surviv(AL) House

INNOVATION Narrative

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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.

Team Alabama has worked to devise innovative solutions to the problems of heat, humidity, and severe weather events. These solutions include the use of targeted site orientation, clever cooling devices, and protection against natural disasters.

CLIMATE SPECIFIC DESIGN

S u r v i v (A L) House employs passive solar design to take advantage of our home's site, climate, and materials to minimize energy use. The University of Alabama at Birmingham's SURVIV(AL) 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.

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,

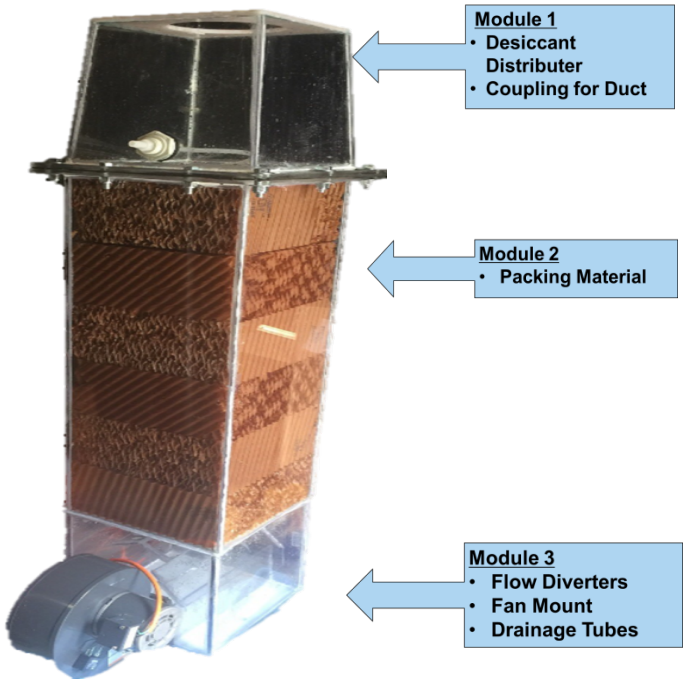
with high temperatures averaging over 90 °F (32 °C) throughout the summer in many parts of the State. Winters are mild — the average winter minimum for the entire state is 35 °F (2 °C), and the temperature falls below the freezing point fewer than 35 days in each year.

The **s u r v i v (A L)** House is designed to be climate specific. In order to achieve a model of efficiency and cost effectiveness, **s u r v i v (A L)** house implements 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. Most of the 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.

TEAM DEVELOPED TECHNOLOGY

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

The world's population is growing at a rapid rate and with that comes an increase in demand for energy. Cooling an entire house with traditional air conditioners or mini-split systems is very costly, which is why we have designed a robotic cooler to provide localized spot cooling of a human occupant. This cooler is designed for use in any home where energy conservation and sustainability are desired. It is programmed using the open source Arduino platform which makes it adaptable, affordable, and maintainable.

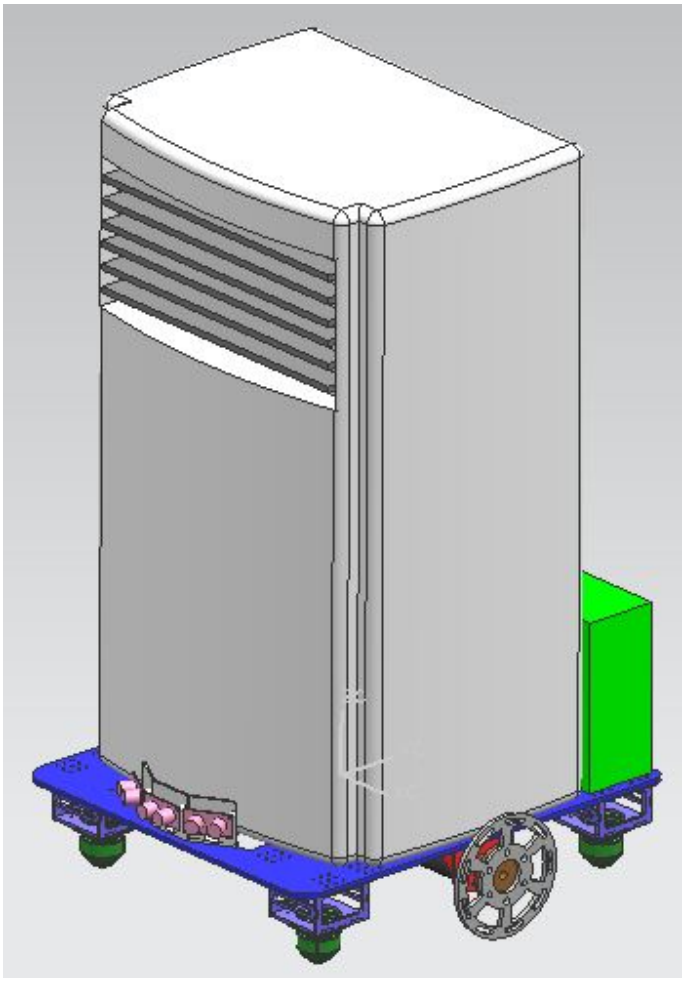
Evaporative cooling technology was selected for this application due to its low energy consumption and its effectiveness in dry climates. A Sunpentown SF-607H evaporative cooler was selected for use in the design due to its high efficiency atomizing technology, multiple fan settings, small size, and 75 W rating. This cooler was modified to run off of an onboard 12 VDC deep cell lithium Ion battery capable of maneuvering and cooling for up to 3 hours. The robot was created by attaching the cooler to a motorized base outfitted with ultrasonic sensors for object avoidance and ultra-wideband technology called Pozyx for accurate positioning and navigation around the interior of the house. At the heart of the robotic cooler is an Arduino Mega programmed with a pathfinding algorithm that uses Pozyx's state of the art positioning system. The robotic cooler has an automatic docking feature that allows for it to be charged without the user having to manually plug it in. The charging terminals on the front of the robot and on the charger remain deenergized while the robot is not charging.

The Pozyx system consists of tags and anchors. The tags are movable and utilize an accelerometer, gyroscope, magnetometer, pressure sensor, and an ultra-wideband (UWB) transceiver, while the anchors are fixed devices acting as "satellites." The devices use two-way ranging to verify positioning to get accurate indoor positioning with centimeter accuracy. The principal component is

the DW1000 UWB-chip from Decawave that is used for wireless ranging and messaging. The Pozyx shield in the remote control provides the position of the user needing to be cooled, as well as other control functionality (e.g. call from charger, go to charger, and manual override drivability)

The robot is driven by two gear motors with encoder feedback connected to an Arduino Mega. The Arduino microcontroller was selected for its low cost, open source software platform, ease of modification, easy expansion through its multiple digital and analog input/output pins, and easy access to replacement components and hardware around the country and world. The Mega is programmed with a pathfinding algorithm that allows the robot to calculate the shortest distance to the user or charger while simultaneously avoiding obstacles. The remote control's microcontroller consists of an Arduino Uno, Pozyx shield, and a SparkFun Joystick Shield. This setup provides advanced innovation with the Pozyx positioning system along with common microcontroller components that are readily available.

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. The robot provides evaporative cooling to occupants when summoned and is capable of autonomously navigating around obstacles in the home using infrared sensors and Bluetooth signals to find occupants.



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 the 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 percent 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 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. 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.

INNOVATIVE WATER TECHNOLOGY

WATER MONITORING

S u r v i v (A L) House will incorporate the use of the DRiY system from Ark Labs of Florence, Alabama. DRiY is a smart water monitoring device equipped with a remote shut off valve and

empowered by artificial intelligence software. The DRiY system is designed to learn the home's water usage. For example, the device will be able to tell how many times the dishwasher is normally used and then, when an anomaly from the norm occurs, either through inefficiency or a major pipe burst, based on the cognitive learning of usage, DRiY will alert the homeowner through a smart phone app, allowing them to shut the water off remotely. If there is significant jump, DRiY will automatically shut off the water flow while alerting the homeowner.

Ark Labs uses machine learning software to build a unique pattern of usage for each residence. By learning the time of day, day of the week, and week of the month of the normal usage over 30 days, the system can build a model of what is normal. Then through real time monitoring, each time water flows, a powerful analytics server searches through 100,000s lines of data to see if that current water flow is normal for that household.

Ark Labs encourages conservation through real time monitoring, daily usage statistics and monthly comparisons. For example, at the end of each day residents of **s u r v i v (A L)** House will know how their daily consumption compared to the same period the previous week, and how it compared to others in their locale. Each day, **s u r v i v (A L)** team members will have a chance to earn badges which in turn will turn saving water into a game or competition. Without the data and knowledge, there can't be conservation. Ark Labs brings this information to the users' smartphone and then purposes it in a way that makes it simple to understand and use.

WATER PURIFICATION

When tornadoes strike, whole communities can be left without shelter, transportation, phone and cell service, food, and clean water. The **s u r v i v (A L)** House storm shelter will contain a device that can be quickly implemented so that the home's residents and their neighbors will have quick access to clean water.

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

M-100 WATER PURIFIER

As contaminated water circulates through the system, chlorine gas is injected into the water. When the water has reached the recommended chlorine level of 5 PPM - and till has a 2 PPM chlorine level after setting for two or more hours - the waterborne pathogens have been killed.

The device is called the WaterStep M-100 Chlorine Generator, and it was developed in response to a need that affects nearly one billion people around the globe: unsafe drinking water. In fact, waterborne disease claims more lives each day than armed conflict, HIV/AIDS, and cancer combined.

For more than 140 years, chlorine has been added to water to kill disease-causing bacteria and pathogens. The M-100 is a portable, affordable way to chlorinate water for the purpose of eliminating waterborne pathogens. Through the process of electrolysis, the M-100 creates chlorine gas from salt water. The chlorine gas, which evenly disburses throughout the water, kills waterborne bacteria in two hours.

WaterStep is a non-profit organization that provides safe water to communities in developing countries. Team Alabama collaborated with engineering program students at Thompson High School in

Alabaster, Alabama to showcase the system in the **s u r v i v (A L)** House safe room. Thompson students, under the guidance of their instructor Brian Copes (2017 Top 50 Teachers in the World, Varkey Foundation Global Teacher Prize winner and People Magazine's Top 5 Teachers in 2012) have helped to implement the Chlorine Generator system in three water-stressed villages in Jutiapa, Honduras.

A FLEXIBLE AND RESPONSIVE BATHROOM

THE SHARED SHOWER

S u r v i v (A L) House student designers placed a high priority on maximizing flexibility and use of space. The team believed that for our target customer, it was important for the home to supply two bathrooms for residents and guests. As a result of thoughtful and careful planning, the team was able to provide an innovative solution to the problem of limited space: a shared shower.

S u r v i v (A L) House a features one bathroom that is entered through the main bedroom, and an additional bathroom that is entered from the common living spaces. These rooms are bisected by a shower that can be entered from either side. Each sliding shower door is made completely opaque through the use of privacy glass

INTERACTIVE MIRROR

UAB's Makerspace Decathletes have devised a multi-touch interactive mirror that combines the usefulness of an integrative home hub display and crosses it with the utility of a bathroom mirror. The mirror can be used to

quickly monitor the status of the house: water usage, tripped security devices, electricity usage, air quality, noise pollution, gas usage, and internal and external temperatures to name a few.

The mirror also has the capacity to be linked to a Bluetooth weight scale to monitor weight, and to calendars, to-do lists, and sleep monitoring data synced between smartphone and smartwatch devices to streamline self-care and self-organizing tools onto one easy to use device. In the future, the team will provide further app development that will create services for streamlining home shopping, child/pet monitoring, wardrobe management, self-photography, and other uses.