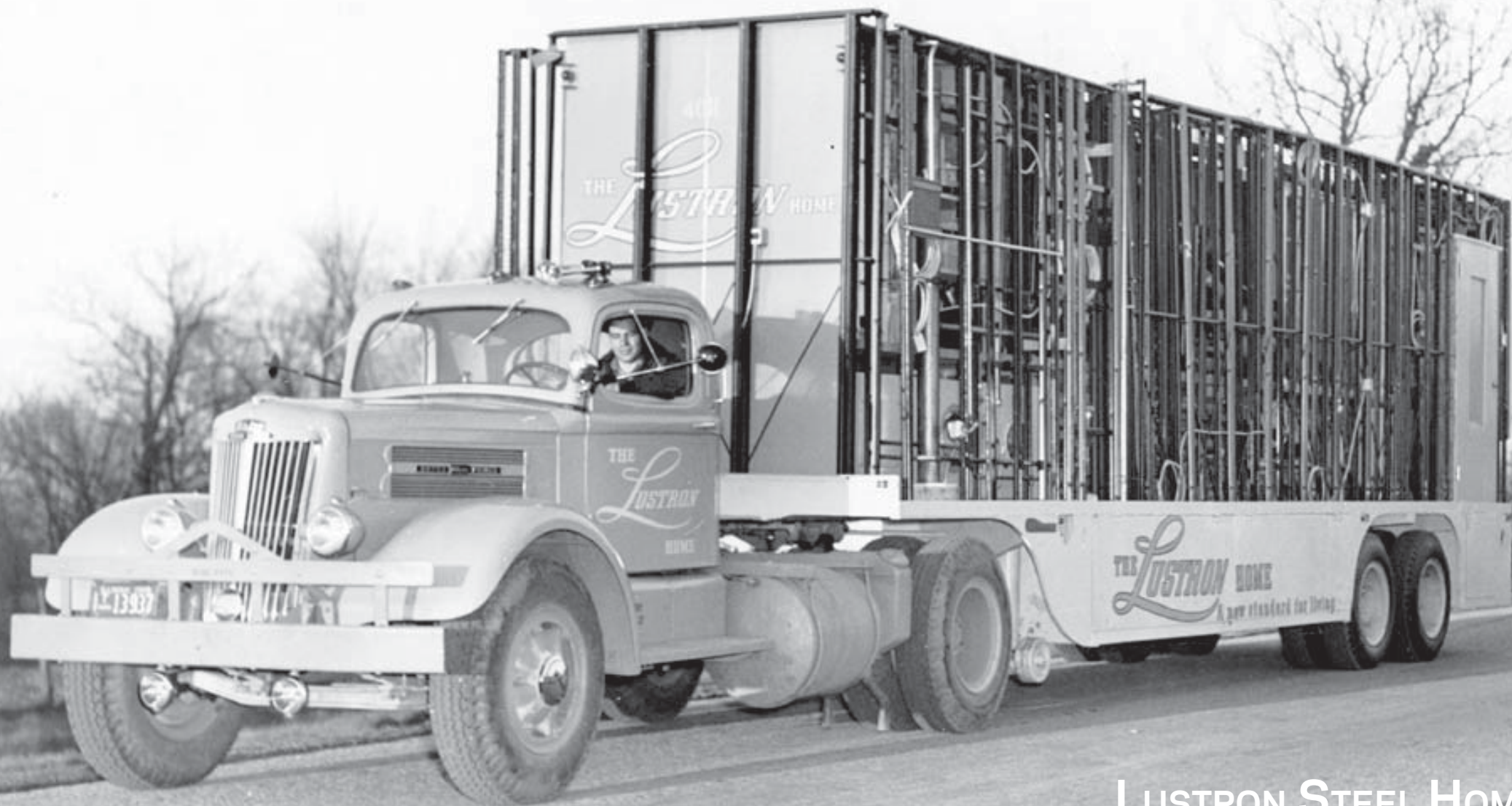
**HISTORY**





MAISON DOMINO





LUSTRON STEEL HOMES





LE CORBUSIER - UNITÉ D'HABITATION



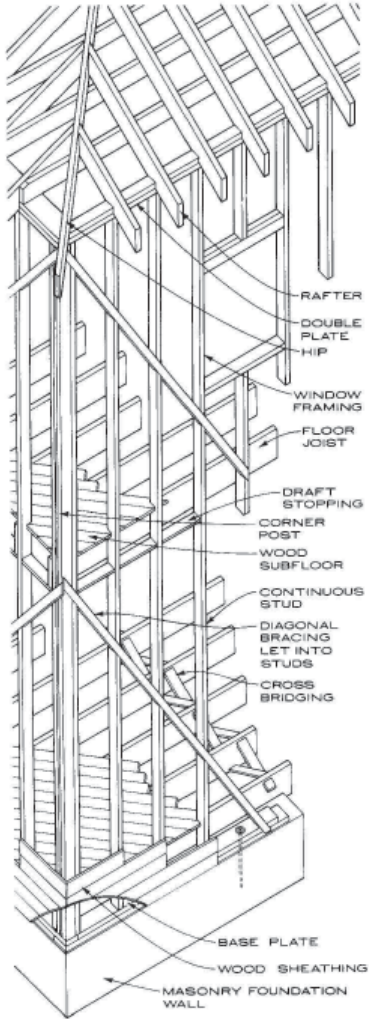
MOSHE SAFDIE - HABITAT 67



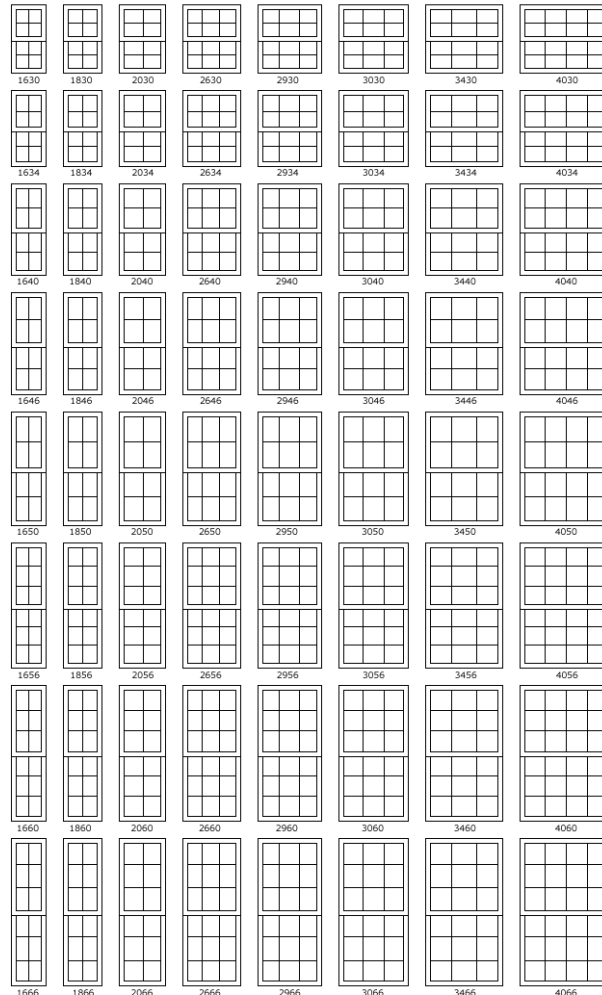




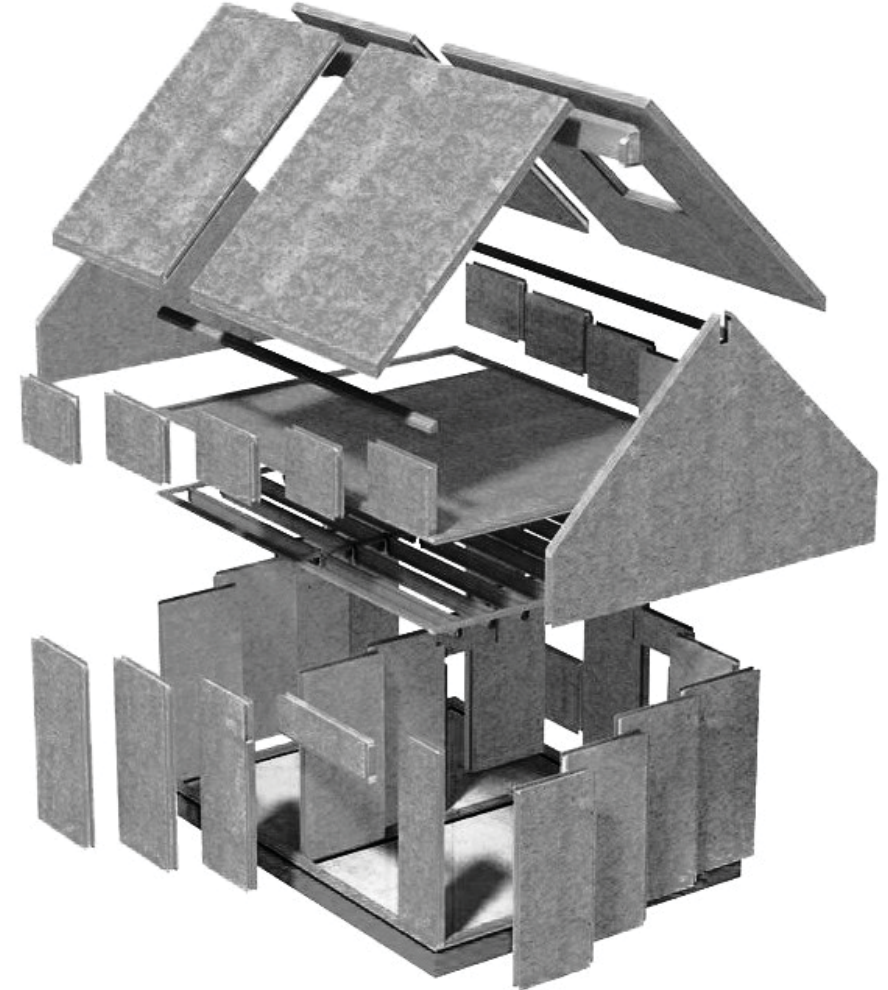
# MODULAR BUILDING COMPONENTS



**BALLOON FRAME**

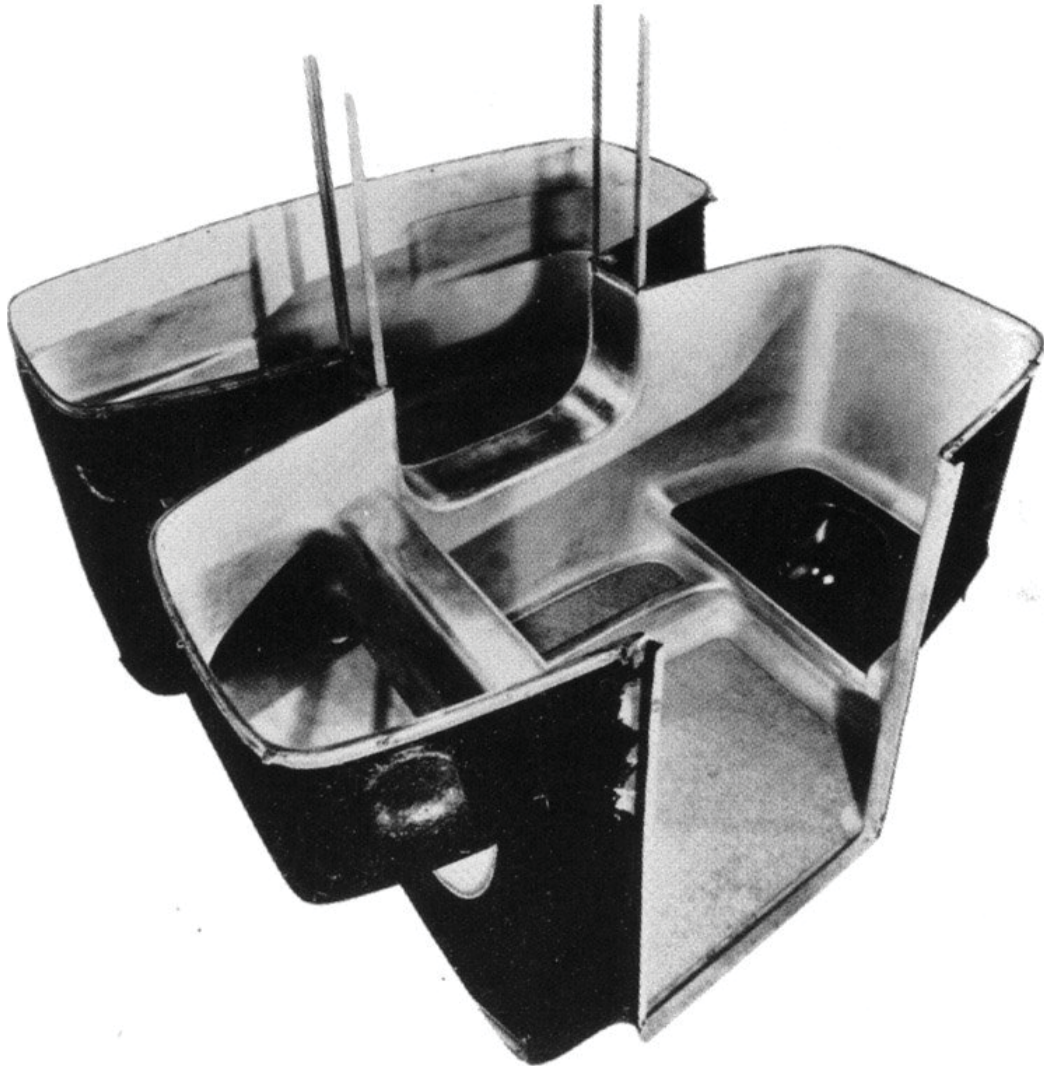


**WINDOWS**

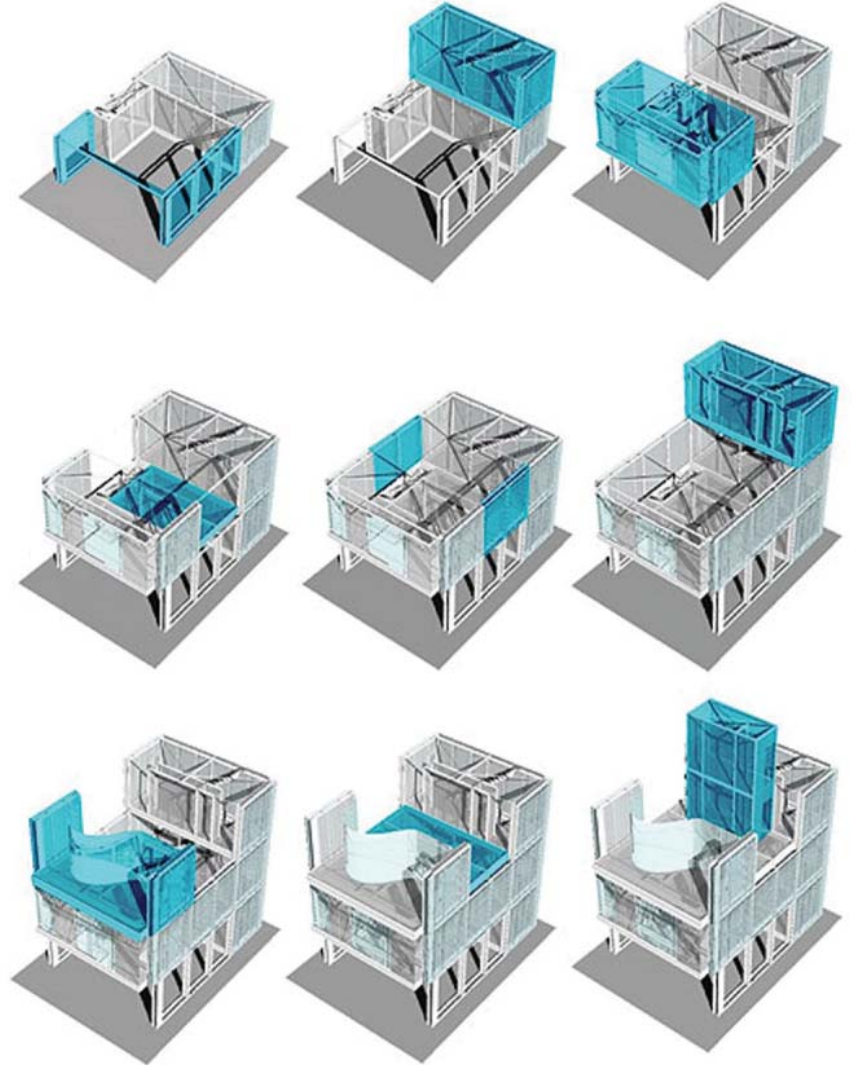


**SIPS PANELS**

# MODULAR BATHROOM SYSTEMS



**FULLER - BATHROOM POD**

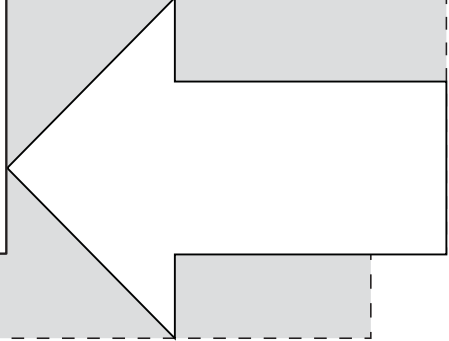


**KIERAN + TIMBERLAKE - CELLOPHANE HOUSE**

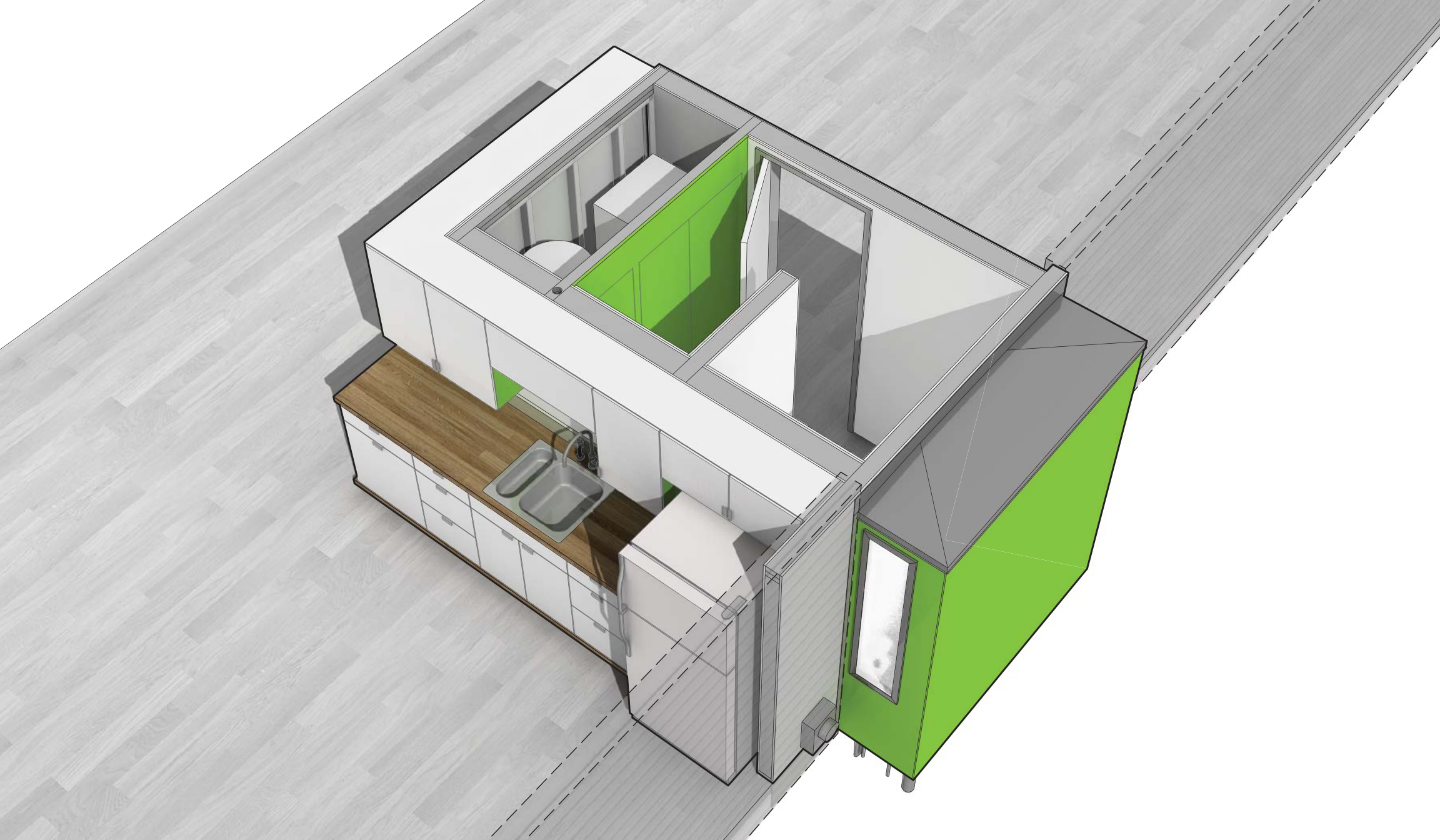
**P**ROJECT

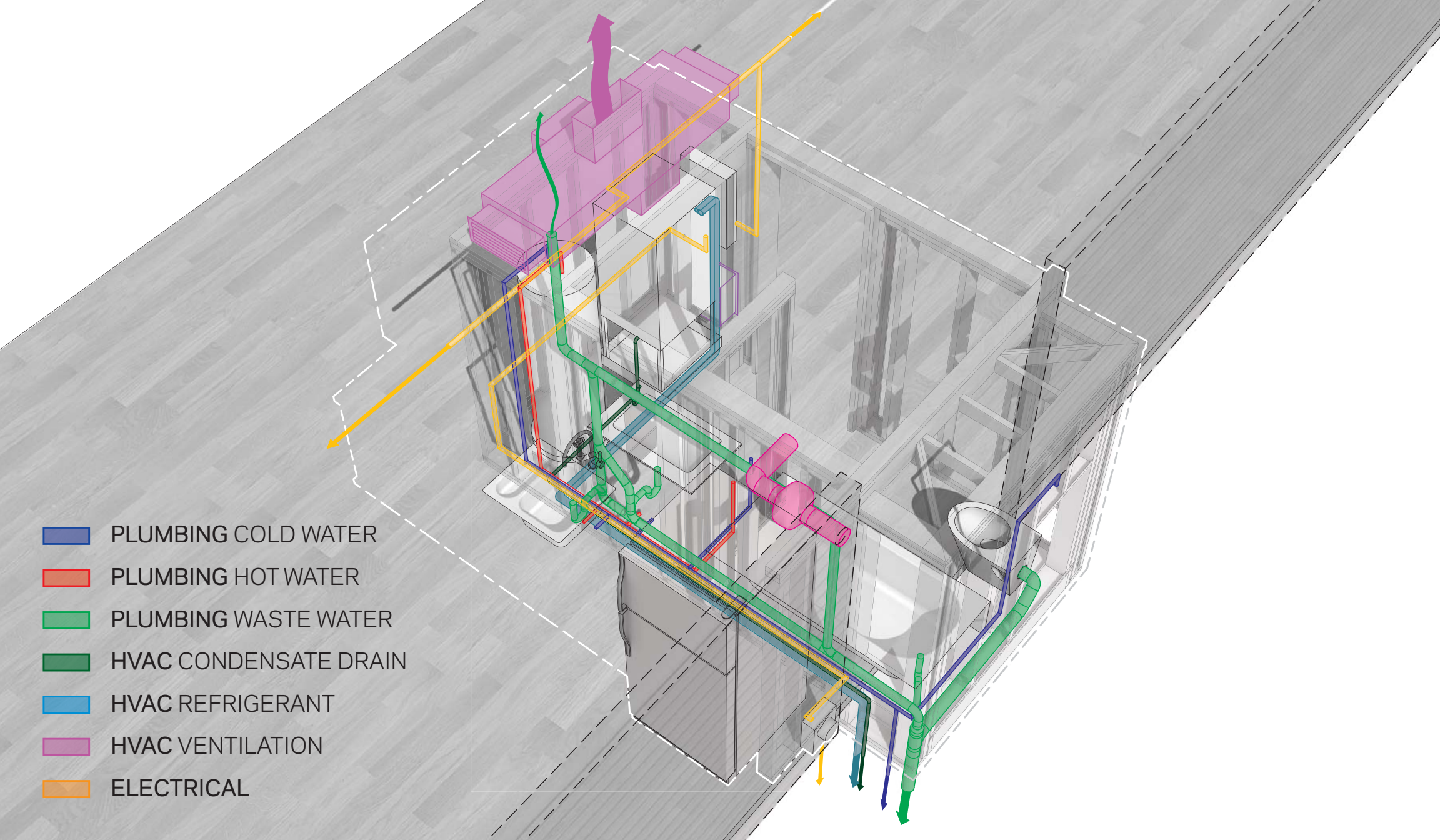
SLEEP  
LIVE

+OFFICE  
MECH  
BATH  
KITCHEN

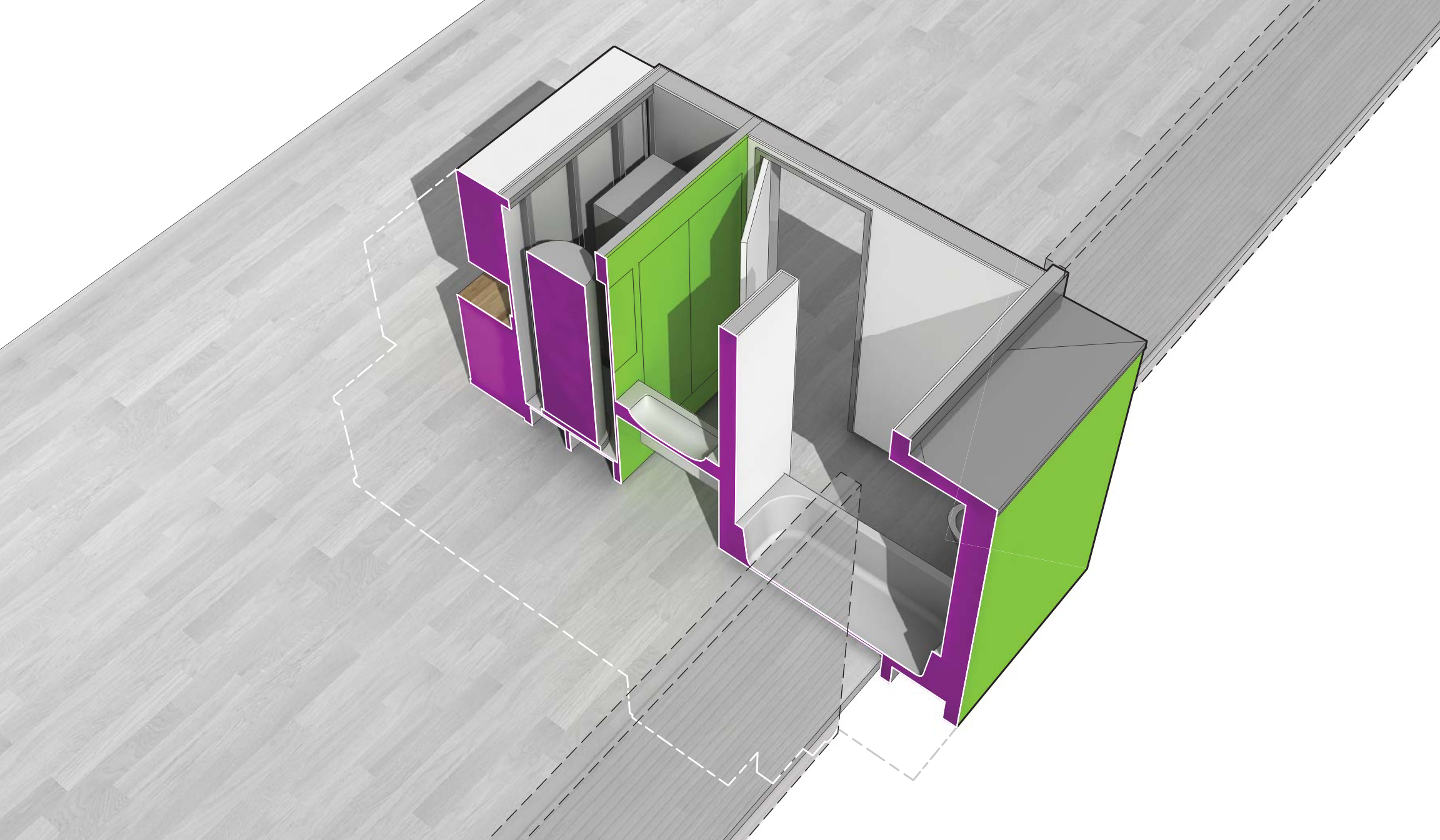


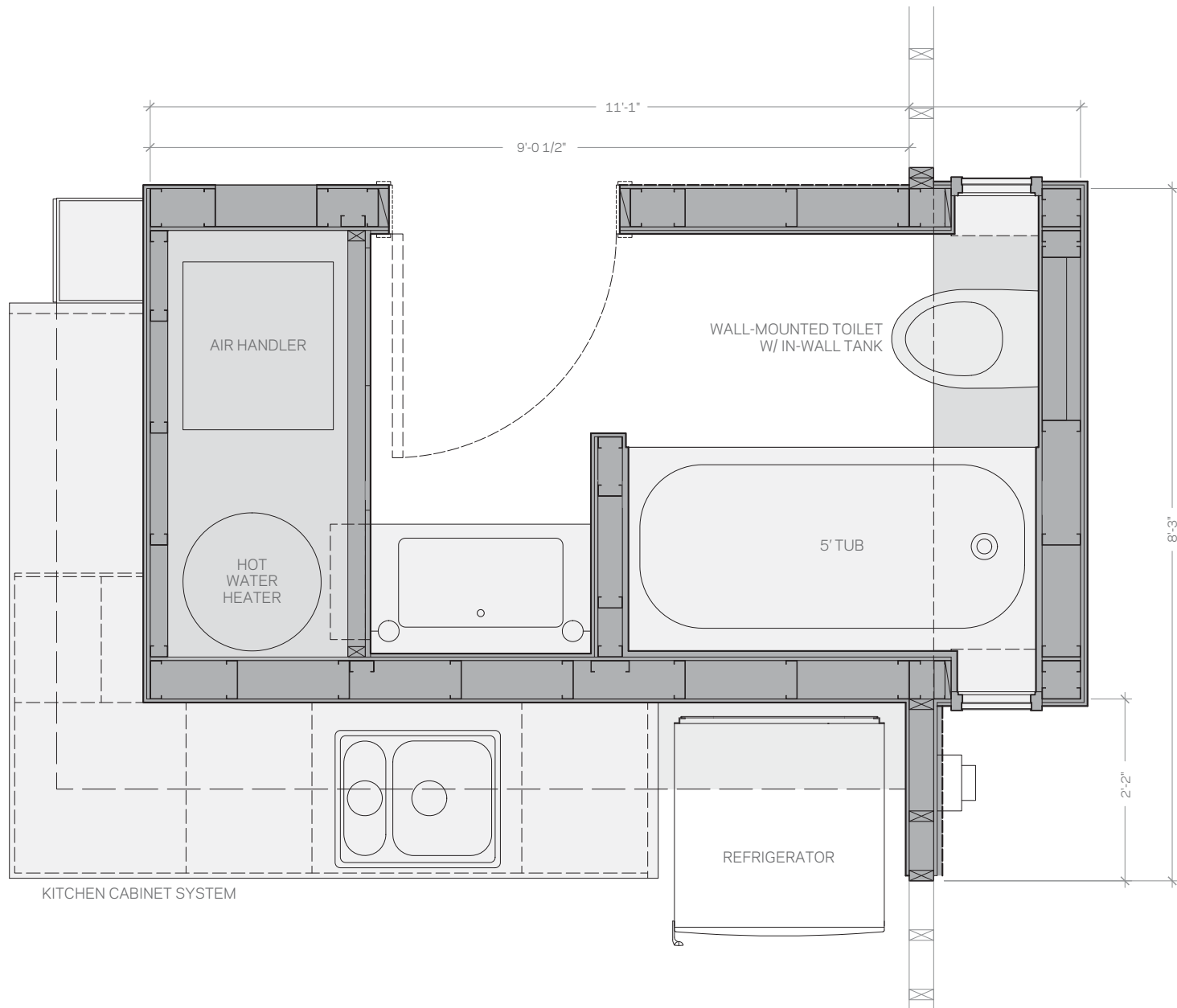




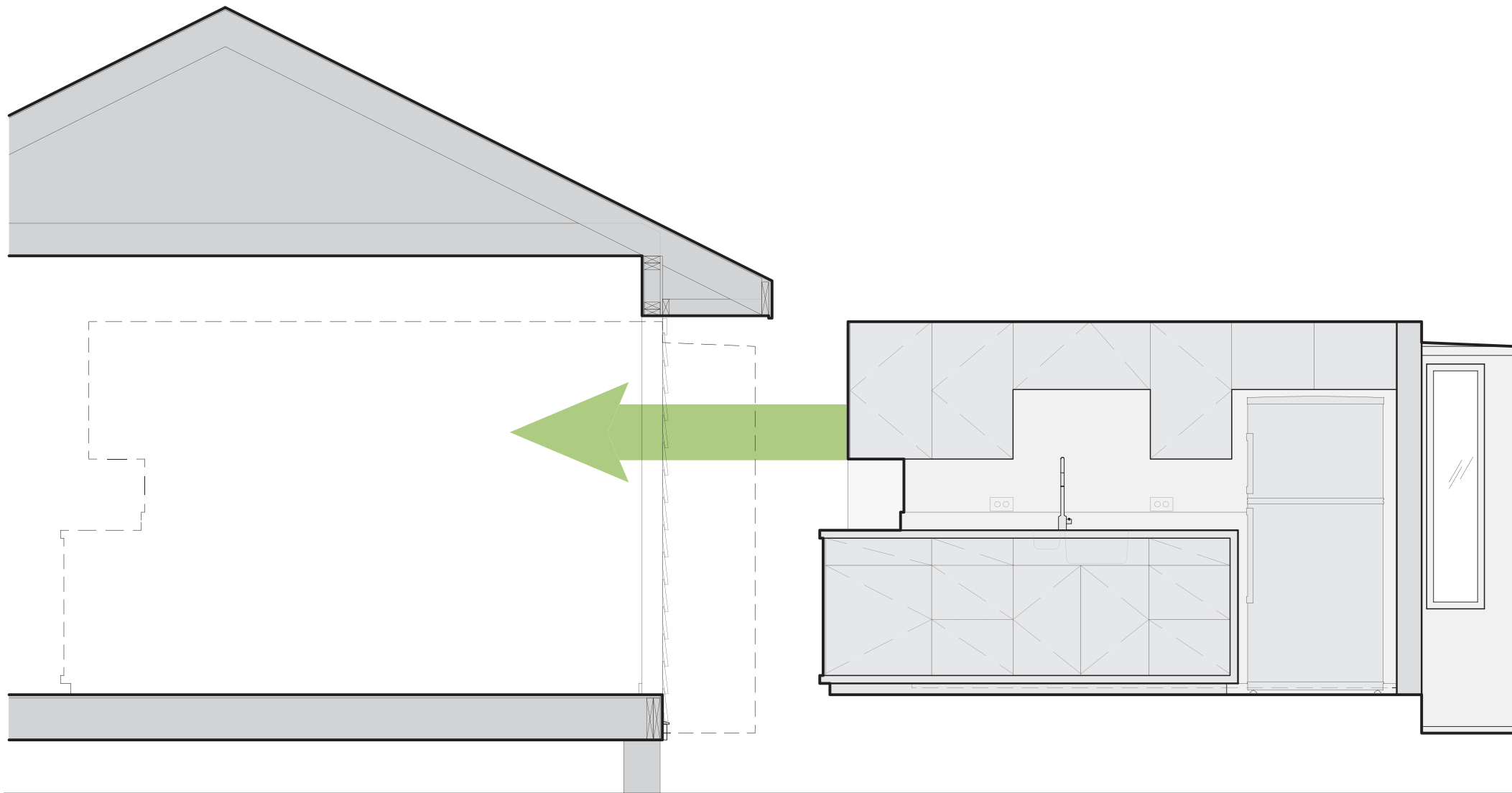
- 
- This 3D cutaway diagram illustrates the complex network of pipes and ducts within a building's structure. The building is shown in a perspective view, with a dashed white line indicating the cutaway plane. The interior reveals a bathroom with a toilet and sink, and a kitchen area with a sink. The plumbing system is color-coded: blue for cold water, red for hot water, and green for waste water. The HVAC system is also color-coded: dark green for condensate drain, light blue for refrigerant, and purple for ventilation. Electrical conduits are shown in orange. Arrows indicate the flow direction for each system. The building is situated on a wooden deck, and a road is visible in the background.
- PLUMBING COLD WATER
  - PLUMBING HOT WATER
  - PLUMBING WASTE WATER
  - HVAC CONDENSATE DRAIN
  - HVAC REFRIGERANT
  - HVAC VENTILATION
  - ELECTRICAL











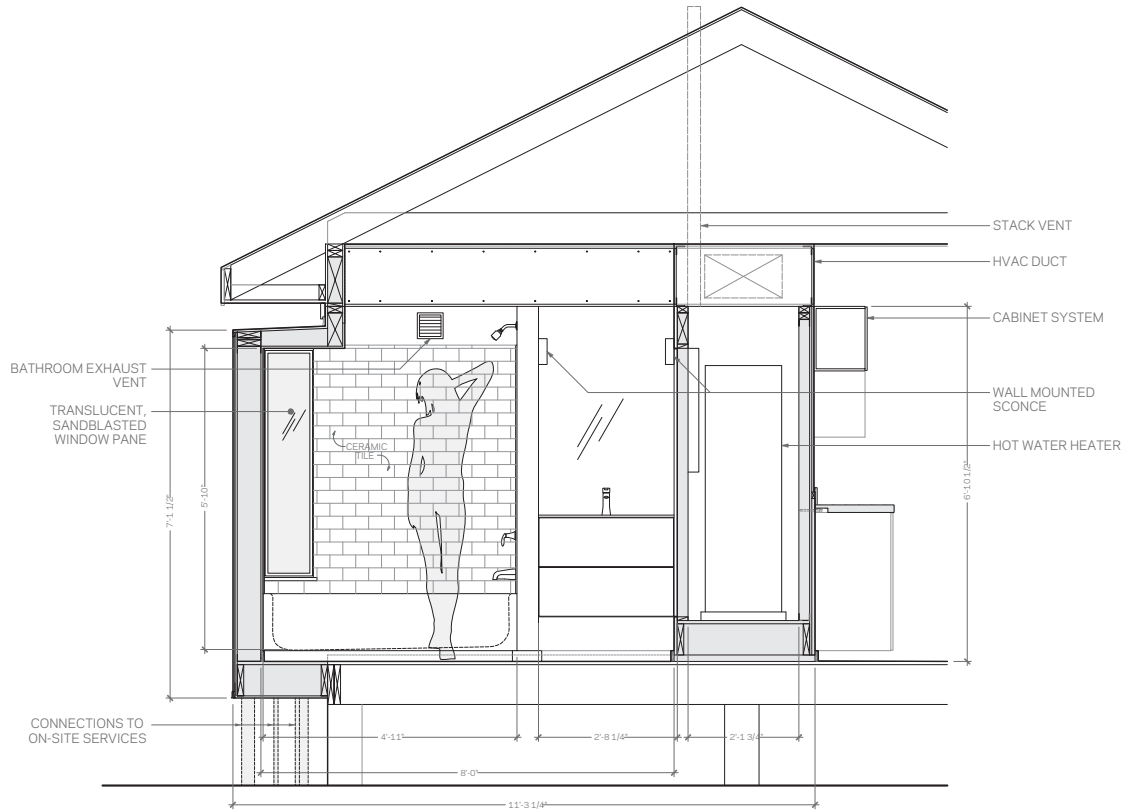




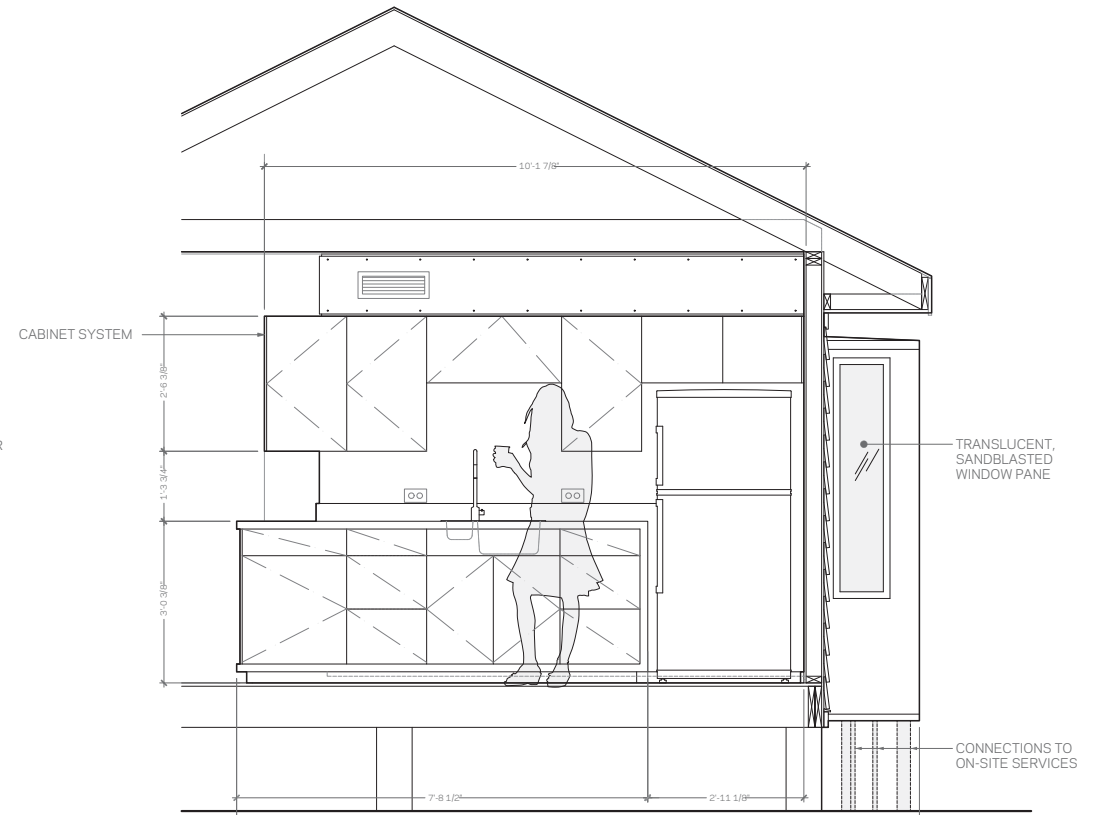




**VISION**



**SECTION : BATHROOM**

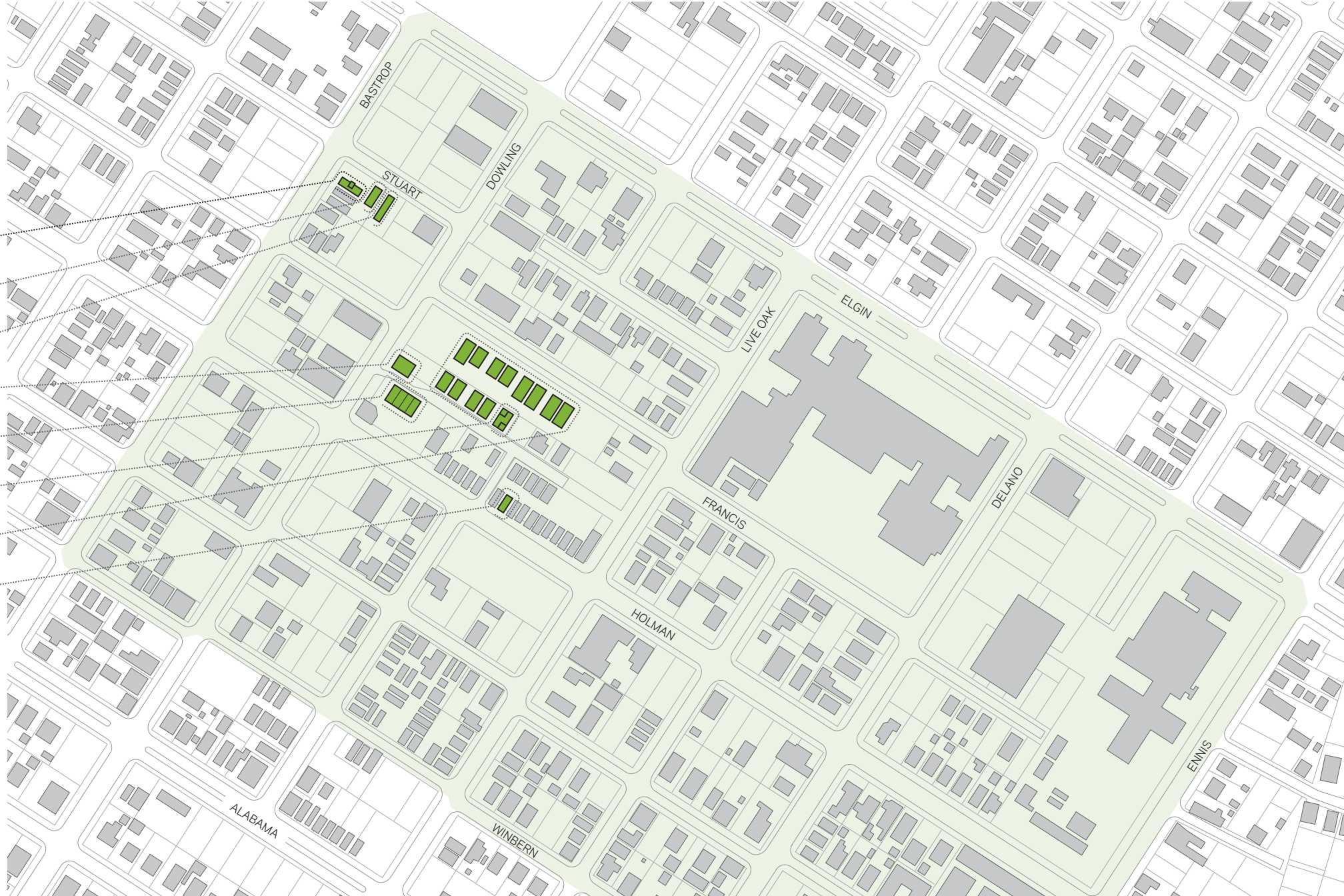


**SECTION : KITCHEN**









**OUTHOUSE**  
2012

**XS HOUSE**  
2003

**zeROW HOUSE**  
2008-2009

**DELIA'S**  
2005

**WORKYARD**  
2006

**SIX SQUARE HOUSE**  
1999

**DUPLEXES**  
2008

**CORE INSERT**  
2008





**EXISTING CONSTRUCTION CONDITION**







PLUMBING



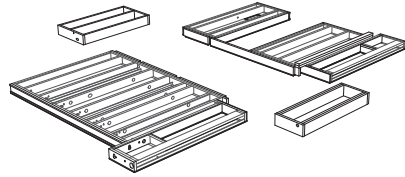
ELECTRICAL



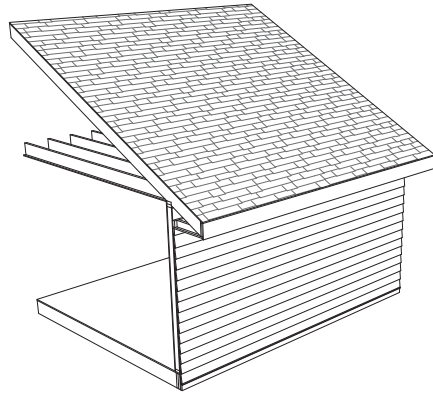
MECHANICAL



**PARALLEL TIMELINES**



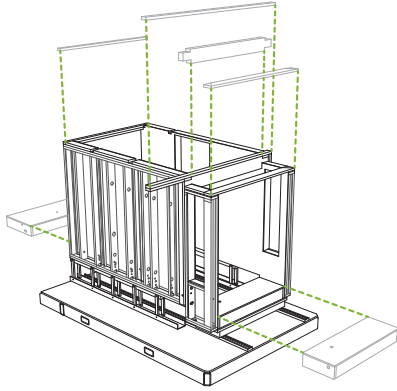
FLAT ASSEMBLE PRIMARY WALLS.  
FACTORY SEQUENCE



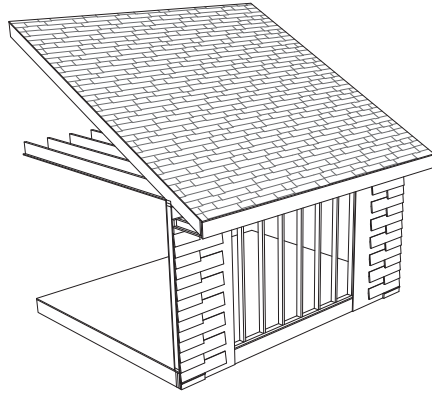
EXISTING HOUSE.  
ON-SITE PREPARATION SEQUENCE







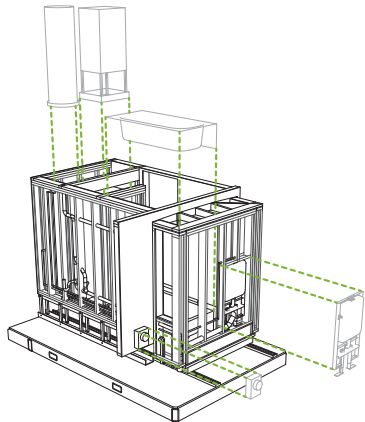
**ERECT WALLS + ATTACH FLOOR ASSEMBLIES.**  
**FACTORY SEQUENCE**



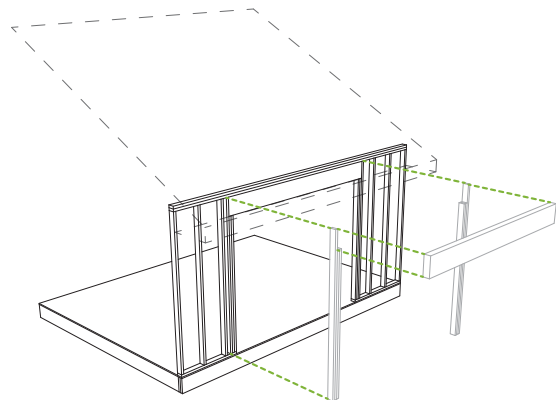
**REMOVE + SALVAGE EXISTING EXTERIOR CLADDING.**  
**ON-SITE PREPARATION SEQUENCE**







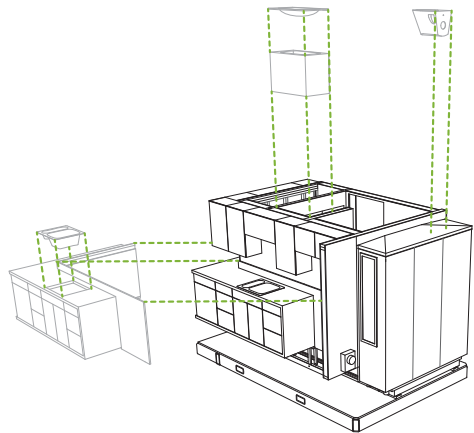
**ROUGH-IN MECHANICAL.**  
**FACTORY SEQUENCE**



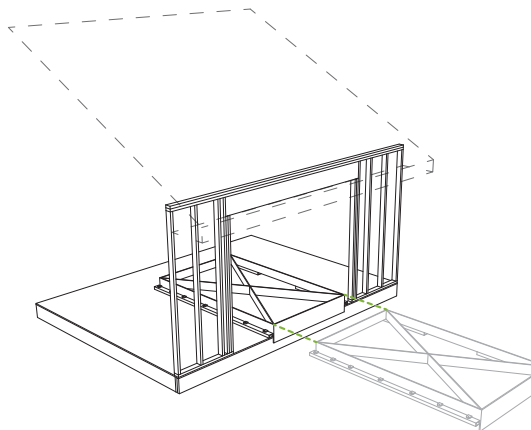
**FRAME OPENING.**  
**ON-SITE PREPARATION SEQUENCE**







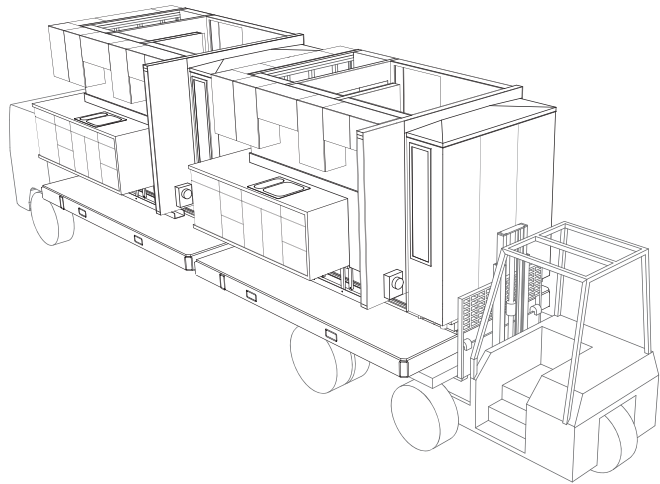
**INSTALL CABINETS + FIXTURES.**



**INSTALL + LEVEL GUIDE TRACKS.**



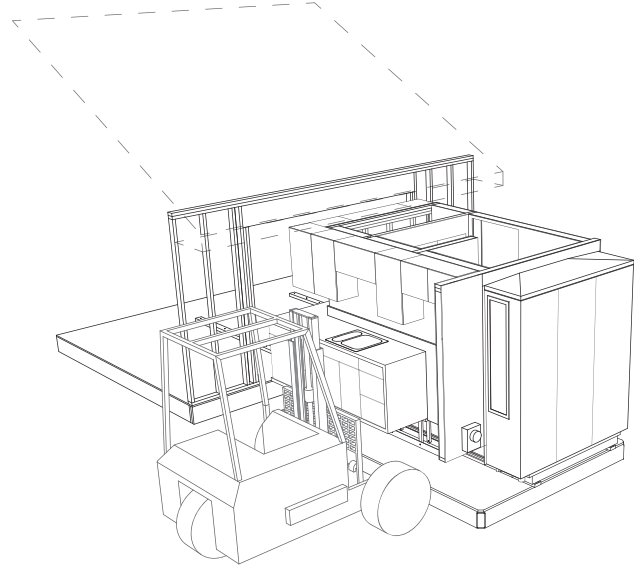




DELIVER TO SITE.  
DELIVERY SEQUENCE



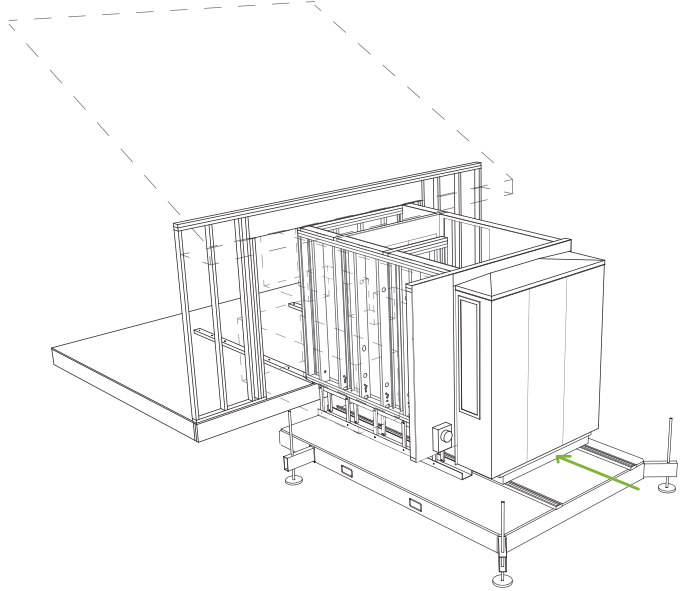




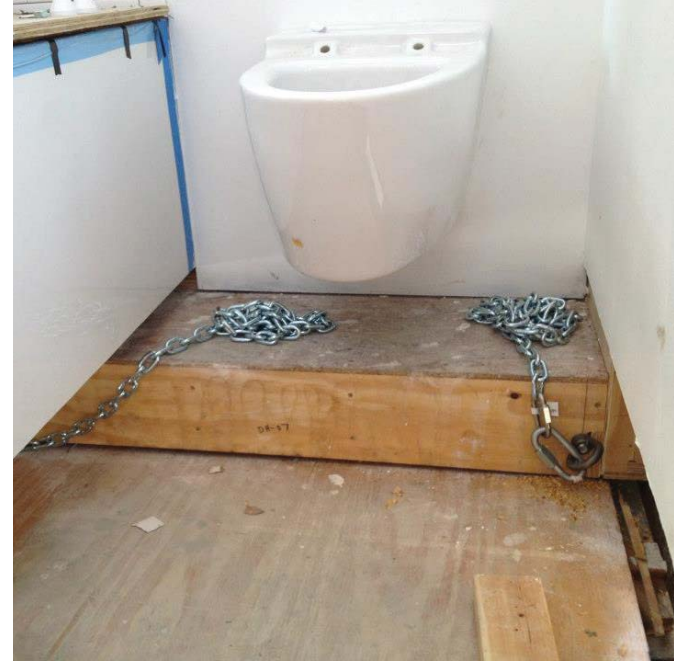
**POSITION** OutHouse.  
**DELIVERY SEQUENCE**



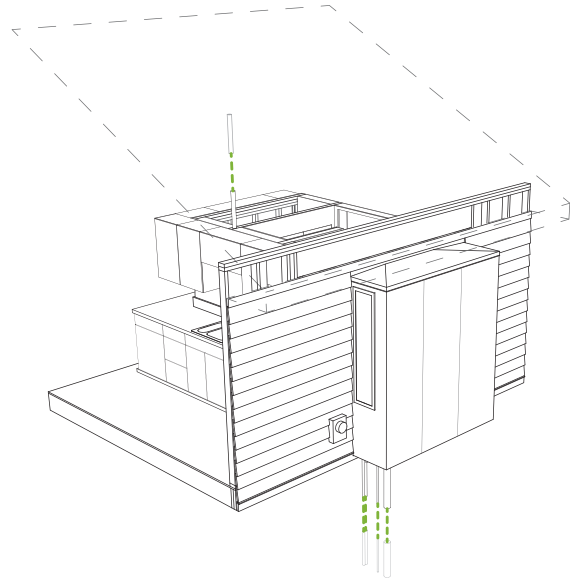




**INSERT** OutHouse.  
**INSTALLATION SEQUENCE**







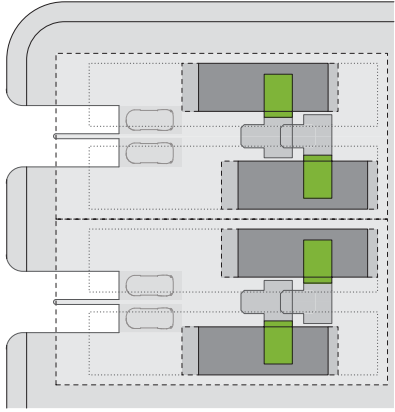
CONNECT SERVICES.  
INSTALLATION SEQUENCE



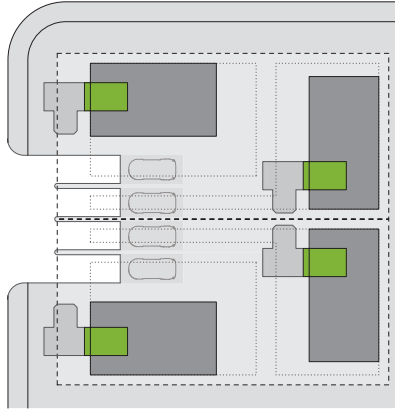


# CHALLENGES OF PRE-FABRICATION

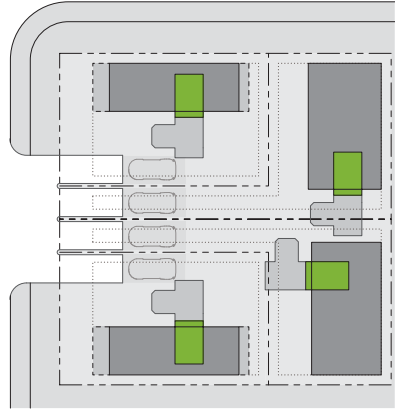




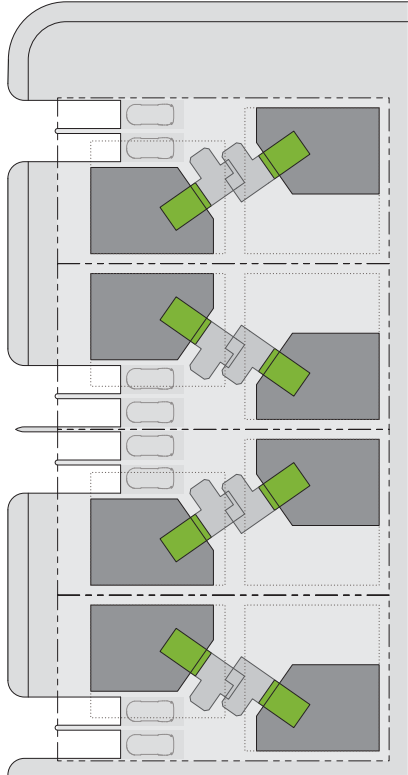
SITE PLAN ONE BEDROOM UNITS



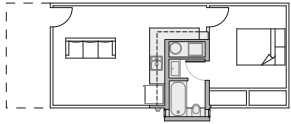
SITE PLAN TWO BEDROOM UNITS



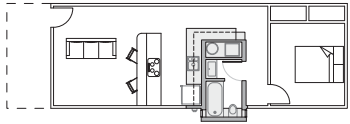
SITE PLAN MIXED UNITS



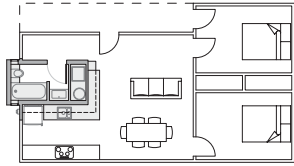
BLOCK PLAN TWO BEDROOM UNITS



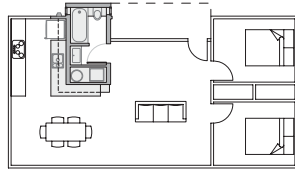
ONE BEDROOM 480 sf



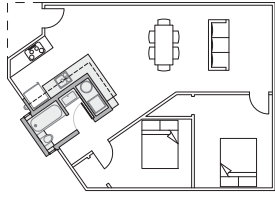
ONE BEDROOM 600 sf



TWO BEDROOM 840 sf



TWO BEDROOM 840 sf



TWO BEDROOM 880 sf





**CASE STUDY**

LABOR  
SAVINGS



MATERIAL  
SAVINGS



FACTORY  
OVERHEAD



COST OF  
TRANSPORT



SITE BUILT ANALOGUE COST ESTIMATE

Item	Materials Cost	Labor Cost	Total Cost
Framing	\$700.00	\$800.00	\$1,500.00
Plumbing	\$800.00	\$1,200.00	\$2,000.00
Electrical	\$800.00	\$1,200.00	\$2,000.00
Mechanical	\$3,500.00	\$1,250.00	\$4,750.00
Insulation	\$650.00	\$200.00	\$850.00
Siding	\$250.00	\$600.00	\$850.00
Window	\$150.00	\$100.00	\$250.00
Gypsum Board	\$200.00	\$800.00	\$1,000.00
Paint	\$250.00	\$600.00	\$850.00
Tile	\$450.00	\$400.00	\$850.00
Door + Trim	\$700.00	\$300.00	\$1,000.00
Cabinets + Counter	\$1,200.00	\$800.00	\$2,000.00
Fixtures + Appliances	\$8,000.00	\$0.00	\$8,000.00
TOTALS	\$17,650.00	\$8,250.00	\$25,900.00

COMPARATIVE LABOR HOURS ESTIMATES

Item	Analogue On-Site	OutHouse Factory	OutHouse On-Site
Framing	32	8	16
Plumbing	48	22	4
Electrical	48	22	4
Mechanical	50	23	4
Insulation	8	4	0
Siding	24	0	24
Window	4	2	0
Gypsum Board	32	12	8
Paint	24	10	4
Tile	16	8	0
Door + Trim	12	0	12
Cabinets + Counter	32	16	0
TOTALS	330	127	76

ON-SITE LABOR HOURS COMPARISON



OVERALL LABOR HOURS COMPARISON



MATERIAL COST COMPARISON



PREFABRICATION COSTS



\$2,697.25 Total Savings Per Outhouse Unit

# CONCLUSIONS:

- (1) Prototype = Testing ground for hypotheses and technical issues
- (2) Prototype = Proof of Concept
- (3) OutHouse reimagines status quo of site-based construction
- (4) OutHouse represents an alternative future for decaying urban communities
- (5) OutHouse operates as building system, residential space, and community emblem.



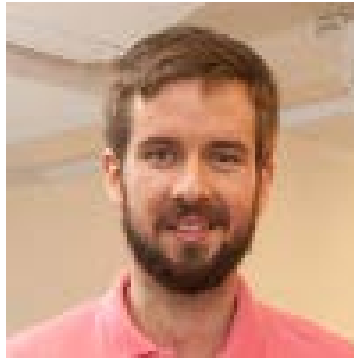
# CONCLUSIONS:

- (6) A small package can have broad sweeping impact
- (7) OutHouse as a small package allows flexibility and adaptability
- (8) OutHouse can effect change through efficient and exhaustive design, despite being small
- (9) OutHouse can be feasible and attractive to broad sets of audiences



**Peter Muessig, Assoc. AIA**

Designer  
Interloop Architecture  
Houston, TX  
Speaker



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University of Massachusetts Amherst  
Moderator

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