**Answers to engineering questions about the Autonomous Sea Waste Collection System**

**Basic Overview**

The sea waste transport system is intended to load sea waste collected from the “Great Pacific Garbage Patch” and transport it to a land-based recycling and processing center on the coast of either California or Hawaii. It is expected that the sea waste transport system will be operational 365 days per year with service interruptions only for prescribed maintenance or as-needed repair. The maximum duration of allowable down time is 7 days every 4 months. The development team is expected to identify the requirements of any necessary maintenance facilities and specialty equipment based on the design of the waste transport system. Once underway, any anomalous situations that require human intervention will be communicated to the ground station. To ensure expediency, any personnel that will be required to respond to anomalous situations will be transported to the vessel by helicopter, if in range. If out of range, they will travel by surface vessel. The engineering team is tasked with evaluating the likelihood of failures that would require human intervention and determine if, during validation and for a period after the system is commissioned, there should be a network of sea-based support vessels that are available to respond to problems.

This is a prototype system that will be used to evaluate the efficacy of the program for future expansion. Efficacy of the program will be determined as a function of up time, total cost of ownership, collateral environmental damage, and volume of waste returned to shore. If successful, the prototypes will be revisited to evaluate the necessity of enhancements to each of the sea waste removal system elements. The transport vessel is one element in the sea waste removal system. Other elements include the sea-based collection system, the land-based recycling center, and the ground station that provides oversight and emergency control to the transport vessel. It may be useful to think of the sea waste removal system as a system of systems.

**Budget**

This project is supported by coastal communities who are seeking to improve their local environments and reduce human impact to marine ecosystems. Through donations from private sources, crowd funding, conservation organizations, and regional government bodies of coastal cities, your project has a budget of $56M. This budget is managed by a non-profit foundation established to ensure the project is effective and determine if the project should be expanded to include a network of collection sites and multiple transport vessels deployed to sites around the world. The budget should cover at least one transport vessel (ideally up to 3) and 3 years of support services provided by the non-profit. At the end of the second year, the foundation will decide if the program should be expanded. At which time, additional funding will be made available to support the program’s expansion. Any revenue generated from recycling operations will be used to support the collection system; assist in funding its expansion, if it is deemed successful; and to support safe decommissioning of the system.

**Development Timeline and Expectations**

The stakeholders expect to place all elements of the sea waste removal system in service by August, 2021.

The stakeholders expect the engineering team to develop system requirements, concept (SysML) models (logical, if applicable, and structural) of their proposed system, and evaluate risk related to the operation of the transport vessel. No physical prototypes are required at this stage.

**Navigation**

The transport vessel must have a range of at least 3500 nautical miles. It is expected that the collection systems will initially be placed in international waters between 1000 and 1200 nautical miles from Long Beach, CA or Honolulu, HI, in the Pacific between HI and the mainland US. The transport vessel must be piloted while in port. The vessel must also be piloted between the harbor and a shipping lane. After the pilot has successfully navigated out of port, the vessel will be placed in “auto” mode by the ground station. The vessel will hold its position until the pilot has exited. The vessel will then navigate to and from the collection systems autonomously. Autonomous operation is desired to support the vessel’s duty cycle, reduce personnel overhead, and enhance safety. In emergency situations, the vessel may be piloted remotely, from the ground station, or locally by a passenger appropriately trained and credentialed. It is expected that the vessel maintains a minimum distance of at least 0.25 nautical miles from all vessels when in autonomous mode. The vessel’s route is expected to not interfere with animal migration patterns, whenever possible.

The vessel is expected to have all necessary safety systems (running lights, audio indicators, radar, etc.) as required to communicate with other vessels while under way. While it is desirable to have living quarters for up to 5 researchers, expect that most of the missions will be completed with no personnel on board. The stakeholders/project sponsors are concerned about the security of the vessel and want to mitigate piracy. There is also a need to address cybersecurity threats that could compromise an autonomous mission or hijack the vessel. They are looking to the engineering staff to analyze those risks and adopt appropriate mitigations to this threat.

There are three collection systems located 25 nautical miles from each other placed around the perimeter of the garbage patch on the perimeter nearest the destination port. The collection systems will be allowed to drift up to 5 miles from the site of deployment. The ground station will determine the order in which the transport vessel will receive waste from the collection stations. The vessel may service one or more collection systems during a single mission.

The transport vessel will broadcast its position at all times to a ground station. The vessel will receive coordinates of each collection system as well as the contained volume of each collection system from the ground station. The vessel will report anomalous conditions to the ground station. At the discretion of the ground station staff, the vessel may be controlled remotely by the ground station. Additionally, staff at the ground station may communicate with other vessels near the transport vessel as needed to ensure safety. This communication should be via the transport vessel’s radio.

Preference will be given to designs that limit impact to marine life. Designs should consider disposal of the transport vessel at the end of its life or when no longer serviceable. Preference will be given to designs that can be repurposed, recycled, or otherwise have limited environmental impact.

**Waste Transfer**

Once the transport vessel has arrived at the collection system, it will dock to the collection system by capturing and connecting to four hooks on the collection system. The vessel will use these hooks to ensure the collection system and transport vessel maintain relative alignment to facilitate the transfer of collected waste. The collection system maintains buoyancy during transfer and docking operations; as a result, the collection system is not lifted or supported by the transport vessel. The collection system may weigh up to 3 tons. The collected waste is contained by a floating structure in the ocean until collection, so it is not considered in the weight of the collection system. A reflective laser target will be attached to the collection system docking interface to assist with locating the interface.

The waste will be transferred to the transport vessel by a conveyor belt. The outlet of the conveyor belt sits 20’ above the waterline. The conveyor belt is powered by the transport vessel via a 220Vrms 50A power output. The conveyer belt is activated and deactivated by the transport vessel once the vessel determines that it is successfully docked to the collection system. Activation is achieved by application of power through the power connector located next to the top left docking feature. Deactivation is achieved by removing power from the conveyer subsystem.

The conveyer subsystem is capable of transferring waste at a rate of up to 20 cubic feet per minute. The conveyer subsystem is 30” wide at the outlet. The collection system can contain up to 5000 cubic feet of waste. It is expected that the collection system will collect up to 200 cubic feet of waste per day. It is desirable to have the waste removed from the collection system and transported to the processing center every 10 days. The transport vessel should accommodate collections of at least 6460 cubic feet of waste per trip. The waste is expected to be composed of 98% plastic, post-consumer material. Of this material, more than 40% is expected to be discarded fishing equipment, including nets. The waste includes particulates as small as 0.125” in diameter and as large as 6 cubic feet. As the waste will remain in the ocean until it is loaded into the transport vessel, some sea water will be loaded into the transport vessel as the waste is loaded. It is expected that biologic material (e.g. seaweed and dead sea animals) may be loaded into the transport vessel along with waste. All separation and processing will be achieved by the recycling center.

To ensure waste is transferred efficiently and to minimize collected waste escaping, the transport vessel will only dock to the collection system when ocean swells are 6’ or less. It is expected that at least 97% of the trash being transferred from the collection system to the transport vessel is successfully contained in the transport vessel after transfer is complete. The vessel is expected to provide information to the ground station about its status (docking, docked, transferring waste, current load volume/weight, undocking, underway, etc.) The vessel should employ the following communications capabilities, at a minimum: VHF Radiotelephone (156-162MHz), Single Sideband Radiotelehpone (2-27.5 MHz), Satellite Radio, Radar, Digital Selective Calling (DSC), and Emergency positions Indicating Radio Beacons (EPIRB). The primary concern is that communication is robust and reliable. The vessel should accommodate both line-of-sight and over-the-horizon communications.

All waste transfer operations are expected to be autonomous.

**Waste Delivery**

Upon return to the recycling center, a pilot will board the vessel to guide it into port and dock the vessel at the recycling center. The recycling center can receive a transfer of waste at a rate of 100 cubic feet per minute. The interface is a chute whose opening is vertical and square with dimension 5’x5’. The bottom of the chute is 10’ from the top of the pier on which the recycling center sits. The recycling center does not require power from the transport vessel.

The minimum depth (water surface to sea floor) at the pier (considering tides) is 45’. At low tide, the pier may be up to 20’ above the surface of the water. The recycling center is operational 24hours/day, 7 days/week. The staff at the recycling center will be available to facilitate waste transfer out of the transport vessel; although, this is not desirable. The recycling centers are located at shipping ports and in the vicinity of busy airports. Access to airspace will be very limited, as a result.

**Bunkering**

If the vessel requires fuel to be replenished, it will need to be piloted to a bunker station. Bunkering operations will be conducted by trained personnel. As the International Maritime Organization (IMO) has directed the maritime industry to decrease sulfur emissions by 2020, it is desirable that the transport vessel be powered by diesel, if oil-based fuel is selected.

If possible, it is desirable to power all or part of the transport vessel using renewable or “clean” forms of fuel/power. The project sponsors look to the engineering team to identify possible power sources and select the most attractive alternative.

Preference will be given to designs that utilize renewable or “clean” energy sources for all or part of the mission.