Easy Mark Tarp

EDSGN 100

Section 21

Spring 2015

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Team Tarp: Steven Crowe, Dan Piorkowski, John Jupena, Faizan Siddiquie
Mission Statement

Our goal is to design a cost effective grid layout called "The Easy Mark Tarp." Our product will be used to accurately mark a six meter by six meter grid, where holes will need to be dug so that posts for a greenhouse can be firmly anchored. The product must require little to no maintenance and be able to be easily transported and cheap to manufacture. Assuming that the people who will be using our product may not be capable of reading through instructions on how to use the product, the design must be simple and self-explanatory to use and consistently mark the correct hole position. The Easy Mark Tarp must be able to hold up against the natural conditions, such as extreme heat and rough terrain, and stand the test of time. We hope to develop a product that can be easily manufactured in developing countries where the product will be used, giving jobs to the people there as well as an easy to use and durable product.

HESE Summary

Humanitarian Engineering and Social Entrepreneurship (HESE), is an organization at Penn State, which collaborates with students and faculty to innovate practical solutions to address problems in the developing world. HESE aims to achieve the four hallmarks of sustainability: “technologically appropriate, environmentally benign, socially acceptable and economically sustainable”. It has given the opportunity to aspiring engineers to effectively work on solutions to tackle real world problems. HESE has worked on several projects, such as Wishvast, Project Prerana, in India, Biogas Digester in Nicaragua, and many more. Its current ventures include Low cost solar dryers, ceramic filter presses, and affordable greenhouses.

Our current project consists of designing user friendly and cost effective equipment, which allows a convenient and accurate layout of the markings for the construction of affordable greenhouses.

Location Research

Mozambique is located on the south east coast of Africa and stretches 1,535 miles long (2,470 km), which is almost twice the size of California. Within Mozambique there are 25 rivers that all flow into the Indian Ocean. The largest river being Zambezi, which provides access to central Africa. The climate in Mozambique is mostly warm, and has a tropical climate year round. The temperature averages at about 82 degrees Fahrenheit (28
degrees Celsius). Winters are warm for the most part and summers usually rainy and humid. During the months of June through October is usually the dry season in Mozambique.

In the country of Mozambique, 99.6% of the country is African, with the Makhuwa, Tsonga, Lomwe, and Sena making up a large portion of the group. The other small percent is made up of Europeans and Indians. Mozambique uses a multiparty republic with a single legislative house. Their President is Filipe Nyusi, who just took office in 2015. He previously served as Minister of Defense from 2008 to 2014.

The official language of Mozambique is Portuguese followed by Nyungwe. There are a total of 43 individual languages with 18 of them being vigorous languages. The interesting thing is that only 43 percent of the population of Mozambique is literate. This comes into effect because it means that the product that we create must be easy to operate, basically self-explainable so that whoever is using it can understand how it works.

Mozambique earned its freedom from Portugal in 1975. It adopted its constitution in the mid 1990s. It celebrates its national day on 25th June. Portugal trades many of its resources with Portugal Spain and Belgium. It is a member of the African Union, Commonwealth of Nations, the Community of Portuguese Language Countries, the Latin Union, Organization of Islamic Cooperation and Southern African Development Community.

The most common sources of water that is available to the people of Mozambique are the 104 river basins, two lakes, and groundwater. Groundwater is utilized on a large scale in a number of urban areas for drinking water supply, whereas in the rural areas throughout the country rely on hand pump-mounted boreholes and shallow wells. The main consumer of water is agriculture, accounting for 550 million m³ or 87 percent of the water used in Mozambique. The greenhouses that we are making should reduce this percentage, leaving more water for the people of the country.

Since 1992, Mozambique has made impressive improvements in restoring food production. The country is virtually self-sufficient in terms of food grain production, with the exception of wheat and rice. However, food availability is often stunted because of natural disasters such as floods and droughts. The private farms account for about 95 percent of the area under production and produces almost all the food crops, such as maize, cassava, rice and beans; however, they often have a hard time producing this because of the lack of technology, like powered farm equipment. Small and medium private companies represent the commercial sub-sector. They provide jobs to the people and are often more productive because they have the needed equipment. One competitive product in Mozambique is oil. Over the next few years, new refineries are expected to be built in Mozambique and they will sell more of it.
Healthcare in Mozambique isn’t the easiest thing to get your hands on, even if all of its international and national commitments to health spending are met. Mozambique still needs an extra $35.2 USD per person per year to ensure that all of the population has access to basic healthcare. Many of the health services available to the citizens are paid out of pocket. Mozambique is actually ranked at 184 out of 187 nations on the UN’s Human Development Index. 48% of the population is malnourished, two thirds of the population is illiterate, and 55% of women give birth in health institutions.

Its leading industries are aluminum, petroleum products, chemicals (fertilizer, soap, paint), textiles, cement, glass, asbestos, and tobacco. Imports are machinery and equipment, vehicles, fuel, chemicals, metal products, textiles. Its export commodities are aluminum, prawns, cashews, cotton, sugar, citrus, timber, and bulk electricity. Its main agriculture products are cotton, cashew nuts, sugarcane, tea, cassava, corn, coconuts, sisal, tropical fruits, potatoes, sunflowers, beef and poultry. Many of these agriculture products mentioned could be grown in the greenhouse that we are helping to create.

Selection Matrices

Right from the beginning, we all had an idea of a tarp like design that would easily be laid out on the ground. From there we had to think of other designs that could possibly cheaper, more efficient, or easier to use. The only other idea that we came up with was 8, 1.5m. planks hinged together to make an L like shape with edges of lengths 6m. that could easily be folded up to a 1.5m block. This design was far more complex and required many more slight details (such as how to make 90degree angles or mark the center 4 holes); however, it could be done. Using these two ideas, we put them into the 2 matrices shown below (table 1 and table 2). These matrices helped us decide which of the two options would be a better prototype to start with. Table 1 compares the two ideas to a reference, which is using string and measuring tapes to find where the posts are supposed to go. Using the criteria, we had to determine whether our ideas were better or worse than the reference. Table 2 adds a weight to the categories. This gives a more accurate representation of how much better one idea is than the other because certain criteria are more important than others, and it is important that our prototype addresses these criteria the most. Adding up the total weighted scores show how much better (or worse) our ideas are, compared to the reference.
Table 1 shows criteria for selecting a design for prototype 1.

**Table 1**

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>A (ref)</th>
<th>B Tarp</th>
<th>C Hinged Planks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Less than 10 minutes to assemble</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Durability</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Less than $50</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Portable</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sum +’s</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sum 0’ s</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum -’ s</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Net Score</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Rank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continue?</td>
<td>Yes</td>
<td></td>
<td>Possibly</td>
</tr>
</tbody>
</table>

Note: From this perspective, it seems as though the tarp is the better idea and that the hinged planks will be our second option for an idea.

Table 2 shows testing criteria for selecting a design for prototype 1.

**Table 2**

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Weight (%)</th>
<th>Rating</th>
<th>Weighted Score</th>
<th>Rating</th>
<th>Weighted Score</th>
<th>Rating</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use</td>
<td>35%</td>
<td>3</td>
<td>1.05</td>
<td>4</td>
<td>1.4</td>
<td>3</td>
<td>1.05</td>
</tr>
<tr>
<td>Less than 10 minutes to assemble</td>
<td>5%</td>
<td>3</td>
<td>0.15</td>
<td>4</td>
<td>0.2</td>
<td>4</td>
<td>0.2</td>
</tr>
<tr>
<td>Durability</td>
<td>17.5%</td>
<td>3</td>
<td>0.525</td>
<td>4</td>
<td>0.7</td>
<td>4</td>
<td>0.7</td>
</tr>
<tr>
<td>Less than $50</td>
<td>25%</td>
<td>3</td>
<td>0.75</td>
<td>3</td>
<td>0.75</td>
<td>3</td>
<td>0.75</td>
</tr>
<tr>
<td>Portable</td>
<td>17.5%</td>
<td>3</td>
<td>0.525</td>
<td>4</td>
<td>0.7</td>
<td>2</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Total Score: 3, 3.75, 3.05

Rank: #3, #1, #2

Continue? No Yes Most likely not

Notes: The tarp scored much higher than the others, so our plan is to use that as our main design and see if there
Prototype Planning, Fabrication, and Testing

- Prototype 1

After deciding that we were going to proceed with the tarp idea from help with the matrices, it was time to move on to the next step. Before we could go and start working on assembling our prototype, we had to decide what materials we were going to build it out of. This was possibly one of the most important and time-consuming steps. We had to find a material that could cover an area of 6.5m. x 6.5m. (we needed a little extra material on the ends) that wouldn’t go over our budget of $50. Furthermore, we had to find a material that would be either accessible to people in Mozambique or cheap to ship to them, meaning that it would have to be light. The final criterion for the material was that it was going to have to be durable. It was hard to combine all these criteria and come up with a material, but we did our best and decided to buy a 10ft. x 25ft. roll of 3.5mm. plastic sheeting. Our plan was to scale the prototype down from a 6m. x 6m. to a 6ft. x 6ft. model. And with all of these criteria in mind and the materials in our possession, we began to assemble the first prototype.

The goal that HESE gave us was that they wanted a simple, easy-to-use gridding pattern to quickly mark where the 16 posts were going to be dug in under 10 minutes with a budget of only $50. It also had to be rugged for the rough terrain and portable for workers to be able to carry it miles to remote villages. Due to this we decided to test our prototype exactly against their criteria along with some criteria of our own. Below, Table 3 shows a table of the testing that we were going to put our prototype through, what it would need to pass the test, and materials needed to run the tests. Our idea was to ask someone, who did not know what the product was, to use it and mark where the holes were supposed to go with only simple verbal instructions. We tested to see if they were able to do this under 10 minutes and how accurate the placement of the holes were (a criteria that HESE did not specify, but to us seemed to be fairly important). Then we did two separate tests to analyze the durability and portability.
Table 3

Prototype 1 Testing Plan - Worksheet
EDSGN 100

Team Name: Team Tarp
Project Name: The Easy Mark Tarp

Date: 2/17/15

<table>
<thead>
<tr>
<th>User Need / Feature / Requirement</th>
<th>Describe Test</th>
<th>What is “pass”?</th>
<th>Materials / tools needed to run tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use</td>
<td>Give it to someone not in our group with simple instructions and see if they are able to use it correctly.</td>
<td>The test passes if the person is able to understand the instructions and do it by themselves with little to no difficulty.</td>
<td>The completed prototype with instructions, a marker, a surface that can be marked, as well as a willing person to use the product.</td>
</tr>
<tr>
<td>Less than 10 minutes to assemble</td>
<td>In the previous test, see if the person is able to mark of the 16 holes in less than 10 minutes with only the simple instructions given.</td>
<td>The test passes if the person above is able to complete the task under 10 minutes.</td>
<td>The same materials as above but also including a stop watch.</td>
</tr>
<tr>
<td>Durability</td>
<td>We could put the tarp through pull testing to see if it could withstand stretching. We could also put a weight on the top if it and pull it through rugged terrain to simulate the extensive wear and tear the product will be undergoing.</td>
<td>The test passes if both the tarp does not stretch or break from a substantial about amount of force pulling on it and if it retains little to no damage from being dragged across a rugged surface.</td>
<td>Scales to see how much force the people are pulling on the tarp before it breaks and a weight to place on the tarp.</td>
</tr>
<tr>
<td>Less than $50</td>
<td>Gather a list of materials that will need to be used and calculate an estimated price.</td>
<td>The test passes if the list of materials costs less than $50.</td>
<td>A list of materials and access to a hardware store or the internet.</td>
</tr>
<tr>
<td>Portability</td>
<td>We would have to weigh the final product and see if it is light enough to be able to be carried for miles and if it can easily fit in a backpack.</td>
<td>The test passes if the final product weighs 30 lbs or less and fits in a backpack.</td>
<td>A scale and a backpack.</td>
</tr>
<tr>
<td>Accuracy in placing the 16 holes for the posts</td>
<td>Place the tarp on a surface that can be marked and put a mark in each of the 16 holes on the tarp.</td>
<td>The test passes if the holes are no more than 5cm away from where they should be if the prototype were scaled up to full size.</td>
<td>Paper to be marked, a marker to mark the holes, and measuring tape.</td>
</tr>
</tbody>
</table>

Table 3 shows criteria for testing prototype 1.
Below is a detailed explanation of Table 3:

**Easy to use test:** To test if our product was easy enough to use without specific instructions we gave our prototype to someone not in our group and just told them what our product was used for. We then observed them on how they would use the product without being told how. The test passed without difficulty and the student had no problem figuring out exactly how our product was intended to be used. The results of this test proved that our design was simple enough that the people of developing countries wouldn’t have a problem using our product, even if they are not capable of reading instructions.

**Less than 10 min:** to test that our product could be assembled and ready to start marking in less than 10 minutes we timed the same person from the last test as he removed the product from a backpack laid the tarp down and marked where the holes needed to be. The holes were marked and the tarp was returned back into the backpack in only 1 minute and 40 seconds, which was even less time than we had anticipated. This test gave us confidence that the time it would take for the holes to be marked would not be a problem.

**Durability:** to test the durability of our product we performed two separate tests. First we took our prototype outside and laid it on a rough surface and walked on top of the tarp repeatedly and observed how the tarp held up. We noticed that small rocks and sticks were piercing the plastic tarp and damaging our product. This came at a bit of a surprise to us because we thought that the tarp would hold up better against the elements. The second durability test we performed was to place weights on top of the tarp and drag it across the floor and observe how the tarp held up. We noticed that after a few times dragging the tarp the plastic began to stretch and become inaccurate over time. We hadn’t thought of the possibility of the plastic stretching over time before this test and the results showed us that we had a serious flaw in our first prototype.

**Less than 50$:** to test that our product would cost less than 50$ to manufacture we simply made a list of all the materials we used and the cost of each. We paid 10$ for 50 foot long roll of “Weed Block” ($0.20 per foot), and 10$ for a pack of 50 brass grommets ($0.20 per grommet). This proved that our product would cost well under 50$.

**Portability:** To test the portability of our product we weighed our prototype to make sure it wasn’t much of a hassle to transport the tarp from work site to work site. The prototype weighed in at less than 3 lbs. and could easily be folded up and put into a backpack for easy transportation.
**Accuracy:** accuracy was the most important aspect of our product. After all if the product didn’t consistently mark where holes needed to be dug the product would be useless. To test the accuracy of our product we laid the tarp down and marked where the 16 holes needed to be and then measured the distance between the marks to ensure that the markings were accurate. We preformed this test after every test we preformed to make sure that the tarp marked the correct position consistently and the other tests we put our prototype through didn’t affect the accuracy of our product. The tarp accurately marked where the holes were needed time and time again and proved that our product would work consistently and accurately.

- **Prototype 2**

After much testing and thought of our first prototype we realized our design could be improved. We put our first prototype through many different test to test the durability of our product. By doing this we learned that the area around the holes we cut would be the area that would take the most abuse from poking at it or walking on top of the tarp. By preforming test such as laying the tarp on a rough surface and repeatedly walking on top of the tarp we learned that things like sticks and small rocks were likely to pierce through and damage the plastic tarp material we used for our first prototype. Also we performed a durability test by placing weights on top of the tarp and dragging it across the floor. We then realized that the plastic material was likely to stretch over time and could possibly become inaccurate. We kept these results in mind while designing our second prototype and decided to change the material we used for our tarp.

After researching many different materials we could use we decided on using a product called “Weed Block” for our main material for the tarp. “Weed Block” is a cloth like material that is designed to be laid on the ground under mulch to prevent weeds from coming into your garden. Since the Weed Block material is designed to be used on the ground it provides the durability we needed and things like sticks and rocks were much less likely to damage our product and the cloth like material is much less likely to stretch over time as well. In order to better support the area around the holes that would be taking the most abuse we researched many different materials to put around the holes to strengthen it such as things like plastidip, and duct tape. We finally decided to use brass grommets to cover the circumference of the holes. The grommets provided a strong ring around the holes that protected our product from the abuse it would be
taking. By putting our prototypes through many test and keeping those results in mind while designing our second prototype we are confident that we have created a durable product that will stand the test of time.
Lesson Learned:

Constant use and from being placed on the ground, the largest concern with the tarp is durability. Because of this, if we had a prototype 3, we would sew the edges of our tarp in order to keep it from fraying. Also, there are different thicknesses available for the material we used for the tarp. For prototype 3, we would experiment with thicker material. Also, we would create a packing design. Right now the tarp is folded up randomly. If a packing system was created, it would ensure reduction of accidental damages (exposure to sharp objects, etc.).

If a prototype 3 was required, it wouldn’t be an issue because each person in the group contributed evenly and worked well together. We all had appropriate machine shop skills, which helped us work efficiently and not waste time. Also, our research skills helped us find appropriate materials at a low price. We all contributed ideas for prototypes, and all ideas were considered and evaluated. The best idea was chosen by consensus.

The budget was limited which initially gave us a tough time. We struggled generating ideas and couldn’t decide which would work best. While we were thinking of ideas, other teams began working and we started to get more frustrated. The initial prototyping matrix confused us and we were unsure of what tests to conduct.

There were also things that we believed could improve the project. For example, the representative from HESE could have been more elaborate when explaining the project. From the very beginning we were completely confused on what we were supposed to be making until we asked on the second day of the project. If HESE had an FAQ section on their website related to the topic, it would be a lot easier to comprehend the project.
References:

11. http://www.reuters.com/article/2013/02/21/africa-oilproducts-idUSL6N0BJ9XX20130221