ASSEMBLY / DISASSEMBLY:

OVERVIEW:
LTU SOLAR DECATHLON home was designed as a system of modules and deliverable to any site via semi-trucks and trailers. Systematically these individual components shall be installed with the intention of minimizing energy consumption and labor man hours. These instructions are intended to direct the assembly and disassembly team in proper attachment and removal of foundation, building modules and system components.

Note: Not all of these steps comply to the final site installation and shall be noted throughout these instructions.

SAFETY RULES:
Read all safety rules and instructions carefully.

A Geotechnical site survey shall be performed to verify that the site soil conditions meet a minimum bearing capacity of 1500psi. If site conditions do not meet this minimum bearing capacity, consult with a structural engineer licensed in the state where the home is being installed.

Adhere to all local zoning ordinances at final site installation.

Prior to digging foundations at final site installation, contact all local utility companies to verify and mark location of any underground utilities.

Make note of all overhead conditions prior to crane operation.

Proper Personal Protection Equipment (PPE) must be worn at all times during construction. Make note of the PPE items listed below and select the proper PPE for the task being performed.

- Hard hats
- Steel-toe boots
- Eye protection
- Impact or chemical
- Work Gloves
- Chemical resistant when working with batteries
- Climbing harness

Do not operate electrical power equipment in damp locations.
**FOUNDATION:**

**Determining foundation location:**
It is important the home is sited so that the sloped roof surfaces face south. Measure off of each property line so that the home is situated within the required distances to maintain the local municipalities minimum setbacks.

For the competition in Washington DC, measure off of the northern property line to beam “A” 17’ x 11’. Next measure off of the east property line to beam “B” 16’-10” (see Figure 1). Mark both of these distances with lines parallel to the property line.

**Determining Foundation Height:**
The high point of the grade at the building site must be determined to set proper foundation elevation. Using a rotating laser level determine the high point of the site and mark on a wood stake driven into the ground— the top of the foundation beam will be 1’-4-3/4” above this mark. You are now ready to begin the installation of the foundation.

**Foundation Installation:**
The foundation is made up of four components; foundation beams, bent bracket, 4x4 wood posts and 1/2” thick steel bearing plates (Figure 2). Each of these four components will be connected mechanically to one another by the use of through bolts.

Begin the foundation installation at beam “B” shown in Figure 1. Construct a pier by using the found top of foundation beam height, begin cutting the 4 x 4 wood posts to support the foundation beams to conform to grade elevations maintaining a level top of foundation beam. Insert a post into the sleeve welded to the bearing plate and secure with two (2) ½” x 7” through bolts. At the top of the 4 x 4 post install a bent bracket and secure with two (2) ½” x 7” through bolts (see Figure 3). Repeat this process at each of the 36 pier locations. Temporarily support the piers with 2x4 kickers. Insert the beams and fasten to the bent brackets with two (2) ½” x 7” through bolts, do not tighten. Level both vertically and horizontally. Note shims may be required to achieve proper alignment, and check for square. All bolts now can be fully tightened.
MODULES:

LTU SOLAR DECATHLON home is made up of three individual modules which are divided into an upper and lower section (see Figure 4). Each of the lower sections will be placed onto the foundation and the upper sections will be placed on the respective lower modules by the use of a crane.

Lower Module Placement:
Lower module 1 will be the first module to be placed on the foundation beams. Unwrap shrink wrap from module. Connect lifting straps from crane to “D” rings on steel lifting frame attached prior to shipment. Attach one guide line to each of the four outside corner lifting plates located under the module. These guide lines will be manned to keep the module steady while being lifted and lowered. Slowly and carefully lift and place module on the foundation beams aligning holes in lifting plate to the corresponding holes in the foundation beam. Insert four (4) ¾” x 7” through bolts in the lifting plate at all six locations, and finger tighten. Do not detach crane from steel lifting frame. Undue nuts located at the top of the module at the six threaded rods, hoist steel lifting frame off of module 1 and place onto module 3. Reuse nuts and tighten. Disconnect crane from module 3 and prepare for installation of module 2.

Do to its light weight, lower module 2 will be lifted into place by the use of straps provided by crane supplier. Wrap straps around module at the open ends of the module. This will ensure that the south wall window will not be damaged. Carefully lift module into place. Note: this module does not have attachment plates underneath, align north wall of module 2 with the north wall of module 1. Attach module 2 to module 1 (and module 3 after placement) with 2-1/2” wood screws at north wall intersections (exterior only) and with 12” long red structural screws where south wall abuts adjacent wall of modules 1 & 3 (see Figure 5). Detach crane and reattach to module 3 at steel lifting frame.

For module 3 placement see lifting instruction above for module 1. Remove steel lifting frame and place on trailer, it will be used during the disassembly process.
After all lower modules have been placed, tighten all bolts and screws. Install 5/8” backer rod insulation along the top edge of walls. For final installation backer rod will be replace with R-Control Duo-Ply adhesive.

**Upper section module placement:**

**Note:** The placement of the upper sections of the modules does not follow the same sequence as previously stated in the lower module placement instructions.

The upper section of module 1 will be placed first. Prepare the section for lifting by installing the tubular lifting assembly. Attach frame with 3/4” diameter bolts (provided) to continuous metal plate installed on sidewalls of the upper section approximately 10” below the roof. There are two (2) attachment points per side. Install tubular spreader bars to frame and tighten. Frame is ready to be connected to the crane at upper holes, using “D” rings from steel lifting frame. Attach guide lines to each corner of lifting frame to steady section during lifting and placement. Lift section into place. Align guide holes in the base of walls of upper section with each of the trenched rods projecting from top of lower module 1 and 3. Fasten upper section to lower module with 2-1/2” long wood screw for both interior and exterior at holes provided. Detach lifting frame assembly and install on upper section of module 3.

Repeat this process for upper section of module 3.

Upper section of module 2 is the last to be installed. Prior to lifting, inspect underside of lower drip cap to ensure that weather stripping is in place. If not install ½” diameter foam rod (provided) at internal bend. This is important to ensure that no water will enter the home. Connect only one half of the lifting frame used for both upper section 1 and 3 to upper section 2 using ¾” bolts (one per side of section). Attach guide lines and lift into place. Attach to lower module 2 with 2-1/2” wood screws from both interior and exterior at the holes provided.

Figure 6 is an illustration of the completed form of the home.
DECKS AND PLANTER:
With the installation of the home modules completed, the installation of the deck and planters can begin. The deck is broken up in to a series of 10 sections. The order in which these sections are installed is depicted in Figure 7.

Begin by installing section #1. This section is installed between module 1 and 3 of the home and is supported by the preinstalled 12” long angles. Fasten deck section to the home with 3/8” lag screws, insert into holes provided. Continue onto deck section #2, this section is again mounted to angles attached to the home and on section #1 as well as supported by additional piers (see Figure 8) similar to those used on the home. Attach deck section #2 to home and temporarily support the deck at its outer edges. Level this with section #1. With the deck section level, begin installing the piers, beginning from the outer edge working inward towards the home. Make certain that the length of 4 x 4 posts for the piers are cut accurately. This will ensure no differential settling to occur. Fasten top of 4 x 4 post of pier to angles welded on deck frames with two (2) ½” x 6” through bolts.

The remaining deck sections including the ramps will be attached to the previous section at provided brackets setting its elevation. The installation of the piers will continue as described for deck section 2.

Once the deck sections are complete install the planter sections. Begin by inserting 2 x 8 cantilevered joists at outer parameter of the deck. Be careful to in install the numbered joist at their corresponding number on the deck frames. Fasten joist to metal stirrups with ½” x 3” through bolts (see Figure 8). Each planter is constructed with slots which allow them to be slid over the joists. Install numbered planters at corresponding number on deck frame. Remove upper planter base and fastened planters to joists with ½” x 2” wood screws from the interior concealing any connections.

At the evacuated tubes install nine 2” x 6” aluminum tube uprights in corresponding slots in planter and slide into place until they are completely seated in metal brackets welded to the side of deck section 5. Install ½” x 8” through bolt below deck fastening the uprights in place.

Figure 7: Deck Section Layout

Figure 8: Deck Planter Section
EXTERIOR RAINSCREEN INSTALLATION:
Select areas of the exterior cladding system (rainscreen) have been removed prior to shipping. These areas allow for accessibility of attachment points between upper and lower module sections. With module and deck construction completed, installation of the rainscreen panels can be performed.

Shaded areas in figure 9 represent location of removed panels. These panels are numbered and have corresponding numbers marked on the side of module sections.

Install rainscreen from bottom. Insert upper rainscreen panels behind Rheinzink roof flashing. The rainscreen panels are predrilled and shall be fastened to the modules with stainless steel screws and stainless steel decorative washers. Do not overtighten the screws.

PHOTOVOLTAIC SUPPORT AND TRELLIS:
The roof modules are prepared for installation of 2"x6" extruded aluminum photovoltaic (PV) panel supports system which transitions into trellis system above the deck. Each support has been numbered and has corresponding number marked on aluminum roof supports.

Module 1, insert correctly numbered extruded aluminum support between aluminum angles secured to roof prior to shipping (see Figure 10). Fasten extruded aluminum with \( \frac{1}{2} \times 3 \) " through bolts. Note: bolts installed in the field have been colored green in Figure 10. There are a total of six supports on module 1.

Prior to installation of supports for module 3, install trellis posts and beams at pre installed anchor points. Temporarily brace these members until trellis is securely fastened. You may begin to install PV supports, following same procedure as outlined for module 1. PV support for module 3 will continue past south wall and will turn into the trellis of the deck. Fasten in place with \( \frac{1}{2} \times 3 \) " through bolts. Remove temporary supports and trellis columns and continue on to PV panel installation.

Figure 9: Rainscreen Panels

Figure 10: PV Support Detail
PHOTOVOLTAIC PANEL INSTALLATION:

Warning and Safety:
Verify proper grounding of integrated mounting system to earth prior to installation of PV panels.

The PV panels generate electricity when exposed to light. Arrays of many modules can cause lethal shock or burn. To reduce risk of shock or burn cover PV panels with opaque material during installation and wiring. Do not touch terminals with bare hands.

Do not step on PV panels.

Installation:
PV panels are installed between the 2 x 6 extruded aluminum tubes located on the roof (see Figure 10). Slide each panel in place from top down till they rest securely against stop at bottom of extrusion. Module 1 houses a total 20 panels and module 2 houses 16 panels. Connect necessary wiring of PV panels so that there are three panels in a string and 12 strings in parallel. This is to be done at the same time the panels are laid in place. Secure panels in place by installing aluminum strip and fasten with supplied machine thread bolts (see Figure 10). Note: Strips are to be installed with neoprene gasket abutting frame of PV panels.

Route wires through wire loops located on inside of aluminum extrusions. All wires are to be routed towards top of roof and over to combiner boxes mounted on side of solar chimney.

BATTERY TRAILER AND ELECTRICAL CONNECTION:
A trailer will only be utilized in Washington DC for the competition. Battery storage will be determined at later date for final site installation.

Refer to wiring diagrams in contract documents for proper installation of electrical system connection. Inter-module connections will be done in a series of junction boxes provided in the electrical closet located in module 2. All wires from modules are pre-labeled and connect via wire nuts to corresponding labeled wires leading to main breaker panel. Important: Verify that the main breaker is in the off position prior to connection of any wire.

MECHANICAL CONNECTIONS:
All of the rigid duct work will be installed in the modules. A flex duct connection for the supply ductwork will be made at the intersection of module 1 & 2 as well as between module 2 & 3.

Energy Recovery Ventilator:
Install the Energy Recovery Ventilator (ERV) in the upper portion of the solar chimney. Attach necessary electrical wiring to junction box located adjacent to ERV. Make duct connection from ERV to rigid sleeve penetrating ceiling of electrical closet with 6" diameter flex duct. Connect rigid duct in electrical closet to rigid duct stubs located a side walls of electrical closet. Connect ERV to exhaust duct and intake duct by means of 6" flex duct.

AC Condensing Unit:
Install DC Flex-Cool Condensing Unit on east exterior wall of solar chimney. Route refrigerant hoses from fan coil located above mechanical closet to condensing units through provided holes. Extreme care should be taken not to cut or crimp refrigerant hose. Follow manufacturers installation manual for proper tightening torque specification for #6 and #10 hoses. Unit will be fully charged with R134A refrigerant prior to shipping.

Hydronic In-Floor Heating System:
All hydronic in-floor heating pipes will be installed in the modules prior to shipping. Remove finish floor panel in module 2 and route lines from module 1 and 3 through floor to copper fittings located approximately 4" above floor of electrical closet. Extreme care should be taken when routing pipes to avoid crimping. System will be filled with distilled water prior to shipping. Remove end caps from tubes one at a time and connect to proper manifold lead. Pipes will be labeled return or supply. There are a total of eight pipes, four supply and four returns. Bled system and check for leaks prior to reinstallation of finish floor panel.

PLUMBING CONNECTIONS:
Evacuated Tube Installation:
Three evacuated tube solar collectors are located at the southwest corner of the roof (see Figure 7). Install evacuated tubes to aluminum uprights installed during the assembly of the deck and planter sections. Connect supply and return lines from the home to corresponding supply and return manifold located at top of the evacuated tubes.

Potable Water Supply:
Located on the trailer with the batteries will be one 450 gallon water supply tank, pressure tank and booster pump. Connect potable water line from trailer to fitting at module 1 along north wall. Connect threaded fitting in mechanical closet which were removed for shipping to minimize damage due to vibration. Pressurize and check for leaks.

Waste Water:
Connect remaining waste water pipe under home to leads installed prior to shipping. In line connection should be made using "Ferrco" style flexible pipe connectors. Connect waste water line to waste water tank located beneath home (competition only).

For final site installation all connection shall be rigid PVC pipe couplings and fittings. Connect waste water line to municipal sanitary sewer or approved septic system.

INTERIOR FINISHES:
All interior finishes will be installed prior to shipping, with the exception of furniture. Portion of the interior trim was remove prior to shipping to access points of attachment. These locations are:
- Stil below clerestory windows in kitchen and bedroom;
- Corner of wall leading from kitchen to back hall and corner of wall form master bedroom to back hall (see Figure 5);
- Trim above coff in living room and master bedroom.

Reinstall listed trim pieces, inspect home for any cracks or damage which may have occurred during shipping, and repair and repaint as necessary.

LANDSCAPING:
Install plant material in planters and cover with mulch. Water plant material during installation and monitor during course of the competition.
DISASSEMBLY:

IMPORTANT: STEPS LISTED BELOW ARE CRITICAL PRIOR TO DISASSEMBLING HOME IN REVERSE ORDER OF ASSEMBLY INSTRUCTIONS.

MECHANICAL DISASSEMBLY:
Refer to manufacturer's specifications for condenser shut down procedures. Refrigerant will be evacuated for pipes and contained in compressor for disassembly and shipping. Verify that all valves are shut off to prevent and leaking of R134A refrigerant.

ATTENTION:
Disconnect PV and battery banks from DC Combiner Box by using the three PV disconnect and three battery bank disconnect switches. If there is any AC source present (from a generator or grid) disconnect that source as well. ALL Breakers must be switched to the off position in both the AC and DC distribution boxes.

CHARGE CONTROLLER DISASSEMBLY:
Open the front cover and disconnect the wiring from the PV+ and PV- terminals as well as the Bat+ and Bat- wirings. Remove the data cable from the charge controller, unscrew the mounting screws from the charge controller mounts. Package the controller properly for shipping.

INVERTER/CHARGER DISASSEMBLY:
Open the front cover and disconnect the DC wiring from the DC combiner box. Unscrew the AC Inverter cover and remove the AC in and out source as well as the AC in and out load wiring. Disconnect the Remote Temperature Sensor on the main Inverter and disconnect the data cables from each of the inverters. Once disconnected, unscrew the four mounting screws. Please note that two screws on the inside of the mounting plate WILL hold the inverter in place even with the four mounting screws removed. Have a minimum of two people to lift and remove the inverter from the hanging screws and package the inverter properly for shipping.

MODULE ELECTRICAL DISASSEMBLY:
Prior to performing this step, verify that ALL sources of power are disconnected. Unscrew the junction box cover and unscrew the electrical nut on each of the branch conductors. Please note the labeling of the branch circuits and DO NOT RECONNECT without verifying the source and destination of each circuit.

BATTERY TRAILER DISASSEMBLY:
Prior to servicing or disassembly, disconnect the battery bank with the battery disconnect switch inside the trailer. Unbolt each conductor to the positive and negative bus bar. Take these conductors and feed them back to the electrical closet inside the home.

PHOTOVOLTAIC REMOVAL:
Cover PV panels with opaque material to avoid shock or burns prior to performing any of these steps. Disconnect PV wiring at the combiner box, and feed lines back to panels. Remove bolts on retainer strip and begin lifting out panels—work form the highest point down to lowest. Disconnect individual wire leads as panels are removed. Package for shipping.

GROUNDING ROD REMOVAL:
Do this step after ALL disassembly is complete. Remove the PVC pipe that covers the grounding conductor and grounding rod. Disconnect the #8 AWG conductor and place it to avoid damage during shipping. Remove the grounding rod from the soil and package properly for shipping.

PLUMBING DISSASSEMBLY:
Important: Waste water must be pumped from tank prior to removing sanitary pipes. Reverse steps during assembly for under-module and interior connection.

GENERAL DISASSEMBLY NOTES:
Remove furniture and items from interior prior to disassembly of home.

Use proper shoring and bracing to support sections of deck and foundation beams during disassembly to avoid injury.

Package and secure all items properly for shipping.

Shrink wrap modules prior to shipping to protect home from damage caused by adverse weather conditions, wind, and road debris.

Walk entire site picking up any construction debris and discard properly. Site must be left clean upon exiting.