surviv(AL)House

ARCHITECTURENarrative

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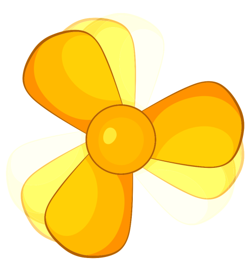
ARCHITECTURE Narrative

Team Alabama's **s u r v i v (A L)** House embodies the irrepressible spirit of Southern communities that have pioneered, adapted, survived and rebuilt. Inspired by the devastating impact of the 2011 tornado super outbreak on the region**, s u r v i v (A L)** House serves as a model for sustainable, resilient housing for severe weather prone communities. Our house offers "Quick Permanence," a term we use to describe a home that can be quickly rebuilt and assembled to provide comfort, security, and energy independence in the aftermath of a disaster.

ALABAMA'S CLIMATE AND THE STORY OF SOUTHERN VERNACULAR ARCHITECTURE

The University of Alabama at Birmingham's **s u r v I v (A L)** House is designed in the tradition of the Southern vernacular, which speaks to the relationship between site, climate, and the elements of building that are taken into consideration in the generation of the building form. What does this mean? Before the development of air conditioning, Southerners had to build their homes in ways that dealt with hot, humid weather by incorporating the use of cross ventilation and wide overhangs. They also took the home's site orientation — the position of a building in relation to an east-west axis — into consideration to make optimal use of both sun and shade.



BEATING THE HEAT

Space conditioning will be provided primarily by a ductless HVAC unit consisting of an inverter-type 3-speed outdoor unit that supplies refrigerant to four high-wall indoor units. The HVAC system is a heat pump capable of working in both cooling and heating modes. This option has almost eliminated any need for ductwork in the house. An energy recovery ventilator (ERV) will provide fresh air to the house. This is necessary since the envelope of the house will be built to achieve ACH<1.0. The ERV system will be controlled both as a scheduled unit and by carbon monoxide level in the house.

DEHUMIDIFICATION

Team Alabama Decathletes have devised a remarkable system for beating the Alabama heat and reducing energy costs — the UAB-developed device uses a liquid desiccant system in combination with a solar collector to take water out of the air. This system dehumidifies the air inside the home at night and recharges the material during the day, reducing the overall load on the home's air conditioning system.

ROBOTIC COOLER

Team Alabama's robotic cooler is a localized, mobile space conditioning robot that can be deployed to allow the overall energy consumption of the residence to be reduced. This robot will provide evaporative cooling to occupants when summoned and will be capable of autonomously navigating around obstacles in the home using infrared sensors and Bluetooth signals to find occupants.

ORIENTATION AND HOT CLIMATE DESIGN

+90°F

Americans in general spend about twice as much for residential heating as for cooling, but that is not the case in much of the South. Alabama is classified as humid subtropical (Cfa) under the Köppen climate classification. Summers in Alabama are some of the hottest in the United States, with high temperatures averaging over 90 °F (32 °C) throughout the summer in many parts of the State. Winters are mild — the average winter minimum for the entire state is 35 °F (2 °C), and the temperature falls below the freezing point fewer than 35 days in each year.

S U R V I V (A L) HOUSE : ARCHITECTURE

The **s u r v i v (A L)** House is designed to be climate specific. To achieve a model of efficiency and cost effectiveness, the **s u r v i v (A L)** House will implement a combination of careful orientation of the building, as well as a heavily insulated envelope and precise protection of glazing. With an architectural design informed by Southern vernacular language, the building is oriented to maximize solar access and to use roof planes for shading for a majority of the year. The home is oriented with the long axis east-west, most windows face north or south, and large window areas are shaded. The large northern porch is covered with a transparent canopy for inclement weather, allowing light to wrap around corners and penetrate in the early morning and late evening, activating the living spaces. Thick, double-stud walls, a well-insulated, high-albedo roof, and an insulated crawlspace, create an efficient envelope that protects from brutal heat intrusion and leakage of valuable cooling. The sleeping zone absorbs daytime heat on the southern exposure and the daytime living zone benefits from a consistent northern light for most of the day.

THE SOUTHERN PORCH

Porches are a significant feature of Southern architecture and play a unique role in the character of Southern life. The South's warm climate is conducive to spending time outdoors, but the strong sun also demands a generous amount of shade. A deep shaded porch becomes a room unto itself, and invites a variety of uses. Porches are (or were) commonly a place for keeping tabs on the neighborhood, sewing, shelling peas, and folding laundry. Porches provided a place to escape the heat indoors and a safe place to send children to when they were underfoot. In the evenings adults sat on the porch and gossiped, told stories and played music. With the advent of television, video games, and air conditioning, the porch has become less of a part of daily life, but it still holds a special place in the hearts and minds of most Southerners.

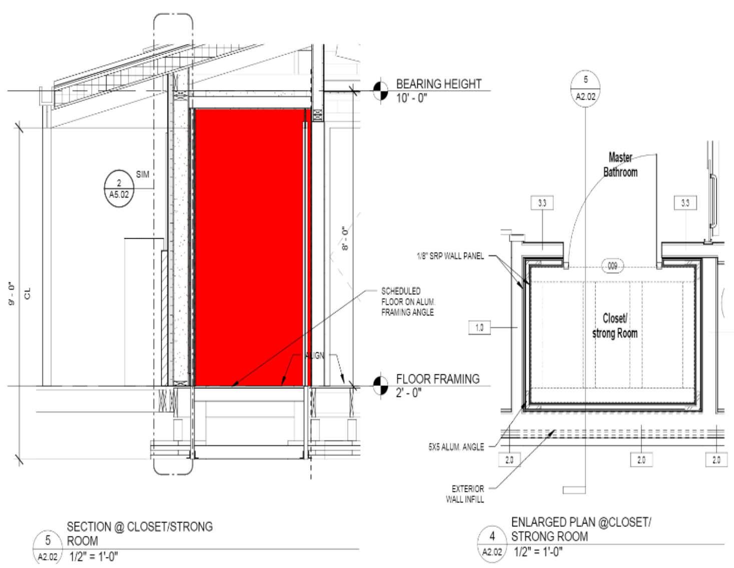
THORNEHILL DOG TROT, GREEN CO. ALABAMA

s u r v i v (A L) HOUSE

The **s u r v i v (A L)** House is designed to encourage porch traditions to return to modern life, and the home features both a front and back porch. The back porch provides full cover for sunny days, and generous front porch supports a deep transparent canopy that allows occupants to be protected from the rain but not fully shaded from the sun.

RESILIENCE IN EXTREME WEATHER

Across the Southeast, populations are vulnerable to ever-increasing severe weather events such as heat waves and droughts, heavy downpours, flooding, and tornados. Catastrophic events that have taken place within the last six years have left our region's residents well aware of the damage that can occur.



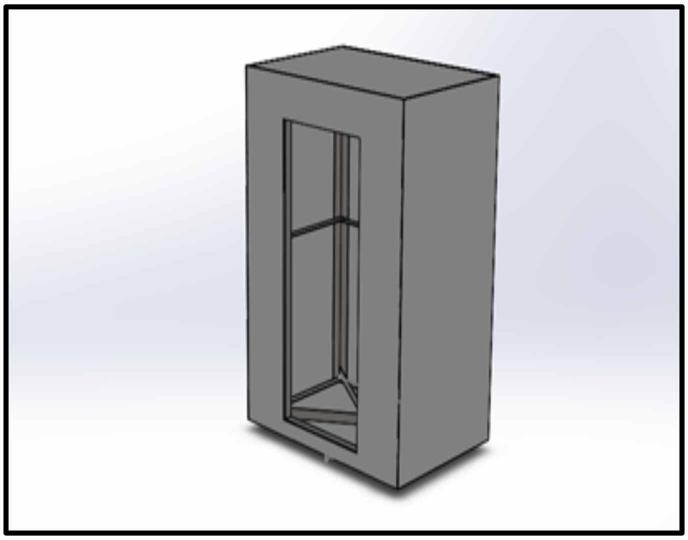
Since 1966, Alabama has been struck by more tornadoes than any other State. The 2011 Super Outbreak was the largest, costliest, and one of the deadliest tornado outbreaks ever recorded, affecting the Southern, Midwestern, and Northeastern United States and leaving widespread destruction in its wake. Over three days, 349 tornadoes were spawned. Alabama was one of two states most severely affected. Of the 219 tornadoes that formed on April 27 - the most active day - 59 touched down in Alabama, resulting in more than two hundred fatalities. Countless homes, neighborhoods and cities were either partially or completely destroyed across the state, and in the days that followed, thousands of people were left without power, water, or any means of transportation or communication.

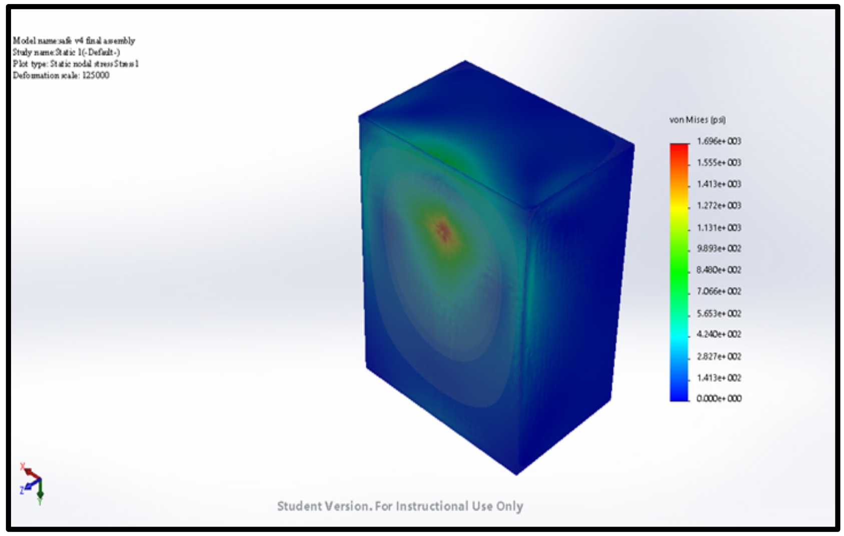
Resilience is the capacity to adapt to changing conditions and to maintain or regain functionality and vitality in the face of stress or disturbance. **S u r v i v (A L)** 's "safe zone" featuring a closet shielded by UAB Tornado Panels, a windowless core, and a water purification system combined with a net-zero PV system embodies resilient design by providing an effective and adaptable buffer against what can be tragic outcomes of extreme weather.

SAFE ROOM

With the increasing prevalence of strong storms and tornados in Alabama, interest in tornado resilience for residential and commercial buildings is proliferating. The outbreak of April 2011 prompted engineers at UAB's Materials Processing and Applications Development (MPAD) Center to create lightweight, tornado-proof composite panels. The composition of thermoplastic and fiberglass resins and fibers used in the panels are stronger per-unit density than the steel used in many current shelters and weigh 80% less. This makes them ideal for use in construction and retrofitting of existing structures.

Using the UAB Tornado-Proof Panels as a key component, a closet within the **s u r v i v (A L)** House works as both a space for both storage and safety during tornadoes. The panels are fastened from within with a student-designed steel frame, and are covered with standard flooring and drywall that hides the true protective nature of the room, leaving a visitor none the wiser. The safe room will extend below the level of the subfloor to allow permanent footings when the house is placed in its final location. The safe room design was modeled by a UAB engineering student (and Decathlete) using the computer-aided-design program SolidWorks and tested using industry-level FEA (Finite Element Analysis) to determine if the safe room could withstand the stresses and loads experienced

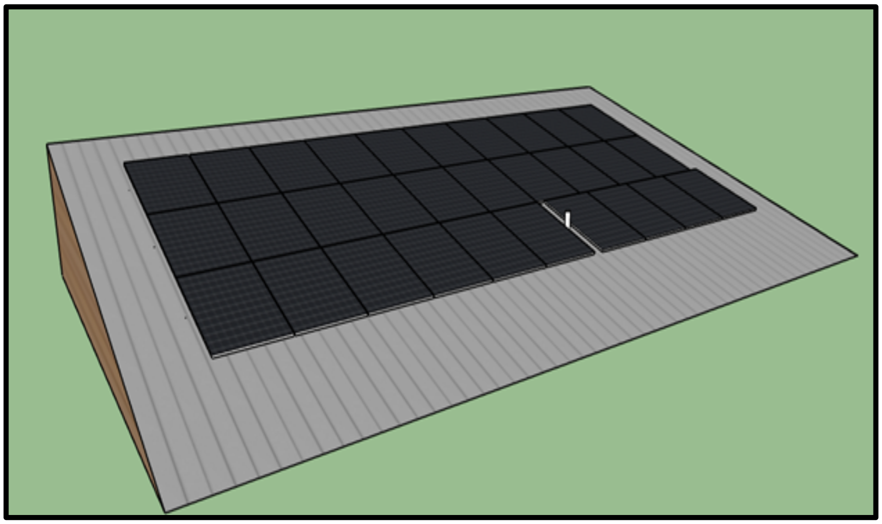




from flying tornado debris. The image above simulates the effect of debris impact during an extreme weather scenario. Per FEMA standards, the load applied to the rear wall of the safe room is 656 lbf and is distributed across an area equivalent to the cross-sectional area of a standard lumber 2x4. This loading is reflective of a four-foot-long section of lumber striking the safe room at 100 mph. The max stress experienced in the rear wall was 1696 psi, resulting in a factor of safety (FS > 10). These results illustrate the ability of the safe room to withstand an impact from flying tornado debris.

QUICK PERMANENCE

When storms ravage an area, thousands of families are forced to take shelter in temporary housing. **S u r v i v (A L)** House was mindfully designed to incorporate "quick permanence" — meaning that in the event of loss or damage in extreme weather, the home can be easily and quickly replicated by any contractor.



THE POWER OF THE SUN

The **s u r v i v (A L)** House solar array consists of 30 Panasonic 330W modules. These modules are exceptional in both performance and design, with a combined capacity of 9.9 kW DC. The Panasonic modules have been arranged into two string circuits of 15 and coupled with SolarEdge optimizers and a string inverter. The N400 optimizers provide module-level power adjustments to counteract shading or other hindrances and maintain the optimal energy output of the string. The modules and optimizers are mounted on a SnapNRack modular solar mounting system. The solar array is anchored to the roof using S-5-S Mini clamps, allowing for a secure and non-roof-penetrating array.

LIVABILITY : A PLACE TO CALL HOME

The interior of Team Alabama's home is designed to maximize use of space while providing extraordinary convenience. For instance, the home's two bathrooms feature a "shared shower" which is a single shower that can be entered from a door on each side leading to either bathroom. The open concept living area features sleek contemporary finishes and an abundance of light from the clerestory windows.

SYSTEMS

S u r v i v (A L) House incorporates a centralized energy management system that can provide access to energy consumption data and allow control of lighting, appliances, and plug loads remotely. Temperature control will be localized based on individual room set-points that will vary according to a schedule, and based on occupancy. The hot water tank will be used as an energy storage device in order to make the house smart-grid ready. Lighting will be dimmable LED distributed around the interior and exterior of the house. Lighting intensity will be controlled by light intensity sensors to monitor the available level of natural light in the room, and occupation status of the room.

Rainwater harvesting allows the house to move away from a municipal water source and use rainwater for plant watering purposes. The rainwater will be collected by using a gutter system on both ends of the house sloping towards either the east side of the house.

MODULAR DESIGN

The unique challenges of the Solar Decathlon – construction, transportation and reassembly – have been addressed by the team, resulting in two "modules" that share a wet wall and will connect easily, surrounded by a porch with large overhangs to create a typical Southern vernacular aesthetic. The Structural Team developed the foundation, walls and trusses to meet the ASCE/SEI 7-10 Minimum Design Loads and Associated Criteria. The subfloor uses engineered I-joists, which are lighter than dimensional lumber and sustainably sourced. Exterior walls consist of 2x6 plates with staggered 2x4 studs and blown closed-cell insulation for an R-26 envelope. The applicable codes are: 2017 Solar Decathlon Building Code 2015 International Residential Code.

THERMAL COMFORT INSULATION:

WALLS: Selecting insulation material for the house is a multi-faceted task. The ultimate goal is to keep the inside conditions at a comfortable range, by limiting heat transfer through the house's envelope, and 2- minimizing infiltration of unconditioned outside air to the house through gaps, cracks, and openings. In order to achieve these goals conscientious decisions must be made. Health concerns are the most important factors, and most commercially available insulating materials have deficiencies in that area. Construction-phase issues include, skin- and eye-irritant chemical fumes, micro fiber inhalation, and skin abrasion. Post-construction issues include flammability, off-gassing, end-of-life environmental issues, and also the same issues as those during construction-phase whenever repair and replace work is required. On the other hand, there is the issue of achieving the highest R-value that is possible in a most compact space, and so hard choices have to be made.

Usually, environmentally benign materials don't provide high R-values or lack other required features such as fireproofing. The exterior vertical walls of the house are built in a staggered double 2x4 stud manner with 2x6 plates on the top and bottom of the wall frame. This provides a cavity space for insulation equal to 5.5 in (14 cm). This cavity is filled with 1 in (2.5 cm) of closed-cell foam sprayed on the ZIP sheathing system. A 2 in (5 cm) layer of fiberglass batt insulation is installed over the spray foam. An additional 3" (7.6 cm) layer of fiberglass paper-faced batt insulation is in place. Then in order to provide a rigid backing to prevent gypsum boards from cracking due to transportation-induced vibration, ½ in plywood sheets are installed to close the wall cavity. Gypsum board is installed on the plywood sheets. On the outside of the exterior sheathing, a 1 in (2.5 cm) slab of rigid foam insulation provides an additional R-5 insulation to the wall. Table 1 shows the thickness and R-value of each individual layer of the vertical exterior walls. Since the house is built in several modules for transportation, there are seams where the modules come in contact. All seams are sealed with weather-resistant tape.

Table 1. Total and individual R-value of exterior vertical wall layers

Wall layer (outside to inside)	Thickness In (cm)	R-value $\frac{°F{\cdot}ft^2{\cdot}h}{BTU}$ $(\frac{°C{\cdot}m^2}{W})$
Cement board	5/16 (.8)	.15 (.026)
Air gap (average)		.15 (.026)
Rigid foam	1 (2.5)	5.0 (.88)
ZIP sheathing	¾ (1.9)	.9 (.16)
Closed-cell foam	1 (2.5)	6.5 (1.14)
Fiberglass batt 1	2 (5)	6.7 (1.16)
Fiberglass batt 2	3 (7.6)	11 (2.25)
Plywood	½ (1.3)	.62 (.11)
Gypsum wall board	½ (1.3)	.45 (.08)
Total:	9.5 (24.3)	25.638(5.9)

Table 2. Total and individual R-value of sloped roof layers

Roof layer (outside to inside)	Thickness In (cm)	R-value $\frac{°F \cdot ft^2 \cdot h}{BTU}$
PV panel shading		
Metal roof sheet	.025 (.063)	negligible
Weatherproofing sheet	.06 (.15)	negligible
Plywood	½ (1.3)	.62
Rigid foam – layer 1	3 (7.6)	15
Rigid foam – layer 2	2.5 (6.4)	12.5
Plywood	½ (1.3)	.62
Foam insulation	1 (2.5)	6.5

ROOF: The sloped roof of the house was built with two layers of rigid polyurethane foam. The first layer is 3" think and the second layer is 2-1/2" thick, for a total of 5-1/2" insulation on the outside. The rigid boards were arranged in a staggered manner so that a continuous seem in the direction normal to the surface of the roof was avoided. For added insulation and increased air sealing effects, 1 -1/2" of spray foam insulation was applied to the underside of the roof.

FLOOR: The underside of the floor of the house is sprayed with 5 in. of closed-cell foam. This provides and R-value of 32.5 $\frac{°F \cdot ft^2 \cdot h}{BTU}$. When the plywood and finish flooring are added to the floor layers, a total R-value of 33 is achieved.