To: Dr. Trevas and GTA

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Subject: ERs and TPs Revamp Memo

The Rural Food Processing capstone project for the 2019-2020 academic year includes creating a roller and dispenser system that prepares the dish Ekwang faster than the current, traditional method. The client is mostly interested in the design package so that the design can be replicated in Africa by local craftsmen. There were not major changes to the requirements last semester, but small adjustments were made and are highlighted in this memo, along with Testing Procedures the team will follow in order to prove the requirements.

1 Customer Requirements (CRs)

The customer requirements for this project originate from Isaac Zama, who is a humanitarian rather than an engineer. Because he is not an engineer, he had a different outlook on the project which contributed greatly to the project. Current Customer Requirements include reliability, durability, lightweight, safe to use, simplicity, low cost, easy to use by anyone, mobility, and faster than hand rolling. Between the Preliminary Report and now, the only changes to the CRs is that "adjustable dispensing" was removed and "easy to use by anyone" was added. This was based on feedback from the client. The client's original intent for adjustable dispensing was discarded in favor of a system that is more standardized with every use. The easy to use by anyone requirement was added after discussions with the client and his emphasis that the design is intended to be used with a wide range of ages and individuals of different backgrounds as well as purpose for the machine (at home use vs. commercial use).

2 Engineering Requirements (ERs)

2.1 ER #1: Low Weight

2.1.1 ER #1: Low Weight Target = 7kg

The target for this requirement was determined based on the client's intent of the device being easy to carry for even children in a village. The team thought of what a realistic weight maximum would be given the anticipated size of the design and what is realistic for a child of around ten years old would easily be able to carry.

2.1.2 ER #1: Low Weight Tolerance = Less than 10kg

The team determined that the requirement necessitated a strictly "less than" tolerance because the goal is to keep the weight as low as possible. By providing a 3kg buffer above the target weight, this allowed for changes in materials to the design, if certain components were deemed to need to be made out of heavier, more durable materials.

2.2 ER #2: (changed from fall) Base Footprint

2.2.1 ER #2: Base Footprint - Target = 0.5m²

The target value of this requirement was determined based on the client's desire for mobility. The team interpreted mobility to translate to a small device, which also reduces weight as a result. The team originally anticipated only needing a target value of $0.125m^2$, but this proved to be too small for the project once a demonstration was held and the prototypes were created

2.2.2 ER #2: Base Footprint - Tolerance = less than 0.625m²

The team determined the tolerance should be a strictly less than relationship because the smallest possible design is ideal in order to meet the CR of mobility and low weight.

2.3 ER #3: Low Price

2.3.1 ER #3: Low Price - Target = $35.00

The team took the upper end of the target price of the design by the client and determined that this target price would be ideal to achieve or even stay under for the final product.

2.3.2 ER #3: Low Price - Tolerance = Less than $45.00

$45.00 was the target dollar amount set by the client for the device. The team determined success can be determined in this requirement by staying under the amount set by the client.

2.4 ER #4: (changed from fall) Minimize time to produce one roll

2.4.1 ER #4: Minimize time to produce one roll - Target = 20 seconds

The team determined based on research and demonstration that the entire process for dispensing and rolling one Ekwang would be reduced to 30 seconds or less in order to be faster than the hand rolling process. If it can consistently roll to this target, it will also prove the system's reliability.

2.4.2 ER #4: Minimize time to produce one roll - Tolerance = Less than 45 seconds

The team originally had a tolerance set to less than 60 seconds, but it was determined that this should be lowered to ensure that the final design has a more significant impact on the time for the process.

2.5 ER #5: Factor of Safety

2.5.1 ER #5: Factor of Safety - Target = 3

One of the customer requirements for the project is that the system is safe to use because of the variability in the age and skill of those operating the device. The team determined a factor of safety of 3 is reasonable for the system because it does not involve sharp parts nor parts that will operate independently of the operator's direct, manual input.

2.5.2 ER #5: Factor of Safety - Tolerance = Greater than 3

The team determined that the factor of safety should be only greater than 3 and not less because of the safety requirement. A factor of safety approaching 1 or less than 1 would create potential hazards to the user and/or a decrease in the reliability and durability of the design.

2.6 ER #6: (changed from fall) Smooth Edges

2.6.1 ER #6: Smooth Edges - Target = Radius = 5mm

The customer requirement for safety drove this requirement. The team determined that one way to ensure safety is to prevent injury. This was interpreted in one way as preventing injury in the form of cuts, which the requirement is designed to accomplish.

2.6.2 ER #6: Smooth Edges - Tolerance = +/- 2.5mm radius

The team determined that edges within a +/- 2.5mm radius is more reasonable of a tolerance than the original tolerance set during the fall. If edges are more rounded than this, that would also be acceptable, but the team would ideally remain in this range to ensure material is not unnecessarily wasted trying to achieve overly rounded edges.

2.7 ER #7: Low Center of Gravity

2.7.1 ER #7: Low Center of Gravity - Target = z-direction height in lower 1/3 total height at rest

The customer requirement for reliability helped to drive this requirement. The team interpreted this through having a stable device, which can be partially achieved through a low center of gravity. The target was determined by determining a reasonable z-direction value, as the x-direction and y-direction should be centered due to the symmetry of the device.

2.7.2 ER #7: Low Center of Gravity - Target = z-direction height in lower 1/2 total height at rest

The team determined that as long as the center of gravity is located in the lower half of the design, this would be acceptable to meeting the requirement, although lower than this is desired.

3 Testing Procedures (TPs)

Tests will be run on the device to evaluate the designs ability to meet the engineering requirements. Test for each requirement was formulated to test the ability of the design to adhere to the tolerances specified. Test such as drop, smooth edges, and roll production or are hands on while software analysis test were completed using computer software. The description of the test a long with the resources need for each are provided below.

3.1 Testing Procedure 1: Roll Production Time

In the Roll Production test, the engineering requirement of rolling one roll in 30 seconds or less will be evaluated. Using the final prototype, the team will use volunteers that have little instruction to see how long it takes them to produce one roll. The uneducated volunteers will represent children first learning how to use the device. This test will take place after the final assembly and drop test of the team's device.

3.1.1 Testing Procedure 1: Objective

After final assembly has been completed, a set of ten volunteers will be gathered. The volunteers will be given brief instruction on how to use the device. Cocoyam leaves will be prepared ahead of time with the cocoyam paste spread to the correct dimensions. Each volunteer will be handed the prepared leaf and asked to roll it using the device. The timer will be started once the volunteer is handed the leaf and stopped once the roll is completed and in the divot in the roller base. If the volunteer completes a roll in under 30 seconds the test is passed any time over 30 seconds the test is failed. If the test is failed the user will be given additional instruction. If the test is still failed the areas of inefficacy will be reviewed. This test uses time to test the ability of the user to quickly learn and operate the device.

3.1.2 Testing Procedure 1: Resources Required

Table 1: Resources for Test 1

Resources	Description	Obtain Resource
People	Volunteers varying in age	Free, voluntary participants
Timer	Stopwatch to measure time to roll	Free, phone timer
Cocoyam Paste	Grated cocoyam and spice mixture	Buy, specialty market
Device	Device completely assembled	Buy, the final product
Location	Any available space	Free, public space

3.1.3 Testing Procedure 1: Schedule

Each test will take roughly one minute. If addition instruction is need it make take up to three minutes. This test will be conducted after the edge test and final assembly. The team plans to run this test during week six of the semester.

3.2 Testing Procedure 2: Drop Test

A drop test will be performed to evaluate the strength of the design and the design's durability. Testing will consist of pushing off or dropping the device from a surface approximately 0.5m high. The distance is representative of the carrying height of a person. Running this test after complete assembly and the smooth edge test allows the team to test the device under more accurate conditions. Running the test before the edge test may subject the device to higher stress concentrations on any surface that is not radiused. If deformation does occur during the drop test the edge test will be performed again after the surfaces are refinished.

3.2.1 Testing Procedure 2: Objective

To start the test the device will be placed on a countertop approximately one meter from the ground. A team member will then push the device of the edge of the counter causing the device to impact the ground. After the device impacts the ground it will be checked for deformation. If the device has any broken parts or deformation that causes the device not to function the test is failed. If little or no deformation occurs the test is passed. This test will be performed on both the roller and dispenser since they are both subject to being dropped. After the devices passes that section of the test a team member will hold the device with their arms parallel to the ground and drop the devices. Using the criteria from above the devices with be given a pass or fail. If the devices do not pass either portion of the test a redesign of the part will be conducted to increase the parts strength. The drop test is testing the strength of the device along with its resistance to deformation. The test does this by subjecting the device to similar amount of force the device may see in use or if dropped.

3.2.2 Testing Procedure 2: Resources Required

Table 2: Resources for Test 2

Resources	Description	Obtain Resource
People	Team Members	Free, self
Countertop	Approximately one meter high	Free, at home/98C
Device	Device completely assembled	Buy, the final product components
Location	Any available space	Free, at home/98C

3.2.3 Testing Procedure 2: Schedule

This test will take approximately ten minutes to complete. If the device fails it will take longer since repairs may be needed along with retesting. The team will complete this test after the edge test to reduce stress concentration on the edges. The edge test and full assembly must be completed before this test can take place. This test is scheduled to be completed during week eight.

3.3 Testing Procedure 3: Stability Test

The stability test will test the ability of the team's design to resist tipping over. Forces will be applied at predetermined locations on the device to see if the design falls over or is stable. The engineering requirement being tested is a low center of gravity. If the device has a low center of gravity it will not tip over with average size forces being applied. This test will be run first using SolidWorks to find the actual center of gravity and then in person after the drop test.

3.3.1 Testing Procedure 3: Objective

The first portion of this test will be to use SolidWorks to find the actual center of gravity of the device. The center of gravity will only be tested on the roller. Once the center is located a force will be applied to the top, bottom and middle of the roller as separate portions of the test. If the device tips over on any portion of this test the test is failed. If it stays up right the device passes the test. If failed the device will be redesigned in SolidWorks to lower the center of gravity. The amount of forced being applied will be measured by a pull gauge. The force will increase in increments of five pounds until 20 pounds is reached. Using this test quickly evaluates if the center of gravity is in the correct position to prevent any malfunctions while in use.

3.3.2 Testing Procedure 3: Resources Required

Table 3: Resources for Test 3

Resources	Description	Obtain Resource
People	Team members	Free, self
Pull Gauge	Gauge that can measure up to 20lbs	Borrow, from professor
Device	Device completely assembled	Buy, the final product
Location	Any available space	Free, 98C

3.3.3 Testing Procedure 3: Schedule

This test will take approximately ten minutes per device. Since the force will be applied multiple times in multiple locations it will take longer than the previous test. This test will be completed after all the other test since they may cause major design changes. The team has decided to test this during week eight.

3.4 Testing Procedure 4: Analysis Software Test

For the engineering requirements that can be validated with numerical values that either meet or fail to meet our goal values, software will be used. The engineering requirements being tested using software are factor of safety, mass (low weight), footprint, and cost. Using the properties tab in SolidWorks along with excel files specific to factor of safety and costing the requirements will be tested. The test will be evaluated on a pass or fail system.

3.4.1 Testing Procedure 4: Objective

The first portion of this test will be run using the properties tab in the SolidWorks files. Each of the engineering requirements has an acceptable value such as a mass less than seven kilograms and footprint under $0.5m^2$. The test will consist of comparing the goal values to the values in the properties tab. If the value is less than the desired the system passes if it is higher the system fails. If a part fails it will be redesigned to meet the desired value. For the excel portion of the test, a spreadsheet created to measure the factor of safety along with the bill of materials will be used. The requirements being tested for this portion are a factory of safety of the fasteners, and a total cost within the target range. The desired fastener's specification will be inputted in to excel spreadsheet where factor of safety is calculated. Using the bill of material and values from the properties tab in SolidWorks a total amount of material needed will be calculated multiplied by the cost of the material. For either to pass this portion of the test the must meet or exceed the factor of safety and be under the desired dollar amount. If they fail the test they will be redesigned and tested again.

3.4.2 Testing Procedure 4: Resources Required

Table 4: Resources for Test 4

Resources	Description	Obtain Resource
People	Team members	Free, self
Software	SolidWorks	Free, access on NAU computers/VPN
Software	Excel for factor of safety of fasteners, BOM	Free, access from Microsoft Excel
Device	SolidWorks Model	Free, created on NAU purchased software
Location	Any available space	Free, EGR building/anywhere on VPN

3.4.3 1.1.3 Testing Procedure 4: Schedule

This test will take approximately ten minutes with the largest amount of time being spent on the cost analysis. This test will not be run second semester but has already been completed during the first semester. This test was done first since it is critical in meeting many of the engineering requirements along with having the most effect on the overall design. The approximate date for this test is by the end of week six.

3.5 Testing Procedure 5: Smooth Edges

This test will verify that all edges of the device are smooth and will not cause any harm to the user. The engineering requirement being tested is smooth edges. The first portion of this test will be reviewing the SolidWorks files and making sure all fillets are within the determined acceptable range. Then using an inflated balloon, a team member will move the balloon across all the prototypes surfaces to see if it pops. This test will be completed after the final prototype is built.

3.5.1 Testing Procedure 5: Objective

After reviewing the SolidWorks part files, a balloon will be inflated to the point just before popping to allow for extra sensitivity. The inflated balloon will then be dragged across all surfaces and edges testing for smoothness. If the balloon pops the test is failed. If a part fails the test, it will be resurfaced so all edges will be sanded down to an acceptable range. After resurfacing, the test will be performed until all surfaces pass. This test is testing the smoothness of the edges and how safe the device is to use. This test simulates a user coming in contact will the surfaces of the design with the balloon popping being correlated with harm to the user.

3.5.2 Testing Procedure 5: Resources Required

Table 5: Resources for Test 5

Resources	**Description**	**Obtain Resource**
People	Team members	Free, self
Balloon	Party balloon style not water balloons	Buy, local store/Free, leftover from member
Device	Device disassembled so all surfaces are testable	Buy, the final product components
Location	Any available space	Free, at home/98C

3.5.3 Testing Procedure 5: Schedule

This test can take from a couple minutes to an hour if the device fails and need to be taken to the machine shop. The team will run this test once all the parts are manufactured. This test will be run at the beginning of week seven.

3.6 Testing Procedure 6: Dimension Test

This test will evaluate the dimensional parameters set by the engineering requirements. The parameters being evaluated for this test are weight and the base footprint. Since these factors directly impact each other, it is best to evaluate them at the same time.

3.6.1 Testing Procedure 6: Objective

Testing for these parameters will be done by inspection using SolidWorks. Using the final SolidWorks model the properties will be inspected for both a plastic and wood version. For the design to past it must fall within the tolerance for both materials. If the design does not fall within the tolerances the design will be modified to meet the tolerance set previously. It will also be determined by inspection using the prototype and final product.

3.6.2 Testing Procedure 6: Resources Required

Table 6: Resources for Test 6

Resources	Description	Obtain Resource
People	Team members	Free, self
Software	SolidWorks	Free, NAU computers
Device	Device disassembled so all surfaces are testable	Buy, the final product components
Scale	Basic scale	Free, member has resource
Ruler	Basic meter stick	Free, available through NAU resources
Location	Any available space	Free, Engineering building

3.6.3 Testing Procedure 6: Schedule

This test was partially conducted last semester once the final CAD package was completed. The test will be run again once the modifications to the CAD model are made. Physical measurements will also be made once final modifications are made to the device. This test will be run by the end of week six.