Course Title:

P2P Site–less House
Design to Production

Spring 2018,
ARCH 732-002
Mondays 9-12 am

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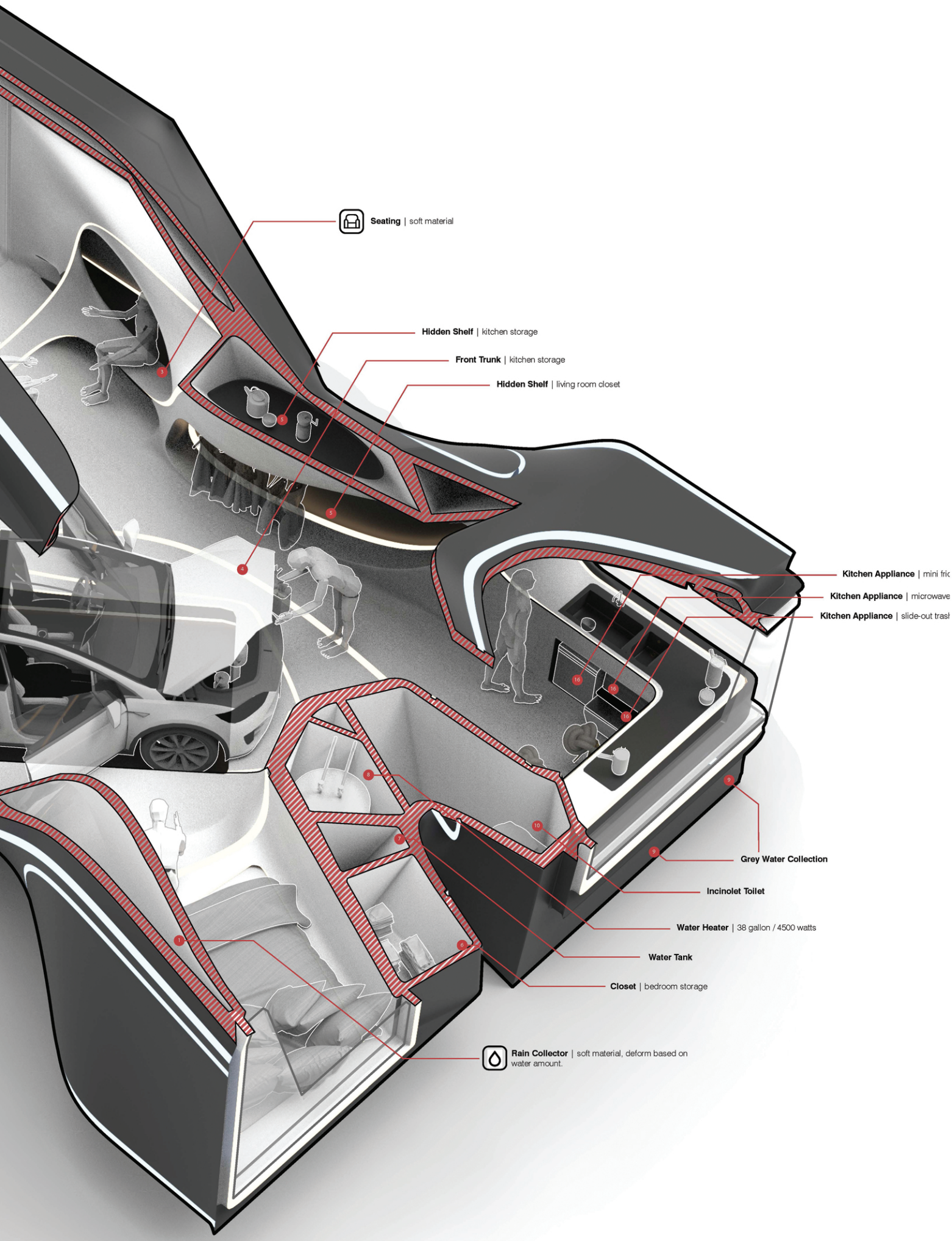
Seating | soft material
Hidden Shelf | kitchen storage
Front Trunk | kitchen storage
Hidden Shelf | living room closet
Kitchen Appliance | mini fric
Kitchen Appliance | microwave
Kitchen Appliance | slide-out trash
Grey Water Collection
Incinolet Toilet
Water Heater | 38 gallon / 4500 watts
Water Tank
Closet | bedroom storage
Rain Collector | soft material, deform based on water amount.

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1 Course description

The course intends to address the challenges in the design development process and fabrication of the *P2P Site-less House* concept developed in the Fall 2017 studio. The primary objective of the course is to prepare the design of the house for fabrication in summer 2018. Therefore, the existing design of the house needs to be rationalized. The rationalization will include: dividing the geometry into prefabricated parts with structural integrity, proper sealing strategies, and meticulous detailing for the interior as well as the exterior of the house.

To achieve these goals, the students will work in teams, and each team will be responsible for the detail design and construction development of specific parts of the house to complete the project. The students will also design the assembly mechanisms for the prefabricated system and they will investigate the material transition from exterior to the interior and will provide solutions to include furniture, equipment, and embedded lighting within the prefabricated parts. The outcome of the course will include a book of the construction document for the entire house and one-to-one scale prototype of minimum three modules assembled to reflect the strategies to deal with various fabrication challenges of the house.

2 Objectives

The primary objective of the course is to address the fabrication challenges of the Tiny House project. The structure of the course is twofold: first to research the fabrication challenges and find solutions to rationalize and improve the existing design of the house; and secondly, to fabricate a part of the house assembled in the form of a mock up to manifest the solutions to construct the entire project.

2.1 Design

In the design research part of the course, students will address the challenges related to assembly, glazing, and the interior space of the house as explained in the following sections.

Rationalizing and descretizing the geometry of the house

The first step in rationalizing the design of the house is to develop an intelligent strategy to divide the complex geometry of the house into smaller parts that can be constructed as prefabricated elements. These parts should address the following challenges:

- each part should be designed for specific size/weight limitation to ease the fabrication and assembly process;
- the parts should preserve the structural integrity of system during and after completion;
- the brittle parts of the joints need special treatment to ensure successful assembly;

- the sealing/waterproofing strategy of the joints;
- the relationship of the prefab parts with the foundation.

Glazing/aperture detail

The research related to glazing and the details of the aperture should address the following topics:

- defining the detail of the glazing for the concrete facade;
- developing a robust strategy to design and detail the operable windows, doors, and apertures for ventilation.

Interior vs Exterior Integration

The interior of the house also need to be designed and configured similar to the facade and glazing. This research should address the following topics:

- developing the detail for the integration of floor/ceiling finishes and furniture with the exterior facade panels;
- detailing the design for equipment, lighting, mechanical systems (HVAC), etc.

2.2 Robotic fabrication

The second part of the course will concentrate on the production of some critical parts of the house to exhibit the current strategies for the final construction. This section will include:

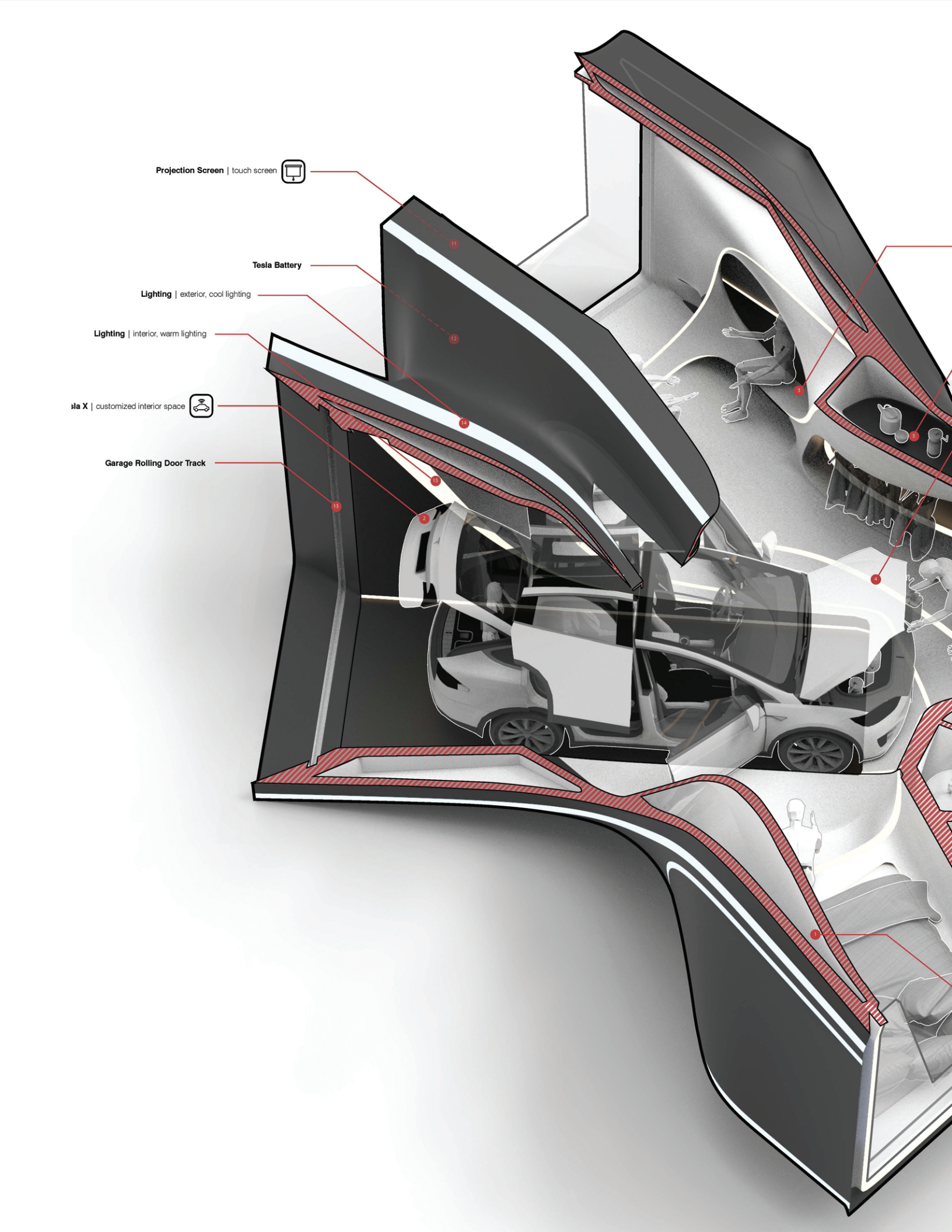
- designing the molds with respect to the complexity of the parts;
- fabricating molds to include exterior, interior and glazing details of the house;
- casting, curing, and assembling the smaller parts to complete each prefabricated module.

Outcome

The outcome of the course will include the construction document for the entire project and the one-to-one part of the house fabricated and assembled to exhibit the research and solution for construction challenges.

3 Lecture schedule

Table 1 represents the schedule including the titles of the lectures and their related exercises.


Projection Screen | touch screen
Tesla Battery
Lighting | exterior, cool lighting
Lighting | interior, warm lighting
ıla X | customized interior space
Garage Rolling Door Track

4 Assignment 1

Each group is responsible to remodel the existing geometry (mesh model) and use rule surfaces to rationalize the complex geometry into a geometry that can be fabricated by robotic wire cutting.

Break down the geometry of the parts that is assigned to you into smaller parts for fabrication and assembly. Note that the largest block of foam is $30'' \times 30'' \times 60''$, so the parts you generate either have to fit the bounding box or designed to be assembled in multiple pieces.

4.1 Deliverable

The following items are expected to be delivered for the Assignment 1:

- Rationalized model of the part of the house that is assigned to your group.
- The strategy for breaking down the geometry of the house into smaller parts for fabrication, including number of parts and their approximate weight.
- for each part please specify the number of ruled surfaces constructing the part.

5 Assignment 2

The main objective of this assignment is to develop a workflow for fabrication of the moulds for concrete casting. The following tasks are necessary to achieve the objective:

- Please rationalise the geometry using the ruled surfaces. Some geometries are complex, but there is a lot of interesting explorations and research you can do to rationalise it. (inspiration: take a look at the Sagrada Familia's complex surfaces as a heavily applied ruled geometry that facilitates the construction process.)
- Drive the primary curves of your part that control the overall shape of the interior and share them with your adjacent teams to ensure all teams work with the same primary curves to rationalise the interior.
- work with the exterior team to develop your pieces, see how you can combine your studies of interior and exterior to derive a unit for fabrication.
- take one completed piece, design a mold for it and run the wire-cutting script to show how you consider the mold to be cut.

5.1 Deliverable

This assignment is due on Monday, Feb 5th. The following items are necessary for the research to be developed:

- general idea to rationalise the whole interior of your assigned part;
- the rationalised geometry of, at least, two adjacent pieces;
- the robotic wire-cutting process to construct the formwork for the pieces.

6 Assignment 3

The primary objective of this exercise is to research the fabrication and assembly of concrete blocks working as the walls, roof and floor system in the house. The profile of the hollow concrete blocks and its construction technique should be investigated to answer the following questions:

- What is the geometry of each hollow block with two thin concrete surfaces on both sides connected to each other inside the block for structural integrity?
- How the exterior surface meets interior and what would be the construction techniques using robotic wire cutting?
- What is the interlocking geometry of the two wall blocks to create a sealed wall?
- How to treat all sides of each block?
- How to make a hollow block with all sides closed using ruled surfaces? Is it necessary to have all sides closed?
- How will the wall block receive the floor?

- Is there any treatment of the panel to allow for the post-tensioning the blocks?
- What is the waterproofing ideas at the junction of the wall and the floor?

6.1 Deliverable

Each team should analyze a corner of their part where the wall, floor, and the glazing frame meet and provide a design and construction strategy to build the blocks such that it can answer the above questions. A scaled 3D printed model can be presented in the class to describe the assembly sequence and the main details of the design.

The following references might be very useful:

- Modern Construction Handbook
- Modern Construction Envelopes
- and the DETAIL magazine

Course Sessions		*Titles*
Jan 10	w1	Introduction to the course; review the previously-developed concepts for the house; introducing the design concept aimed for the final production; clarifying the objectives of the course. Assignment 1: Geometry and rationalization of the parts; breaking down the geometry; optimizing the number of cuts per piece.
Jan 22	w2	Review Assignment 1
Jan 29	w3	Robotic wire cutting workshop; surface articulations; Assignment 2: developing a double-sided form-work for the parts;
Feb 5	w4	Pin up 2
Feb 12	w5	Review Assignment 2
Feb 19	w6	Casting concrete; concrete technology; Cemex presentation; ultra thin, structural concrete, Assignment 3: casting a hollow shell parts
Feb 26	w7	Pin up 3
Mar 12	w8	Review Assignment 3
Mar 19	w9	Geometry of the junctions; sealing the junctions; assembly logic; Assignment 4: Geometry of the assembly and the adjacent parts.
Mar 26	w10	Pin up 4
Apr 2	w11	Review Assignment 4
Apr 9	w12	Incorporating the details and glazing; interior geometry; composite fabrication; embedding mechanical equipment; recessed lighting; Assignment 5: developing form-work for interior detailing and combining the assembly with the concrete facade.
Apr 16	w13	Pin up 5
Apr 23	w14	Review Assignment 5
Apr 30	w15	Final Review: exhibiting the assembled parts and the book of drawings

Table 1: Lecture schedule with specific dates for assignments and reviews.