

## Pilot Boat Zureteiku



### Stats:

1/32 scale

300 W Brushless Motor

7.4 - 11.1 V Battery

Self-Righting Hull

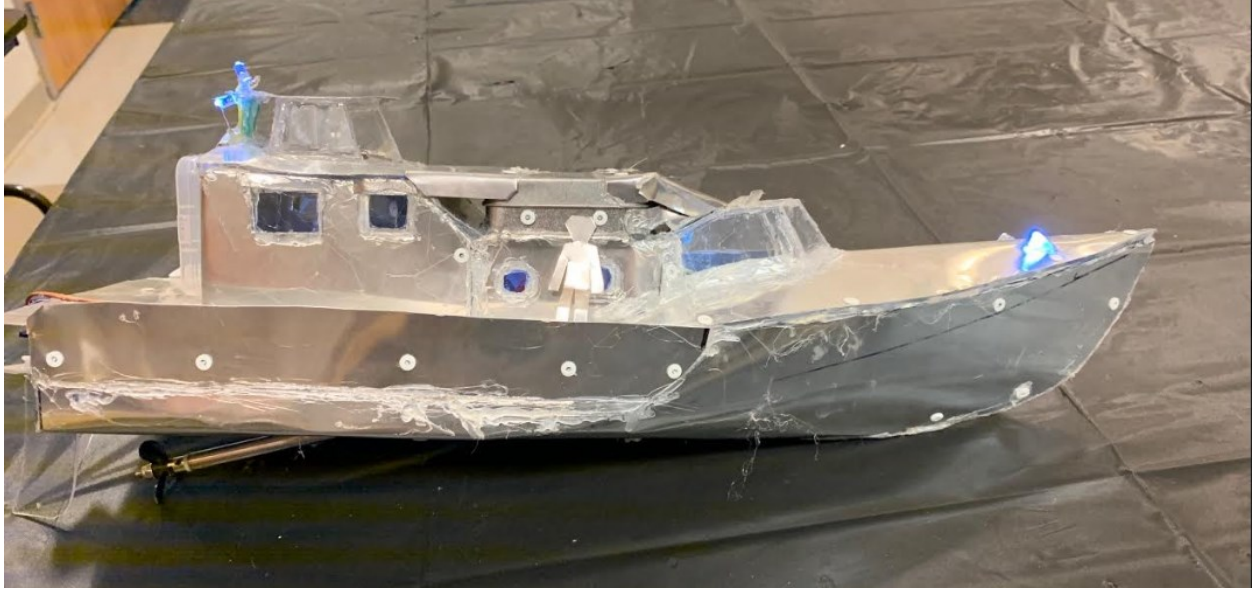
This vessel is designed to be a model of a pilot boat. A pilot is someone with specialized knowledge of the details of a river or harbor whose job is to temporarily take command of a larger vessel in order to dock said vessel safely. Currents, shallow areas, dock peculiarities, and local wind patterns all are factors which pilots are trained to negotiate. When a vessel is incoming, the pilot must be transported to and transferred onto the larger ship. This happens even in storms; in storms, the pilot is even more essential to safe navigation.

Therefore, a pilot boat must be stable in almost any conditions. They must also have an accessible deck for the pilot to use in order to be lifted up from or dropped down to on a Jacob's ladder or winch mechanism. *Zureteiku* has an area of open deck on its stern as well as next to the cabin. It has a wheelhouse in a glazed compartment atop the cabin for improved visibility during maneuvering. The hatches are both watertight and the hull is designed such that the vessel is self-righting – if it is capsized by large seas, it will naturally roll back upright. The bow is designed to cut through waves while avoiding slamming, and the superstructure is intended to easily shed water with low gunwales on the sides and no gunwale extension on the stern. *Zureteiku*, in full scale, could also be used as a Coast Guard search and rescue motor lifeboat, as its self-righting hull and all weather capability would also be useful in that application.

### Building of the Model



The hull is built with aluminum flashing. This is a thin metal, usually bought in large rolls, which is manipulable by hand, but thick enough to be used structurally if designed appropriately. After temporarily duct-taping the seams, hot glue (for sealing) is added, and then the seams are blind-riveted together. In this photo, it can be seen that the motor is directly attached to the wooden bulkhead; this caused problems that are described in more detail below.



As seen above, the rest of the hull was built from the same aluminum flashing. LED lights are connected to the radio receiver, which regulates the voltage that they receive. Usually, this is sufficient, but in this case, the lights shown here burned out in approximately a week, and needed to be replaced with new lights, this time with a resistor in series. The cut-out figure is used to determine appropriate feature scaling; this figure represents a 6' tall person in 1/32 scale.

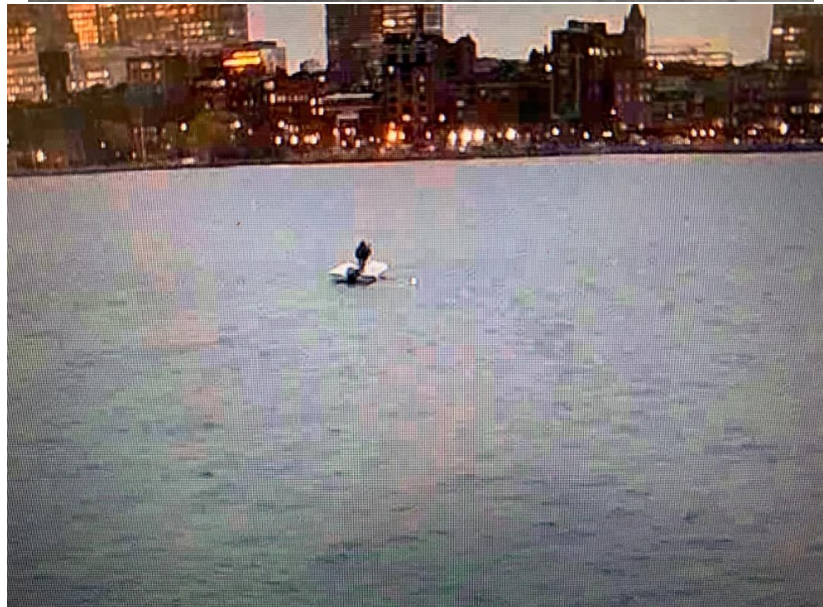
### Initial Sea Trials:



Initial sea trials revealed that the hull was responsive to rudder input during maneuverability tests, as well as relatively efficient, judging from the relatively small bow wave, and also by the lack of churning foam at the bow. This testing was conducted with a 7.4 V (2S) LiPo battery.

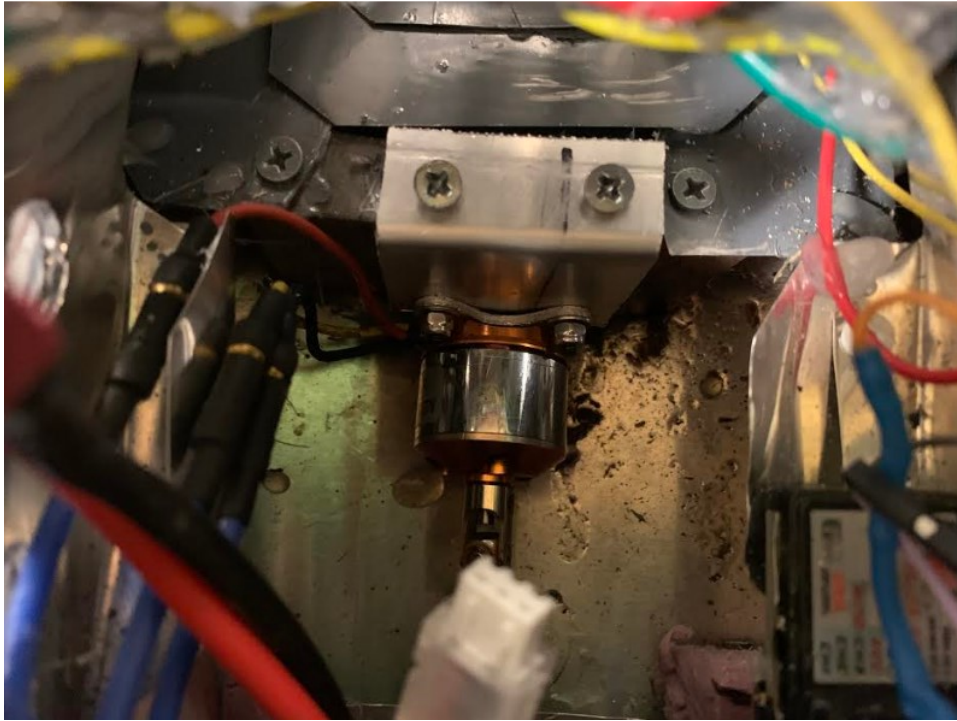


### 11.1 V Test, Motor Mount Failure:



During testing, *Zureteiku* tended to ride a bit bow-high, but otherwise maneuvered well at speed. Unfortunately, the added stress and vibration worked the motor mount screws loose from the wooden bulkhead, so the motor came loose at speed and ripped the motor wires out of the speed controller. Doubly unfortunately, the wind switched at that moment and pushed the vessel out toward the middle of the river. I had to go and teach a laboratory session, so I left and returned a few hours later (after dark) to see if I could spot its running lights along the shore. I figured that it would probably be under the highway overpass, since it was a WSW wind. Having no luck with that, I then went rowing the next day in a snowstorm, but again had no luck. Later, I reviewed footage from the MIT boathouse webcam and discovered that the boat had been recovered by a motorboat from MIT. I later learned that a marine engineer from MIT saw *Zureteiku's* running lights and figured that the boat was in trouble, since it was drifting unattended at dusk. The figure above is a capture from the webcam video that shows the motorboat with *Zureteiku's* masthead light at its right (small white light in the water).

## Motor Mount Redesign



After recovering *Zureteiku*, I assessed the motor mount design and decided to reconfigure it. As the motor had been installed before the superstructure, the screws holding the motor mount to the bulkhead were now nearly impossible to reach. Therefore, I designed the L-shaped aluminum bracket in the above figure to hold the motor. To replace or maintain the motor, the bracket (with motor attached) can be removed by unscrewing the two easily-accessible top screws.

### Adverse Weather Sea Trials, 2.2 Mile Trial



After the motor mount repairs, as well as replacement of a stripped shaft set screw, the vessel was again tested on the Charles River. During its first test, a strong northwest wind was present (blowing onshore, to avoid a repeat of the unintentional MIT trip). The wind was sustained at around 20 mph, which translates to ~110 mph in full scale. Performance was quite good; the bow rose over the wave crests without either slamming or burying. The goal of the test was to complete a 2.2 mile (70.4-mile full scale) trip around an island on the Charles River Esplanade. During this trip, a strong

snow squall developed, with frequent gusts up to 40 mph (220+ mph, Category 5 hurricane force full scale)! The top figure shows the density of the snowfall (and also the utility of the running lights!). The bottom figure shows Zureteiku navigating upwind at full speed, which resulted in considerable air-time as the vessel launched off of one steep wave and landed on the next. Such a vessel in full scale would be equipped with shock absorbing crew seats, as slamming is essentially unavoidable in such extreme conditions. The vessel responded well to rudder and throttle inputs and was very stable both in roll and yaw. It seemed almost impervious to the wind. There were a few waves which were deliberately encountered broadside in an attempt to induce a capsize. One of these succeeded, and the self-righting hull functioned appropriately. These conditions lasted for approximately half of the trip. Battery capacity was at approximately 50% after the 2.2-mile trip, so estimated range would around 4.4 miles (140.8 miles full scale), with potentially more range in calm conditions.

Unfortunately, after a few more trials (less extreme than this one), the servo began randomly moving when the boat was immersed, even though it works well out of the water. It is not clear what is happening, but it appears that the servo needs replacement. The speed controller (part of a \$14 motor/ESC Amazon package) also appears to be failing, so this also will be replaced with a more powerful (14.8 V) ESC. After some testing, the system mysteriously became functional again, so these components will be monitored and replaced if necessary.