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# Autonomous Emergency Water Station

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# Autonomous Emergency Water Station

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## Abstract

An emergency water station for migrants crossing the Texas-Mexico border is designed and implemented. This station uses satellite communication to send the number of remaining water jugs to the volunteers in charge of replenishment. This paper outlines the features of the complete design and discusses the primary functions of the main three subsystems of the station. The first subsystem is the station structure, which holds the water jugs, electronics equipment and the flagpole. The second subsystem consists of the electronics/communication system which tallies and transmits the number of water jugs remained in the station. The third component is the solar-based power system to charge the batteries and provide power to the electronic components. The fully constructed design fits within a standard truck bed (78” x 64”) for easy transportation. It can withstand an operational temperature of 20°F - 140°F and a maximum wind speed of 40mph. Special attention is paid to the operational cost of the communication system to keep it under $5 per month. The number of one-gallon water jugs remained in the station is reported at least once per day within the accuracy of ±1 jug. The station is visible at night from at least one mile away by using LED mounted on top of a 25-foot pole..

## Introduction

While crossing the border between Mexico and Texas, migrants and refugees are often subject to high temperatures, leading to severe dehydration and heat exhaustion. Currently, the South Texas Human Rights Center (STHRC) has placed numerous water stations in different locations along the border to be used by these immigrants. Volunteers have the encumbering duty to physically inspect each station regularly for adequate supply of water for consumption. To ease the burden, STHRC partnered with the Trinity University Engineering Science Department to design and implement portable Emergency Water Stations that can be deployed in the border. These stations use satellite communication to send the number of remaining water jugs so volunteers can add more jugs if necessary.

This design is an iteration on the two previous ones carried by engineering students at Trinity University. These designs were largely successful in providing a functional hydration station, but they suffered from insufficient base strength, poor weatherproofing, and a costly communication system. Therefore, in the current design, four main improvements were identified:

1. Strength of the base structure.
2. Decrease the total cost of transmissions.
3. Environmental resistance.
4. Accuracy of the water jug counting mechanism.

As mentioned before, this new station features three main subsystems the first of which is the base that holds the water, electronics/communication equipment and the flagpole. The second component is the electronics/communication system which tallies and transmits water jug data to the STHRC. The last part consists of the power system which charges the station batteries and powers the electronics components. The following requirements are used in the design of the subsystems of this water station:

- The station is capable of holding at least 18 one-gallon water jugs, flagpole, electronics subsystem, as well as the weight of an average adult human male (Approx. 300 lbs. total).
- The primary components of the electronics and communication systems are IP55 compliant, as outlined by IEC Code 60529.
- The operational cost of the communication system is less than $5 per month.
- The station reports the number of remaining one-gallon water jugs at least once per day to an accuracy of ±1 jug.
- The station is capable of withstanding the adverse weather conditions common to the Texas-Mexico border region (Operational temperature: 20°F - 140°F and maximum wind speed of 40 mph).
- The station is equipped with a light source for easy visibility at night from at least one mile away.
- The complete unassembled water station fits inside an area with dimensions 78” x 64” which is the standard truck bed used by STHRC staff and volunteers for transportation and maintenance.
- The total cost is limited to $1200.

## Design and Method

Here, the details of the design of each subsystem, namely the base, the electronics and the power are discussed.

### Base

The base of the station stores 21 water jugs, houses the electronics and power subsystems and supports a 25-foot flagpole. Due to the unique challenges of supplying water in outdoor border regions, the station is designed to be portable, sturdy enough to withstand harsh weather conditions, and have a shape optimized for minimum weight. The main body is made from polypropylene which is one of the most suitable materials given the conditions mentioned above (see Figure 1).

Previous autonomous water station designs used load cell weight sensors to measure the remaining water in the station. Inaccuracies due to continuous-load sensor drift in load cells (Adam Equipment, 2021) motivated a change to measuring water content using a method involving a ramp and a switch. The main body of the station structure is shaped around storing one-gallon water jugs on ramps. The trigger of a switch at the bottom of each ramp registers the removal of a water jog. A waterproof electronics box located underneath the ramps houses the electronics/communications subsystem which connects to the flagpole mounted on the side of the main body. The flagpole is used to attach a satellite antenna, solar panel, and a green LED which flashes at night to make the station visible. Four 4x4x48 wooden beams is secured to the base with sandbags placed on the ends of each beam to prevent tipping. The station is designed to be easily transported in a truck bed and withstand the weight of at least 18 1-gallon water jugs. The details of the design and implementation of this system is discussed next.

*Station Structure - Size and Portability*

CAD software and Finite Element Analysis (FEA) tools were used to design the base which is optimized for strength, size and portability. Fusion 360, an Autodesk Software, has the feature to perform material optimization simulations which highlights the regions of the base that are critical to supporting constant loads. This software was very helpful in optimal design of polypropylene walls inserted in the base for maximum support. These walls also helped in separating the ramps and minimizing the weight of the base by about 100 pounds. Table 1 shows the initial (not optimized) and the final (optimized) weights of the base. For comparison, the range of low to medium risk weights carried by two and three people are included. The latter data is obtained from Manual Assessment Chart, also called MAC tool, (Health and Safety, 2018). It is obvious from this table that handling the base including the electronics components pose medium and low risks for two and three people, respectively. The carrying weight of the station and the density of the polypropylene material constrained the size of the main body to hold a maximum of 21 1-gallon water jugs.

Three key tools were used to manufacture and assemble the main body of the structure. The first was a CNC router for cutting polypropylene into main body components. The second tool was a plastic welding tool which melts thin strips of polypropylene to run along seams of the body components to plastic weld them together. Finally, a dremel was utilized to ensure the parts can fit together properly. Once the main body was assembled, all structure components were measured to ensure that the whole base fits within an area of 78” x 64”.

Table 1. Comparison of MAC Tool Weights with Structure Weights

| | | Weight (lbs) |
|---|---|---|
| Water Station Main Body Structure | Non-optimized | 192 |
| | Optimized | 87 |
| | Optimized+Electronics | 102 |
| Max Weight Carried by Two People* | Low Risk | < 77 |
| | Medium Risk | 77-143 |
| Max Weight Carried by Two People* | Low Risk | < 121 |
| | Medium Risk | 121-209 |

*(Health and Safety, 2018, p. 13)

*Station Structure - Weight Support and Storage*

The autonomous water station is required to store water which can be accessed by the users. To reduce the likelihood of contamination, water is stored in individual plastic 1-gallon jugs which rest on three parallel ramps in the base. This base is designed to withstand a weight of 300 lbs which is sufficient to contain 21 1-gallon water jugs, electronics components, the flagpole, and the weight of an average human in case a person needs to stand on the base. FEA simulations of the base with constant loads were iteratively performed on CAD models to ensure its proper functionality. These simulations showed no significant deformation in the structure.

*Station Structure - Weatherproofing*

An autonomous water station faces harsh weather in border regions including rain, wind, and extreme temperatures. Therefore, the station is designed to withstand temperature range of 20°F-140°F and have a shape which does not tip over or become damaged by winds up to 40 mph (Figure 1).

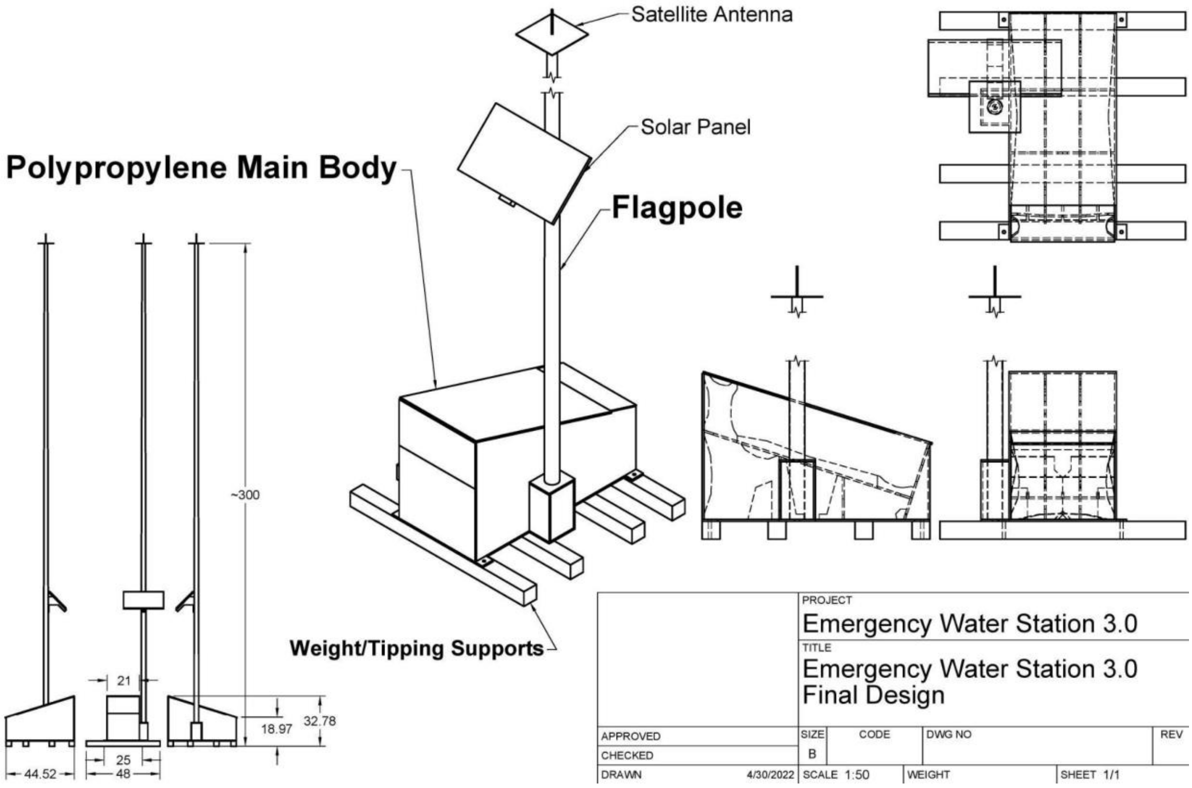


Figure 1. Our Autonomous Emergency Water Station Schematic

To guarantee that the station does not tip over, the forces that the station experiences during maximum wind speed of 40 mph are simulated. The drag force caused by this wind is calculated with the assumption that the air flowing towards the station is far away from the station or ground. This imparts significantly more energy than a brief (1-20 seconds) gust of wind which is more common. This simulation is performed using four horizontal wind directions which are front, back, and both sides of the base.

The total drag force on the station, $F_D$, is assumed to be the sum of the drag forces on the base, $F_{D,Base}$ and the pole $F_{D,Pole}$ as shown in Equation (1).

$$F_D = F_{D,Base} + F_{D,Pole} \tag{1}$$

To find the drag force on each component, Equation (2) is used where $\rho$ is the density of air at STP, $v$ is the velocity of the air, $C_D$ is the drag coefficient and $A_F$ is the frontal area of the corresponding component, namely the base and the pole.

$$F_{D,Base,Pole} = \frac{1}{2}\rho v^2 c_{D,Base,Pole} A_{F,Base,Pole} \tag{2}$$

The drag coefficients of the sides of the station and the pole are estimated using values found from nasa.gov (Hall N., 2021). The empirical relation for $c_D$of a cylinder is obtained from Baracu & Bosneagu's analysis of flows around cylinders (2019) using the Reynolds number calculated in Equation (3). Each of the parameters for (1)-(3) is provided in Tables 2 and 3.

$$Re = \frac{vD}{\nu} \tag{3}$$

The values used in Equations (1-3) are shown in Tables 2 and 3.

Table 2. Parameters Used in Equation (2) to Calculate Drag Forces

| Variables | Value | Units | Comments |
|---|---|---|---|
| $v$ | 40<br>17.9 | $[mph]$<br>$[m/s]$ | Max wind speeds |
| $D$ | 2.5<br>0.06 | $[in]$<br>$[m]$ | Average diameter of flagpole |
| $\nu$ | 1.460E-5<br>1.5723E-4 | $[m^2/s]$<br>$[ft^2/s]$ | Kinematic Viscosity of air |
| Re | 7E4 | $[-]$ | Corresponds to a cylinder $c_D$ = 1.19* |
| ρ | 1.225<br>0.077 | $[kg/m^3]$<br>$[lb/ft^3]$ | Air pressure at Standards Temperature and Pressure (STP) |

*(Baracu, T., 2019)

Computational Fluid Dynamic (CFD) simulations on a simplified model of the final station design (without weight/tipping supports) are performed with 40 mph winds on each side. A large rectangular plane is used to simulate the effect of the ground in slowing down the air flow near the station. Here, this air flow is assumed to be zero. The results of the simulations are compared to the ones obtained from Equations (1-3) to ensure their consistency. These results along with the ones obtained from Equations (4-6) were used to find the tipping moments, M_Tipping, of the base and the counter moments, M_Stabalizing, needed to stabilize the station. These counter moments were implemented using stabilizing counterweights loaded on the base. Note that in these equations the tipping moments are considered negative while counter moments are considered positive as shown in Equations (4).

Table 3. Estimation of $C_D$ for Different Wind Directions

| Category | Approx. Shape | $c_D$ [-] | Approx. Normal Area | $A_F$ [in$^2$] | Center of Area Height [in] | Comments |
|---|---|---|---|---|---|---|
| Station Front | Rectangle | 1.28 | Rectangle | 673 | 14.6 | $c_D$† |
| Station Back | Rectangle | 1.28 | Rectangle | 673 | 14.6 | $c_D$† |
| Station Sides | Rectangle | 1.28 | Trapezoid | 984 | 11.2 | $c_D$† |
| Pole | Cylinder | 1.19 | Trapezoid | 810 | 151.2 | $c_D$ * Eq. 10,<br>center of area of trapezoid<br>h = 27ft<br>a = 2 in<br>b = 3 in |

†(Hall N., 2021)
*(Baracu, 2019)

$$0 \leq \sum M_{edge} = -M_{Tipping} + M_{Stabalizing} \tag{4}$$

$$M_{Tipping} = F_D * r_{center-height} \tag{5}$$

$$M_{Stabilizing} = W_{device-min.} * \frac{r_{width}}{2} + F_{additional} * r_{width} \tag{6}$$

In these equations, r_width is the width of the base, F_D is the drag force calculated via CFD, and r_(center-height) is the vertical location of the total drag force on the station. The counterweights are added to the base in the form of sandbags. The force caused by this weight is calculated by Equation (7) where W_(device-min) is the weight of the base with no water jugs (about 102 lbs.).

$$F_{Additional\ Required} = \frac{1}{r_{width}}\left(M_{Tipping} - W_{Device,min.} * \frac{r_{width}}{2}\right) \tag{7}$$

In this equation, r_width represents the effective width of the base which is increased by adding four 4x4x48 wooden beams to reduce the weight required to prevent the tipping.

**Electronics and Satellite Communication Subsystem**

The station electronics and satellite communication subsystems are responsible for, tracking the number of water jugs remained in the station and relaying this information to the STHRC volunteers for replenishment. These systems are designed with an emphasis on accuracy, longevity, and low operational costs. All components in the electronics and satellite communications systems are IP55 compliant and are rated to withstand the expected temperature range found in the Texas-Mexico border (20°F - 140°F).

The main processing unit chosen for the electronics subsystem is Arduino MEGA. This unit is responsible for keeping track of the number of water jug, flashing the signal LED at night, and scheduling satellite transmissions to the STHRC. The Swarm M138 communication module is utilized to send signals using satellites. This low power device connects to the global Swarm satellite network, allowing the water station to transmit maintenance information to the STHRC for only $5 per month. To monitor water jug removals, a series of three, IP68 rated snap action lever switches are used. To reset the station water tally following a refill, a fourth IP68 rated switch is utilized. Finally, a green LED strip is mounted on top of a 25-foot pole to make the station visible at night.

While the hardware makes communication between the Arduino, M138 modem, and station I/O possible, the software which is discussed next ultimately controls these processes.

Communication between the Arduino and the M138 modem is handled using UART serial communication. Response messages from the M138 modem to the Arduino are handled by the response handler. This handler reads the serial data sent by the M138, converts the data to a string, then analyzes these strings to extract the useful data. The response handler is ultimately responsible for setting variables like the latitude and longitude coordinates of the station, the current date and time and transmission flags. Command messages from the Arduino to the M138 are handled by the command handler. These commands can be date/time requests, satellite transmission commands or various debugging commands. Before sending commands to the M138, each command has a unique NMEA checksum attached to the end of the string. This checksum is calculated by performing the exclusive-or operation on the bytes of the string.

The LED handler is responsible for flashing the LED at night. For effective operation, the sunrise and sunset at the water station's geospatial location is dynamically calculated using GPS position data and the date/time stamp provided by the M138. Between sunset and sunrise, the LED flashes at a frequency of 1Hz as shown in Figure 2.

The button handlers are responsible for monitoring and debouncing the ramp switches and reset button and updating the number of water jugs stored in the station. When any ramp switch is unpressed, the water jug tally is reduced by one. No action occurs when a ramp switch is pressed. When the reset button is pressed, the water jug tally is reset to 18, all the transmission flags are reset, and a reset message is queued for satellite transmission.

Finally, the warning handler is responsible for monitoring the water jug tally and queueing warning messages for satellite transmission. Additionally, the warning handler queues a satellite transmission containing the current water jug tally each day at 11PM CST. A flow chart of the main software loop is shown in Figure 3.

**Power System**

The power system is responsible for collecting and providing power to the electronics subsystem. This power is collected via a 30-watt solar panel mounted on the flagpole. A charge controller manages charging of two 12-volt, 10-amp-hour lithium-ion phosphate batteries connected in parallel. A diagram showing the layout of the power system is shown in Figure 4.

This high-capacity power system ensures constant power supply to the station during operation. When fully charged, the batteries provide 240 watt-hours which is sufficient for 6 days of operation as shown in Equation (8). This calculation is performed based on the fact that the total power needed to operate the electronics components is 1.674 watts. This is ample capacity for normal operation of the station and provides an excellent buffer in the case of long periods with little to no sunlight.

Figure 2. View of the Signal LED Flashing at Night

$$Operational\ Time = \frac{240\ watts * hour}{1.674\ watts} * \frac{1\ day}{24\ hours} = 5.97\ days \quad (8)$$

As shown in Equation (9), it takes 1.6 hours of direct sunlight to charge the battery for one full day of operation of the station. This number should be generally less since it is calculated based on the assumption of 25-watt rating of the solar panel rather than the actual rating of 30 watts. It is important to note that at least 1.6 hours of direct sunlight per day in the Texas Mexico border is very common. It is also noteworthy that the solar panel is capable of generating significant power without direct sunlight (Weatherspark.com).

$$Direct\ Sunlight\ Hours = \frac{1.674\ watts\ *\ 24\ hours}{25\ watts} = 1.6\ hours \quad (9)$$

## Results

After the completion of this project, the emergency water station went through series of tests to make sure it meets the requirements mentioned above. The first test was to ensure it fits inside an area of 78” x 64” when disassembled. It was also confirmed that disassembly, carrying the parts and assembly of the whole station doesn’t require more than two people. Disassembly consists of removing the flagpole (along with the antenna and solar panel wires), collapsing the pole into its five segments, and removing the wooden beams along with the sandbags.

The main body withstood more than the maximum weight of 300 lbs without permanent deformation. The ramps stored 21 one-gallon water jugs, while allowing for withdrawals without damage or tipping of any water jug. During the outdoor testing, it was noticed that the ramps accumulated a noticeable amount of dirt which could eventually impede the movement of the jugs. Consequently, cleaning the ramps before filling them with water jugs should be part of the maintenance of the water station.

When finding the maximum drag forces on the station in the presence of 40-mph wind, CFD simulations produced lower estimates compared to the theoretical calculations from Equation (2). These lower estimates were due to the latter not taking into account the slowdown of air flow near the ground. The result of one of the CFD simulations for 40 mph wind facing the front of the station is shown in Figure 5. Table 4 shows the result of each of the four CFD simulations, along with the associated required additional force to prevent tipping, F_additional. It is determined that by increasing the corresponding width of the station to at least 40”, the required additional force is achievable using 60 lbs sandbags placed on the wooden beams. This is overcompensated by choosing 48” beams with four sandbags placed on the ends of two of the beams connected to the polypropylene main body. This ensures that in the presence of 40 mph wind the station would not tip over, even if it is not filled with water jugs.

The assembled station was placed on the roof of a building for final testing. During this time, the station suffered no damage from rain, direct sunlight, and wind gusts of up to 20 mph. Some water and dirt did accumulate in the station structure, but the electronics box remained dry since it was designed to be waterproof.

Table 4. Tipping Calculations from CFD Drag Force Estimates

| Category | $F_D$ CFD [lbf] | $r_{center\ height}$ [in] | $M_{Tipping}$ [lbf*in] | $r_{width}$ [in] | Weight of Station contribution to $M_{Stabilizing}$ [lbf*in] | Required $F_{Additional}$ [lbf] | Required $F_{Additional}$ $r_{width}$ = 40 [lbf] | Comment |
|---|---|---|---|---|---|---|---|---|
| Front | 49.3 | 110 | 5423 | 44.52 | 2270 | 71 | N/A | Achievable with sandbags placed on wooden planks |
| Back | 44.8 | 119 | 5331 | 44.52 | 2270 | 69 | N/A | |
| Pole Side | 50.6 | 107 | 5414 | 25 | 1275 | 166 | 85 | |
| Flat Side | 51.6 | 113 | 5831 | 25 | 1275 | 182 | 95 | |

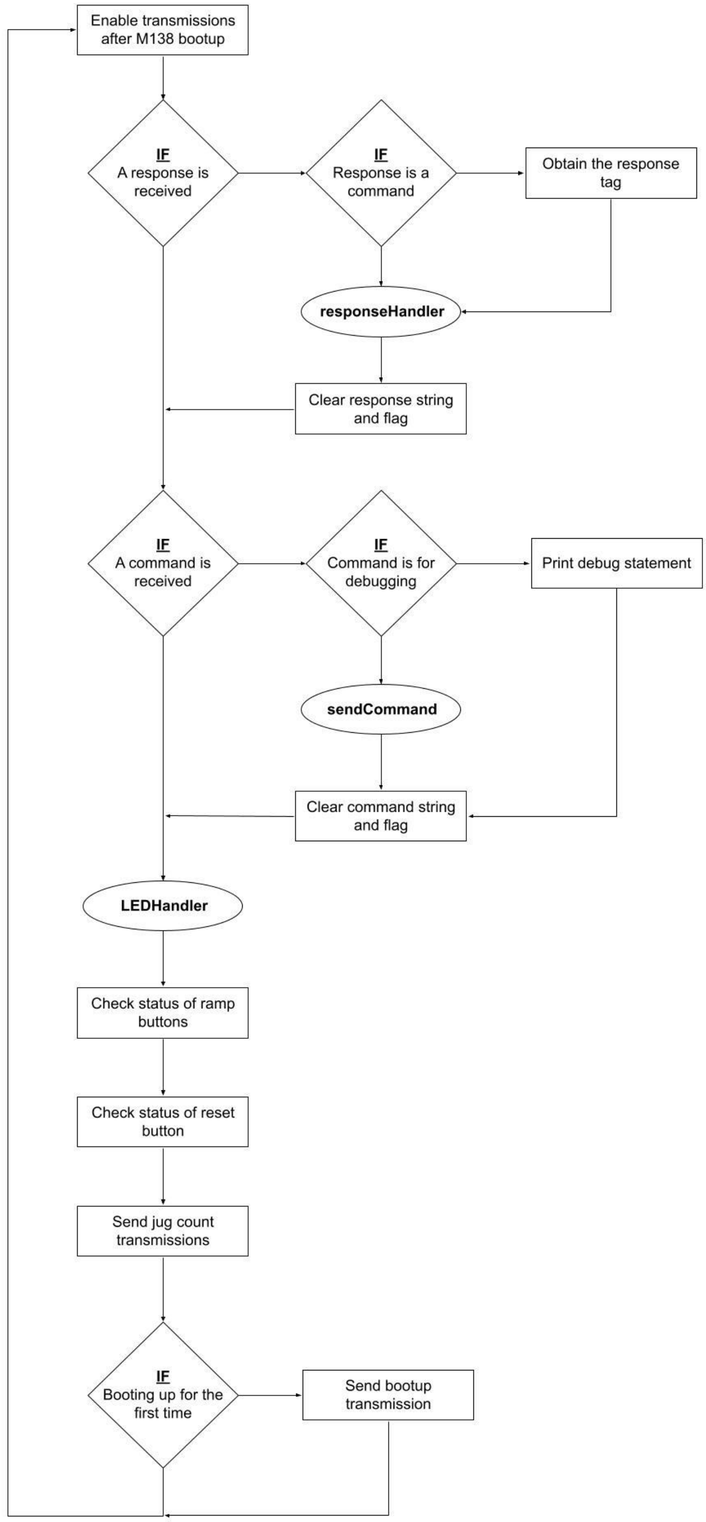


Figure 3. Main Software Loop Flow Chart

A total number of six tests were conducted to ensure the accuracy of the water jug tally. In each test, a different number of water jugs were removed from and added to the base. All of these tests were successful in reporting the correct number of remaining water jugs in the station.

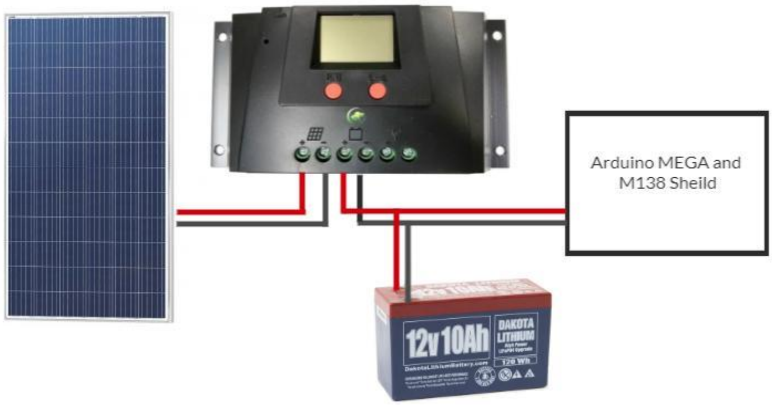


Figure 4. Power System Layout

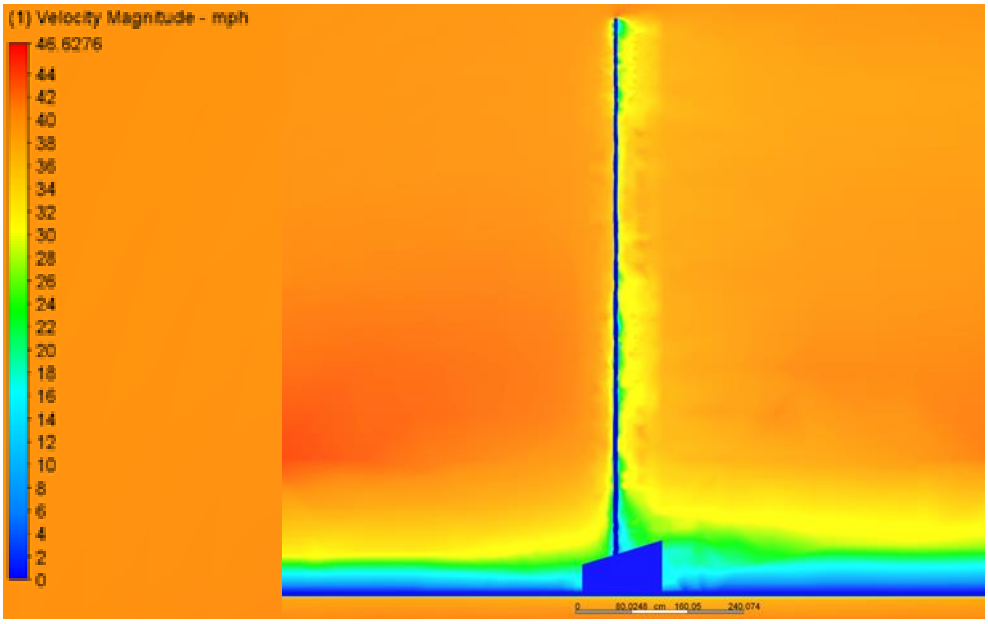


Figure 5. CFD Simulation Result for 40 mph Winds Facing the front of the Base.

The station was tested for a period of two months to ensure it sends the data at least once per day. The ingress protection capabilities of the electronics housing were also tested according to the IP55 certification outlined in IEC Code 60529. Upon conducting the water and dust ingress protection tests, no water or dust was found within the electronics housing.

The signal LED output power was measured to be 1.32 watts. Assuming that the average luminous efficacy of green LEDs is 80 lumens per watt, the luminous intensity of the signal LED was calculated to be 8.4 candela as shown in equation (10). Because the average human eye is capable of seeing a source of one candela from at least 1.6 miles, this result satisfied the signal LED visibility requirement (Krisciunas, 2015).

$$I_v = \frac{Luminous\ Efficacy\ *\ Watts\ Used}{4\pi} = \frac{80\ *\ 1.32}{4\pi} = 8.4\ cd \qquad (10)$$

While deployed in the field, a two-week testing period between April 13th, 2022 and April 25, 2022 was selected to ensure that the power system was able to reliably supply power to the station in many different weather conditions. During this period, a number of rainy, sunny, and overcast days were experienced. A plot showing the station battery voltage is shown in Figure 6. As seen, the battery voltage changed between 13.45 volts (99.2% charged) and 13.55 volts (100% charged). This result showed that the station batteries were providing adequate power to the station regardless of whether condition.

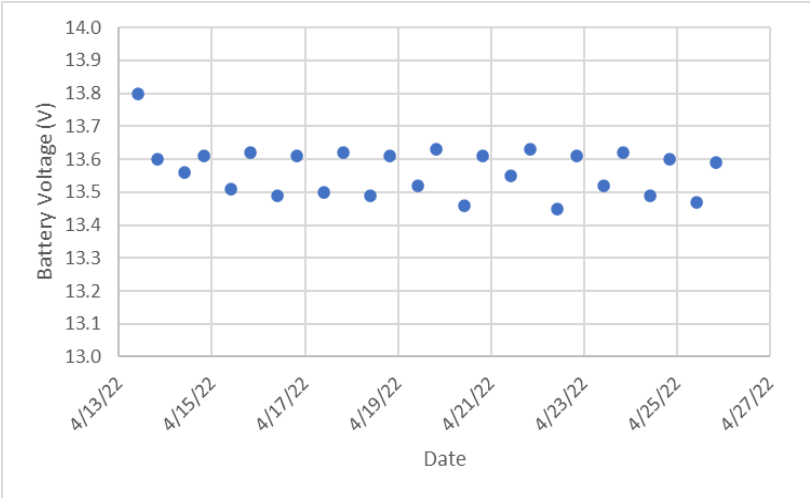


Figure 6. Station Battery Voltage from 4/13/22 to 4/25/22

The complete water station is shown in Figure 8.

Figure 8. Emergency Water Station 3.0

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## References

Adam Equipment USA. (2021). *Creep, Drift and Your Load Cell.* Retrieved June 30, 2022, from https://www.adamequipment.com/aeblog/creep-and-drift

Alhassan, A. I., Farrell, R. M., Saifaddin, B., Mughal, A., Wu, F., DenBaars, S. P., Nakamura, S., & Speck, J. S. (2016). High luminous efficacy green light-emitting diodes with Algan Cap Layer. *Optics Express, 24*(16), 17868. https://doi.org/10.1364/oe.24.017868

Baracu, T., & Bosneagu, R. (2019). *Numerical Analysis of the flow around a cylinder for the ... - ANMB.* Retrieved June 30, 2022, from https://www.anmb.ro/buletinstiintific/buletine/2019_Issue2/01_MES/256.pdf

Beale, A. (2022). *LiFePO4 battery voltage charts (12V, 24V & 48V).* Retrieved June 30, 2022, from https://footprinthero.com/lifepo4-battery-voltage-charts

Dahlinger, D., Farrell, S., Granzino, B., Johnson, T., Kusima, K., Kutach, C., Richter, N., Righes, G., Rodriguez, J., Williams, E., Aminian, M. (2019). *Emergency Water Station Final Design Report.*

Health and Safety Executive. (2018). *Manual Handling Assessment Charts (the MAC tool).* Retrieved June 30, 2022, from https://www.hse.gov.uk/pubns/indg383.pdf

Hall, N. (Ed.). (2021). *Shape effects on drag. Shape Effects on Drag.* Retrieved June 30, 2022, from https://www.grc.nasa.gov/WWW/k-12/airplane/shaped.html

Iridium Everywhere. (2014). *Iridium 9603 SBD Transceiver Developer's Guide*. Retrieved June 30, 2022, from https://cdn.sparkfun.com/assets/6/8/6/6/d/DEV_Iridium_9603-9603N_Developers_Guide__v2.2__1_.pdf

Krisciunas, K., & Carona, D. (2015, July 22). *At what distance can the human eye detect a candle flame?* Retrieved June 30, 2022, from https://doi.org/10.48550/arXiv.1507.06270

Swarm Technologies, Inc. (2022, February). *Swarm M138 Modem Product Manual.* Retrieved June 30, 2022, from https://swarm.space/wp-content/uploads/2022/04/Swarm-M138-Specifications.pdf

Swarm Technologies, Inc. (2022). *Swarm M138 Modem.* Retrieved June 30, 2022, from https://swarm.space/product/swarm-m138-modem/

Vivint Solar. (n.d.). *Best Direction To Put Your Solar Panels | Vivint Solar Learning Center.* Retrieved June 30, 2022, from https://www.vivintsolar.com/learning-center/solar-panels-maintenance

Weatherspark.com. (n.d.). *Falfurrias Climate, Weather By Month, Average Temperature (Texas, United States) - WeatherSpark.* Retrieved June 30, 2022, from https://weatherspark.com/y/7089/Average-Weather-in-Falfurrias-Texas-United-States-Year-Round

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