

# A Tour of Aiko



## Stats:

- 1/32 scale
- 6.5 ft. (1.98 m) long – 205 ft. (62.5 m) full scale
- Turnigy SK3 5045 – 450 motor with Yep brand 100 A helicopter ESC. ~1 260 W with 6s Li Po, probably 630 W with 3S.
- 12 in. beam – 32 ft. beam full scale.

## Design Objectives:

- Provide a proof of concept for a plywood hull construction.
- Handle ocean waves of up to ~3 ft (100 ft full scale).

This ship is the first that I built entirely at SILab. I have a weedwhacker engine that I want to build into a ship, but I didn't have any good hull designs that were suitable for such a large ship (the weedwhacker engine ship will be ~8ft). Based on results from previous ship tests, I decided that I needed a sturdier hull design for large ships than plain aluminum flashing (too thin and difficult to deal with) or glued Popsicle sticks with an internal wood frame and an outer aluminum hull (these hulls are very difficult to seal). The design I settled on is a wooden frame with plywood screwed to it. The gaps between the plywood are filled with hot glue and epoxy. This 6.5 ft. ship will serve as a test bed for this design before building the larger ship.

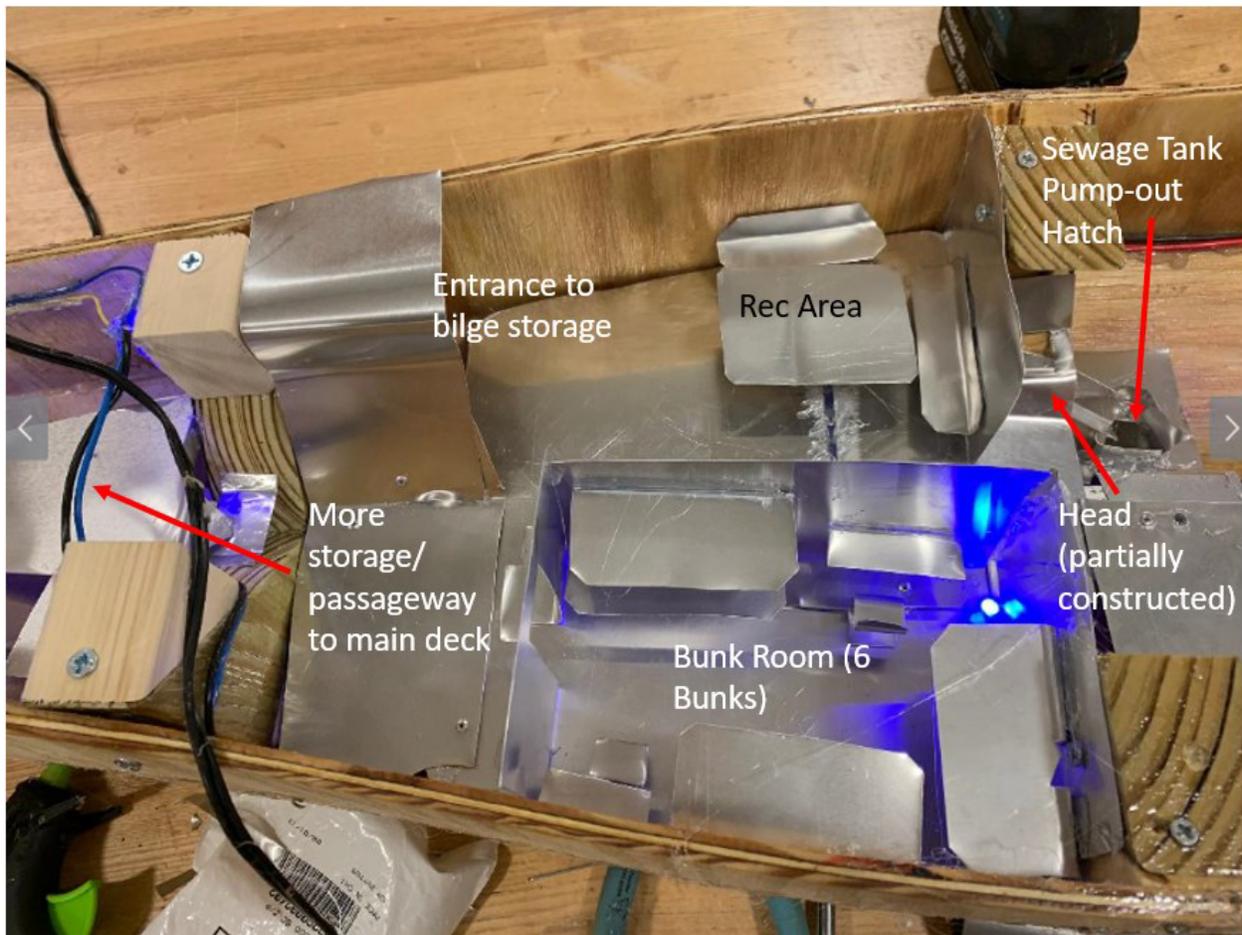




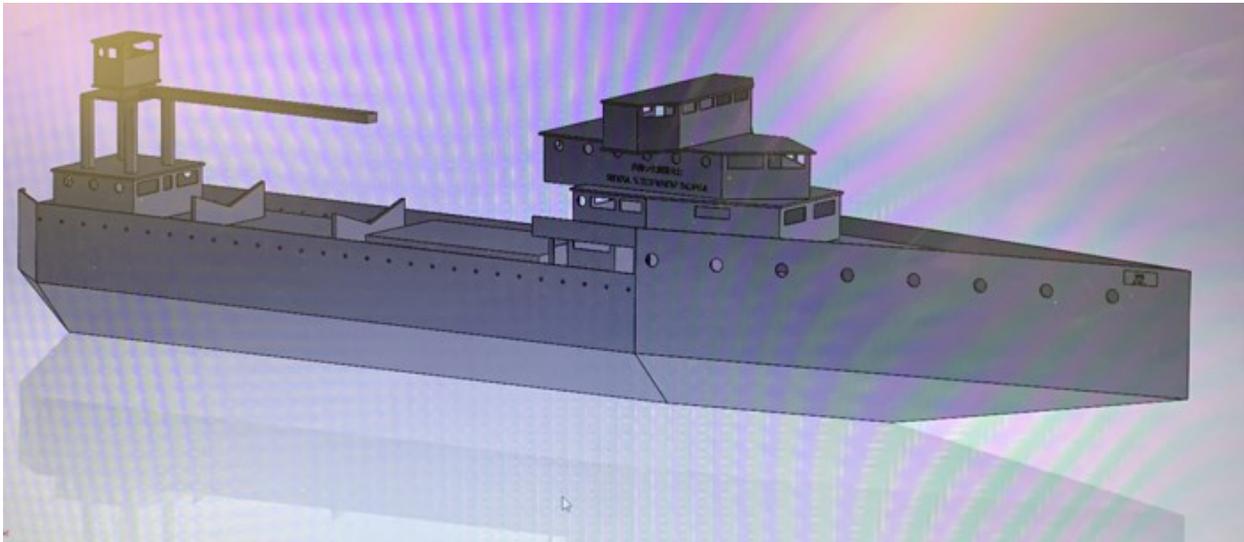
The figure that I am holding in the picture is equivalent to a 6 ft. tall person. Instead of scaling an actual boat down and building a model, these ships are of my own design. Therefore, I use the scale figures to build features that a 1/32 scale crew could use. Also visible are two of the steel bars used to ballast the ship. There are probably 40-50 pounds of ballast in the bilge of the ship.



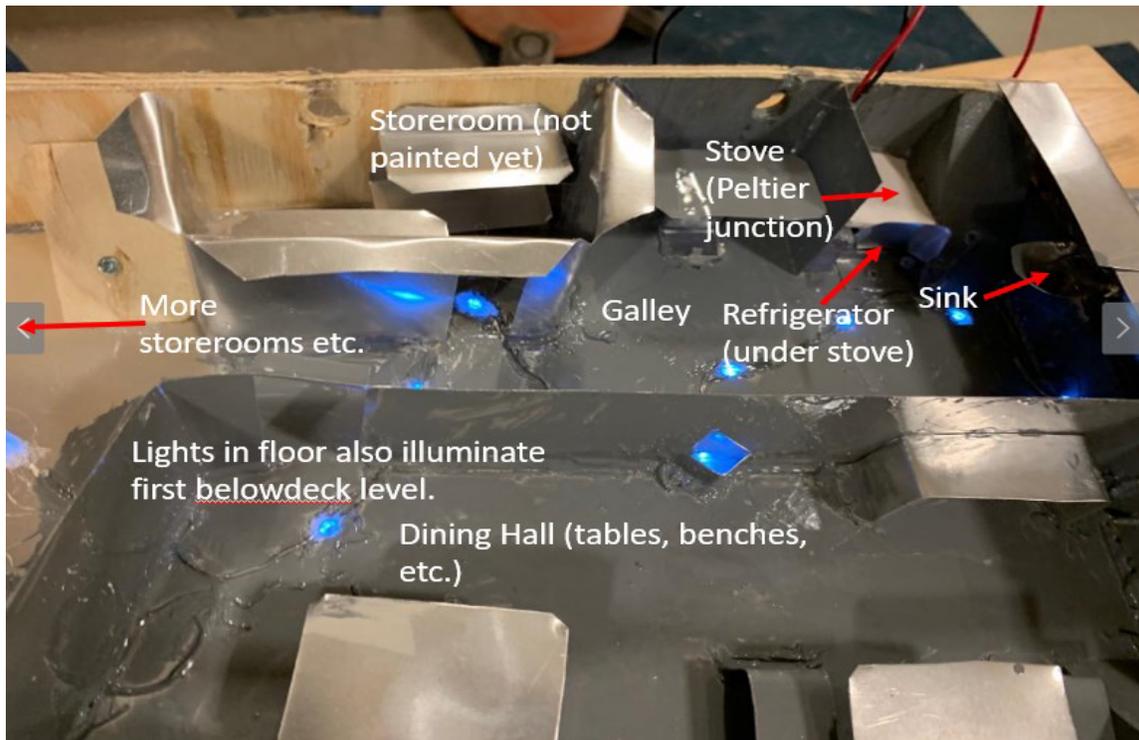
I began adding the deck for the first belowdeck level (second belowdeck level is the bilge where the ballast and sewage tanks are). I also began adding lighting. These are blue LEDs soldered in parallel and connected to two AAA batteries and a switch with a resistor.



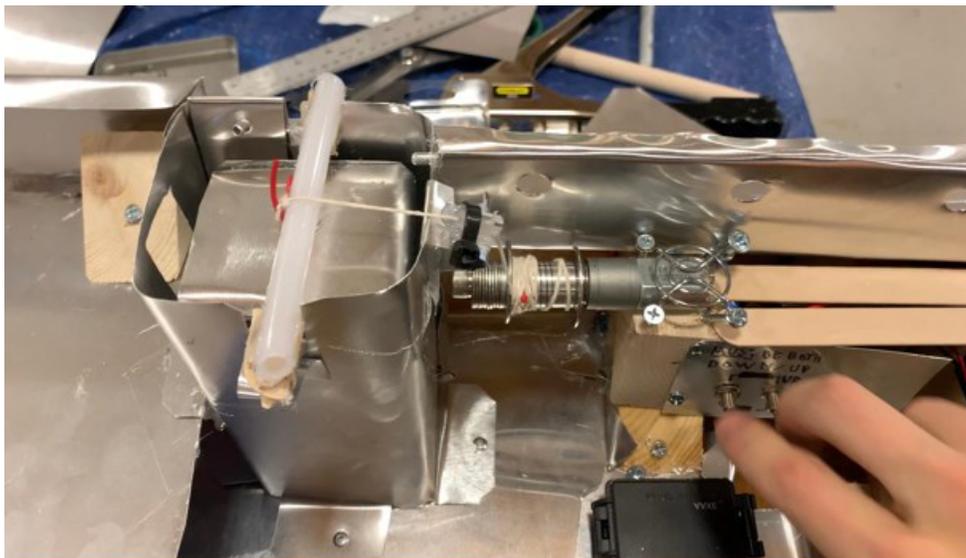
This shows the crew quarters. This level of the ship was left as mostly bare metal and epoxy-coated wood. The crew would consist of 6 members, plus the captain (the captain has separate quarters at the stern of the ship). This is in the first belowdeck level; there is storage in the bilge below. The sewage tank for the head is directly under the pump-out hatch in the bilge. When the head was finished, a wall was installed between the head and the pump-out area, and walls were also constructed around the pump-out room. A pipe also extends into the tank from the galley sink and the second deck head. No sleeping pads, etc. were installed in the bunk room; these would be installed by the crew members on a full scale ship.



At this point, I measured what I had built so far and created a Solidworks model of it. I also added a preliminary superstructure design.

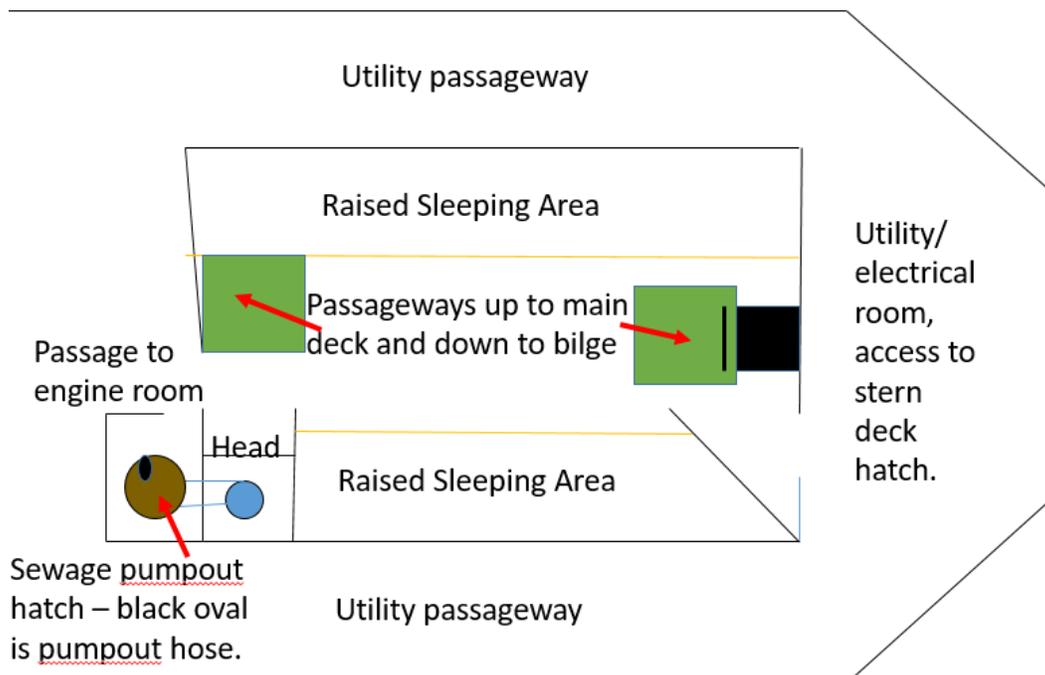


The ship has provisions for a crew living on board for extended periods. There are multiple storerooms, where non-perishable rations would be stored, a small solid state refrigerator for storing perishables (cold side of Peltier junction), a warming plate/stove for heating rations (hot side of Peltier junction), as well as a sink, which is tied to the forward sewage system. The dining hall can easily accommodate the seven crew members, plus extras if necessary. An elevator between the main deck and the first level belowdeck was also constructed.





I began building the first deck of the ship. As this ship is designed for very large seas, in rough water much of the first deck may be under water. Therefore, it is designed to be essentially part of the hull. No passageways lead from the first deck to the outside (except for watertight deck hatches at the bow and stern) and the portholes are small and round for increased strength. The forward walls are plywood screwed into the ship's frame. Unfortunately, I forgot to take photos of the captain's quarters or the room at the stern, so a diagram should suffice. Bow is left, stern is right in diagram. The small stern room on the main deck is not particularly interesting; it just has the rudder post (black square in captain's quarters diagram) and a small readout, as well as a couple lights.





At this point, the ship was turned upside down and the outer hull was coated with epoxy. Once the epoxy cured, the hull was painted, then coated with more epoxy. I also made name plates.

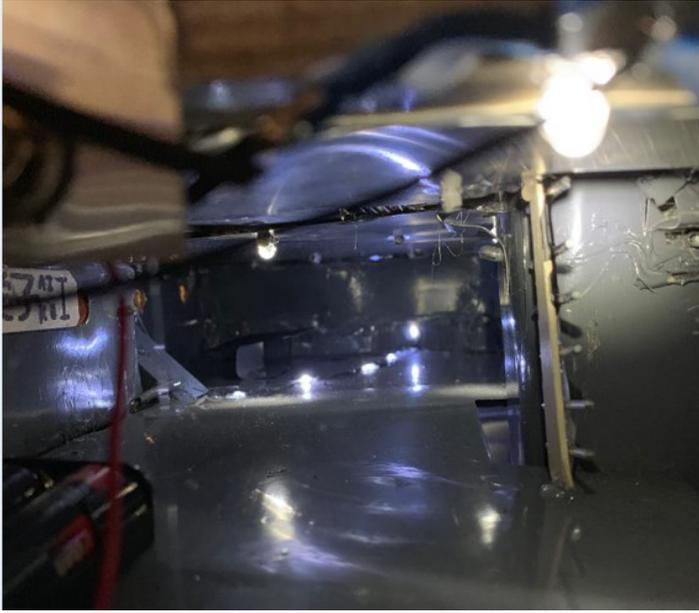




I continued building the superstructure and installing lights. There are two new lighting circuits. One powers most of the main deck lights as well as some of the crew quarters and the upper forward decks. The other illuminates the rest of the upper decks and powers the navigation lights. Note that the nav lights are backwards in this picture due to distracted gluing. This was subsequently fixed.



I finished painting the ship, then ensured that all cracks were caulked or hot glued. Then the entire ship was coated with epoxy to eliminate any remaining cracks.



These are some views of the inside of the ship. Upper left: main deck with elevator shaft on right. Ladder in front of elevator shaft leads to second deck mid-ship compartment (multi-use room). Upper right: Looking down the first level belowdeck hallway. Sewage pump-out room is the box at the right before the narrow hallway. Directly left: View of main deck workshop aft of engine room.



In initial trials, Aiko exhibited very underdamped roll characteristics. This was tested by exciting the hull at its resonant roll frequency using the rudder (the rudder produces roll as well as yaw torque) and observing the response. At approximately 15 degree rudder amplitude, the ship would roll onto its side with each cycle. The phenomenon that this model is encountering is cross seas at the ship's natural roll frequency. Roll dampers were added to eliminate this, and in subsequent tests the roll amplitude at resonance is not much more than the steady state roll created by steady rudder input.





I took the ship to the Charles River with a strong wind creating ~6 in. average waves. The motor provided plenty of power for navigation upwind. Cross-sea performance is quite good with the roll dampers. Downwind performance is stable in all axes also. Upwind, in certain wave conditions, the ship will resonate in pitch. By observing videos of full-scale ships in similar conditions, this seems to be an expected effect.





During the same testing session, I tested a coastal ferry model ( ローリングガール II / Rolling Girl II, above) of the same scale. This demonstrated the advantages of this hull design - the ballast and deeper draft on Aiko improved stability and the lower profile superstructure reduced the roll created by wind loading compared to the ferry. The ferry was nearly impossible to steer, and any steering done was mainly in an effort to keep the ship from capsizing. In contrast, Aiko was very easy to steer and was never close to capsizing. In terms of efficiency in calm water, the two ships are similar. Aiko's sharp bow and rounded hull help efficiency, as does the ferry's semi-planing flat bottom (see next page).



"ローリンガール"



"ローリンガール"