Spring Semester 2021 – iLoo Guidebook and Slide Descriptions.

Background.

Open defecation presents unquestionable health issues not only in the United States but around the world. According to the World Health Organization, in 2015, "892 million people used no sanitation facilities at all, but defecated in field, bushes, water, or other places". It is a major international humanitarian issue. Open defecation pollutes drinking water. Contaminated drinking water kills millions every year. It is all connected. Imagine a low-cost, easy-to-build outdoor toilet that uses readily available materials and gravity sedimentation to safely separate feces and urine for disposal or reuse. But it could do more like offer solar power to charge small electronic devices for internet connectivity, family communications and business opportunities. With battery power, iLoo can have low-cost lighting and sanitation.

LooLoo can be an asset in other situations like post disaster relief. Hurricanes and floods can destroy a sewage treatment plant or make people's homes uninhabitable. If LooLoo construction plans and operation were made available to FEMA, it would provide a short-term solution for safe sanitation. It might be an asset for rebuilding the National Parks Service infrastructure which is sorely needed.

Parallel to the engineering model is the business model that will investigate the management, marketing, manufacturing, and supply chain aspects of the engineering model. Thus, the University of Connecticut Schools of Engineering and Business join to research, design, build and test a re-invention of the outdoor toilet. This multidisciplinary team includes environmental, civil, electrical and computer engineering from the School of Engineering with Management and Engineering for Manufacturing from the School of Business. Deliverables include end-of-semester final reports, CAD models, partial or full-scale models of individual systems or subsystems like the electrical system.

The original intention was to design an outdoor toilet that could be used in domestic locations like construction sites, homeless encampments, disaster relief, national parks and in international settings like refugee encampments, rural areas, and tent cities established to house displaced people in Asia, Africa, India. The business analysis revealed that the domestic market is owned by well-established companies that sell or rent porta potties and portable johns. Thus, it became necessary to focus on the international market especially considering contact with a representative of International Medical Corps by a member of the Management Team.

The MEM Team contacted Marcia Roeder, Senior Resource Development Officer of International Medical Corps (https://internationalmedicalcorps.org/). This non-profit organization excels in providing emergency medical services and aid to disaster affected or poverty affected areas. They work all over the world and have great interest in our product, expressing they think there is a real need for iLoo. IMC will provide some expert guidance on

certain design aspects based on the SolidWorks model. IMC is interested in assisting UCONN in product trials in certain regions they work in using a full-scale model. They believe they could cover all transportation and distribution costs in this regard which will greatly benefit field level testing.

This presentation represents the spring semester 2021 offer by the sponsor, Richard Davids, to the University of Connecticut School of Engineering. This offer is based on the Fall semester 2020 research conducted by the three UCONN teams. Their collaboration and investigation into materials and structural analysis, waste management, renewable energy, relief agency support, electronic capabilities and limitations guide this second offer.

Slide 1. iLoo

Humanitarian engineering focuses on creating awareness about the challenges that under-served communities are facing globally and solving those challenges using simple and innovative approaches concerning affordable materials, design, and sustainable technologies. Humanitarian engineering requires a multi-discipline approach like the one chosen by UCONN to support iLoo design and development. The reader is encouraged to investigate the history and application of humanitarian engineering at:
https://en.wikipedia.org/wiki/Humanitarian_engineering

iLoo overcomes the pre-conception that a toilet has a single function. But that function is performed by every human being. Given the advent of satellite communication systems like Starlink, more people will have the opportunity to connect electronically to anyone or any place else. iLoo combines functionality. It combines waste management function with electronic functionality in a novel innovative way using low cost and readily available materials.

Slide 2. What is iLoo?

The word 'loo' is derived from the French expression "guardez l'eau", which means "watch out for the water". This expression was shortened to 'gardyloo' only to become obsolete and replaced with the phrase 'le lieu' or 'the place' which was a euphemism for the lavatory. The British claim it as a British expression for toilet, bathroom, or lavatory. Here, the word 'iLoo' means a room with a toilet.

ILoo provides the power to connect an electronic device to the internet if connectivity is available. Fortunately, Elon Musk and SpaceX are developing Starlink, a low earth orbit satellite communication network. Once it becomes fully operational in late 2021, Starlink will be able to offer internet access from virtually anywhere on the planet. Initial cost estimate for an antenna and router is $500 although estimates vary.

ILoo electronics are packaged in a removable suitcase. The 100W solar panel is mounted on the roof panel and connected to the electronic suitcase by a rugged wiring harness. The floor and

roof are dual purpose as shipping pallets. Roof, floor, walls, and vertical support posts are readily available in hardware stores.

Nearly all rural outdoor toilets are vault or pit toilets that do not separate solid and liquid waste. ILoo separates solid and liquid waste in a two-stage process. The solid waste tank is inside the main structure while an overflow liquid waste tank is located outside and connected via a flexible hose. ILoo team students discovered that ammonia is formed when feces and urine combine. Ammonia is the odor that makes portable and vault toilets smell bad. ILoo attempts to minimize that odor by separating solids and liquids for disposal or reuse (fertilizer). Until 1960, septic tank waste was a useful fertilizer in Rhode Island, but the addition of soaps, detergents and other chemicals changed the pH of the waste so that it is no longer useful.

Slide 3. What other toilets look like?

Here are some examples of pit or vault toilets that use a 'squat' method quite common and practiced in India, Africa, and Asia. Squat toilets are constructed of brick, tile, wood, metal sheeting, cement – whatever materials are available. Some are raised up on a platform; others are holes above a vault. Most use a 'sanitary platform' to guide waste into the pit hole. A 'sanplat' usually has footprints for safely positioning the feet. The sanplat might have a flapper valve to close off the pit or it might be open. They are made of ceramic, tile, or cement. Water is used to cleanse the anal area, so most floors are constantly wet. Pit toilets may have a door or not. They are about 4-feet wide and deep with walls at least 72 inches high with a roof. But always there is water. Recently, the western style of 'sitting' toilet is becoming more popular. A challenge is to provide both methods is a safe, rugged, stable platform. Stability is extremely critical.

Slide 4. UCONN Engineering Teams and Personnel

ILoo is a complex mechanical, structural, electronic, and environmental engineering project. To meet that challenge, UCONN formed a super-team from three engineering departments – electrical and computer, management, and engineering for manufacturing, and civil environmental. Teams consist of 3 -4 students with a faculty advisor and a teaching assistant assigned. Each team has a lead engineer. Students meet weekly or bi-weekly and use Google Drive to store and share documents, reports, and analyses. Teams meet either individually with the sponsor, Rick Davids, or jointly in a system level design review. Student majors include waste management, hydrology, renewable energy, structural analysis, business, marketing, circuit design, power, and storage technology.

Slide 5. Basic Structure Description

The structure is built from oriented strand board (OSB) lumber, pressure treated lumber, and sewer pipe. The floor and roof are pallets with six 4-inch diameter holes drilled in the corners. These holes serve as handholds for lifting and positioning the base pallet on the ground. Four-inch diameter plastic sewer pipes are inserted into the holes. Wall panels of OSB are inserted

into slots cut in the plastic sewer pipe. An alternative for OSB wall panels is heavy duty corrugated polycarbonate contingent upon price and availability. Standard 4-foot x 8-foot sheets of OSB are used for the floor, roof and wall panels with waste cuts used for the toilet box and step, if needed. The most complicated process is cutting or milling 1/2-inch-wide slots in the plastic sewer pipe to hold the OSB wall panels.

iLoo design separates the structural function from the electronic function by housing the electronics in a removable suitcase. This enables purchasing just the iLoo structure or both the structure and electronics. The solar panel is pre-mounted and wired to hook up the electronics in the field. Electronic devices are charged in a cloth shoe rack attached to an adjacent wall. The user attaches a charging cable and slips the device into the cloth pocket.

Although the squat posture is most common, it is desirable to design and incorporate a toilet box which can accommodate either a squat posture or sitting posture. To accommodate a 225 lb. person squatting requires the toilet box to be structurally sound and rigidly attached to either or both the adjacent posts or walls.

Slide 6. Squat Option.

In this plan view, we see the basic common layout of iLoo. Nominal dimensions are 4-feet wide x 7-feet long x 7-feet high. Six sewer pipe posts lock the base and roof. A hinged door is at one end opposite the toilet box which is securely fastened to the floor, walls, or posts. A step is bolted to the toilet box to assist someone stepping up onto the toilet box. A 23-inch-wide x 18-inch-high plastic drum is inside the toilet box and removed via a hinged or sliding door in one of the wall panels.

A common feature of squat toilets is the sanitary platform or sanplat. The sanplat offers a stable platform for positioning the feet. It is constructed of cement, ceramic, tile, or wood. Considering the lightweight structure of iLoo, a sanplat constructed of cement or ceramic and tile is either too heavy, slippery, and unsafe, or expensive.

An important consideration is cleanliness since water is usually used to cleanse the anal area. Thus, the sanplat must be easy to clean, solid and waterproof. One method of satisfying these objectives is to provide a removable rubber sanplat much like an automobile trunk liner or a heavy-duty rubber boot tray. It would funnel water used in a ‘flush’ toilet into the opening and contain spillage. Boot trays are readily available and cost about $10.00. A heavy-duty cargo mat trimmed to size is about $25.

Slide 7. Sit Option.

The sit configuration is nearly identical to the squat configuration except for the toilet seat or cover. Instead of a sanplat, the sit option uses a western style toilet seat. The intention is to design the toilet box to accept either a sanplat or toilet seat without major alterations. Both

the squat and sit options use a single solid waste tank connected to a liquid waste tank located outside the iLoo. A sliding or hinged door enables removing the solid waste tank for disposal.

Slide 8. Elevation View.

Slide 8 shows a notional side or elevation view of iLoo. Sewer posts support the walls and roof pallet. Posts might be differentially spaced to allow for removing the 2-foot-wide solid waste tank. The base or floor pallet might have forklift slots which should be plugged to prevent rodents and snakes from living in the base. The ceiling is high enough for someone to step up onto the toilet box. There might be a hand rail or handhold to assist in getting onto and off the toilet box. The tops of the posts might be chamfered to sit flat against the roof. Likewise, to provide for water runoff, the roof might be sloped 5 or more degrees. Roof slope requires the posts to be different lengths. A hinged door is preassembled to the door panel.

Slide 9. Full scale mockup of iLoo base pallet corner.

The floor pallet is a sandwich of OSB, and pressure treated lumber. Nominal thickness for the base is 1/2-inch thick OSB; the top plate might be 3/8-inch thick OSB. Standard 2x4x8 boards are used as risers. This depth allows for inserting the 4-inch diameter sewer pipe and securing it with silicone adhesive perhaps. Sheets of OSB are screwed to the risers in a shop and the entire base serves as a shipping pallet.

Slide 10. Sewer Pipe Post Inserted into Base Pallet Cutout.

With a ½-inch wide slot cut or milled into the side of the pipe at the appropriate height and length, the sewer pipe is inserted into the base pallet cutouts in each corner. Two cutouts are located between the corner cutouts.

Slide 11. Wall Panel Slips Into Post Pipe Slot.

Once the six pipe posts are inserted into the base, each individual wall panel can slip into the appropriate slot. A nominal 2-inch overlap should suffice to enable positioning each wall panel on the base and within each post. A total of six wall panels are needed and may be different widths. Wall panels can be secured with a thick bead of silicone adhesive. The center posts have slots 180-degrees apart; corner posts have slots 90-degrees apart.

Slide 12. Roof Pallet – Assembled Corner.

Slide 12 shows a fully assembled corner section of iLoo. The wall panel is not to scale. This mockup shows the 3-4-inch gap between the top of the wall panel and the bottom of the roof or ceiling. This gap is 360 degrees around the structure for full ventilation and light. Silicone adhesive may be applied to interfaces to lock pieces together and prevent rain from entering.

Slide 13. Side View of Assembled Corner.

Slide 13 shows another view of an assembled corner.

Slide 14. Top View of Pipe and Wall Panel.

Slide 14 shows the alignment of a wall panel inside the 4-inch diameter sewer pipe. There appears to be sufficient space to slide the wall panel back and forth to make field level adjustments. The 4-inch diameter pipe allows for at least a 2-inch adjustment.

Slide 15. Manufacturing and Estimated Material Cost.

Many of the iLoo components can be pre-assembled in a shop or factory and shipped as an assembly. For instance, the door frame and door can be preassembled. Likewise, the toilet box, step, wiring harness, roof and base pallets can be preassembled. Electronics mounted in the roof pallet should be pre-assembled and wired in a shop. The retail material cost for the structure is estimated at less than $350. Electronics might cost about the same. These estimates are for materials only and do not factor in labor for assembly, shipping, etc.

Slide 18. Challenges.

To be successful, iLoo must consider many variable like social acceptance, use of local materials, affordability, portability, sanitation, traditions, and taboos. It is extremely complex problem to satisfy so many conditions. It must consider environmental conditions, field level assembly, cultural factors, limitations of electronics in hostile environments, waste containment. These are formidable challenges.

Slide 17. WASH Feature.

A WASH feature is essential for preventing the spread of disease especially in a squat toilet. Incorporating a WASH feature into the basic structure of iLoo is a real challenge considering the dispersal of water. Locating a WASH feature inside is not feasible as locating one on the exterior is not considered feasible. Water must be drained away from the structure. Perhaps it is possible to include a WASH feature as part of the basic kit. Including WASH in a kit eliminates the need for improvising, perhaps improperly, a WASH feature.

Slide 18. Sanitary Platform.

Squat toilets are notoriously wet. Water for cleansing is within hands reach. Both feces and water must be directed by the design of the sanitary platform into the solid waste drum. One idea is to modify a rubber cargo liner. Some have 1-inch lip to contain debris which might work here. They cost about $25. Most sanplats are porcelain, ceramic, or cement. Sanplats have a complex curved depression of 6 or so inches that drop down into the pit. A removable drum that is 18 inches deep precludes this type of deep device into the removable drum zone. The challenge is to develop a low-profile sanplat that is easy to clean, automatically seals itself after cleansing, is inexpensive and available. One idea is to have a removable plastic insert under the rubber sanplat. This shallow insert fits into a keyhole in the wood toilet box and funnels waste and water into the solid waste drum.

Slide 19. Lighting Interior and Exterior.

Light is extremely important for safety in tent encampments. Everyone needs to pee or poop at night. Providing light both outside and inside reduces anxiety and accidents. iLoo can provide low wattage LED lighting both outside and inside. However, light attracts insects. The challenge is to find a color of light

or light frequency that deters insects but provides illumination for humans. The color of light must consider cultural predilections and taboos associated with light. The light performs a dual function. It provides illumination and it indicates if the battery is charged. If there is light, then the battery is charged. No light – no power charge until the battery is recharged via the solar panel.

Slide 20. Electronics.

The electronic power charging capability is a major asset in iLoo. The item of contention is the battery. Although it is sealed, the warnings on the batteries declare – 'Do not charge in a sealed container'. A suitcase or camera case would be a sealed container. The problem is with leaked hydrogen in a sealed container. If it leaks, it could cause a fire. That is why it may be best to mount electronics in the roof pallet. The UB12260 is small enough and powerful that it might be a good choice. Each weighs 18 lbs. Even if two batteries are needed, then the structure could be designed to accommodate two batteries. The other components are small enough to fit in a roof pallet, but the controller might require access to set parameters and monitor charging. The controller can be mounted to a drop-down hinged door in the roof panel. Hinged doors are used in the roof of saunas to hide a compartment for a CD player or radio.

Slide 21. Leak Proof Waste Transfer.

A major sanitary consideration is the separation of solid and liquid waste in iLoo. The combination of solid and liquid waste generates ammonia which is responsible for the foul odor. Separation minimizes that odor. Several variables contribute to the design of separation. An error proof connection is needed. The connection must enable removing the solid waste drum without spilling or leaking due to handling. One solution is to have a hard connection to the solid waste drum with an intermediate connection between the solid and liquid drums. Leak proof pvc connections are commercially available that connect to a flexible hose that hooks up to the liquid drum.