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Subj: ERs and TPs Revamp Memo

The Aneuvas bench team is tasked with the design and construction of a medical bench to be used in the Wettaw Biology building. This bench will provide assistance in tests that will be conducted by Dr. Becker and his team. The budget has been increased from the $1000 limit set last semester. A drainage component was also added to the design to assist in unwanted buildup of fluid.

1 Customer Requirements (CRs)

The customer requirements were gathered from the client description and the many meetings had with the client over the last semester. The following table shows those customer requirements.

Table 1: Customer Requirements

Customer Requirement	**Weight (9/3/1)**
Durable and Robust Design	9
Reliable Design	9
Safe to Operate	9
Maneuverability	9
Cost within Budget	3
Aesthetically Pleasing	1
Multipurpose Design	3
Lightweight Design	3
Shock Absorption	9
Adequate Storage Space	3
Adequate Drainage	3

In terms of customer requirements, two things have changed. One of the things that has changed since the Preliminary report from ME 476C is the fact that the budget could go over the $1000 the team was given. This is because the client does not want to compromise any of the components, considering the expensive technology that will utilize the portable bench. Also, an adequate drainage solution was added

in, which wasn't a concern for the client last semester.

2 Engineering Requirements (ERs)

The following table illustrates the overall engineering requirements for the portable bench, which were compiled from transforming customer requirements into engineering requirements that could be measured. Changes that have been made to this section include the liquid drainage.

Table 2: Engineering Requirements

Engineering Requirement	Units	Target Value	Tolerance
Cost	$	1000	+/- 100
Weight	Lb.	100	+/- 10
Fitting Through Doorway	ft^2	7.5	+/- .1
Tabletop Yield Strength	psi	5	+/- 1
Effective shock absorption	in/s^2	5	+/- 5
Tabletop Deflection	in	0.25	+/- .05
Tabletop Thickness	in	1.00	+/- 0.10
Bench Height	in	36.00	+/- 0.10
Storage Volume	Ft^3	5	+/- 1
Temperature resistance	°F	50	+/- 50
Liquid Drained	%	80	+/- 10

2.1 ER #1: Cost

2.1.1 ER #1: Cost - Target = Cost around $1000

The target value for the cost of the project was set at $1000 by the client. This is important for delivering a quality product for the client while also utilizing the full budget allotted to us.

2.1.2 ER #1: Cost - Tolerance = +/- $100

Based on discussions with the client, approval could be granted to go over budget if needed. This is due to the client wanting a quality product and not wanting to be limited to the original budget.

2.2 ER #2: Overall Weight

2.2.1 ER #2: Weight - Target = 100 lbs.

This target value was created for the client to easily be able to transverse the portable bench with one person. This weight signifies the force the tabletop and metal frame will need to account for.

2.2.2 ER #2: Weight - Tolerance = +/- 10 lbs.

The tolerance for the weight was selected based off of the added force the bench may experience wile being in motion and added equipment that may be added to it.

2.3 ER #3: Fitting Through Doorway

2.3.1 ER #3: Cross-sectional Area - Target = 7.5 ft^2

This ER was set because the bench would need to both fit through a doorway horizontally and vertically. The team was given a maximum height of three feet and a maximum width of two and a half feet.

2.3.2 ER #3: Cross-sectional Area - Tolerance = +/- .1 ft^2

The tolerance was selected due to having almost no wiggle room. Ideally, the target would either be met or would be less.

2.4 ER #4: Tabletop Yield Strength

2.4.1 ER #4: Tabletop Yield Strength - Target = 5 psi

This was determined based on the cross-sectional area of the tabletop and the amount of weight that the tabletop would need to support. This also considers a factor of safety.

2.4.2 ER #4: Tabletop Yield Strength - Tolerance = +/- 1 psi

The tolerance was selected with the tabletop material in mind. With the change from oak to Formica, the team needed to rework the calculations for the tabletop's yield strength. This tolerance will include the weight of the clean room hood and the addition of other equipment.

2.5 ER #5: Effective Shock Absorption

2.5.1 ER #5: Shock Absorption - Target = 5 in/s^2

The shock absorption engineering requirement was created in response to the wheels of the bench. Our client, Dr. Becker, emphasized that the bench needed to be able to move over small obstructions that are found in the path of the bench in transport.

2.5.2 ER #5: Shock Absorption - Tolerance = +/- 5 in/s^2

2.5.3 The tolerance for the wheels was selected in the interest of having confidence that the bench can be transported effectively without any damage being induced on the equipment the bench is carrying.

2.6 ER #6: Tabletop Deflection

2.6.1 ER #6: Tabletop Deflection - Target = 0.25 in.

The deflection of the tabletop was calculated based on the material the team selected. This deflection accounts for how the tabletop may deform when the forces are introduced to it without breaking occurring.

2.6.2 ER #6: Tabletop Deflection - Tolerance = +/- 0.05 in.

This tolerance was measured to ensure the maximum amount of deflection the table can withstand to stay within a reasonable amount of factor of safety.

2.7 ER #7: Tabletop Thickness

2.7.1 ER #7: Tabletop Thickness - Target = 1.00 in.

The thickness of the tabletop was chosen `to the specifications of our client, Dr. Becker. Dr. Becker believed a thickness of 1in would be best for the tabletop.

2.7.2 ER #7: Tabletop Thickness - Tolerance = +/- 0.10 in.

The tolerance for the tabletop thickness was calculated to ensure the bench was within the range Dr. Becker preferred but was also strong enough to support the equipment used in testing.

2.8 ER #8: Bench Height

2.8.1 ER #8: Bench Height - Target = 36.00 in.

The bench height was a set range given to the team. The bench could not exceed a height that would prevent it from traveling through doors with the clean room hood on while also providing leg room for someone working with the bench to be used as a desk.

2.8.2 ER #8: Bench Height - Tolerance = +/- 0.10 in.

Considering the set parameters of the bench height, the tolerance was selected at a small value to ensure the travel capacity of the bench was kept.

2.9 ER #9: Storage Volume

2.9.1 ER #9: Storage Volume - Target = 5 ft^3

The storage space was calculated due to the specifications provided by Dr. Becker. Dr. Becker articulated that having a storage space added to the bench that could hold some equipment and office supplies would be beneficial. The team decided on the volume with the size of the equipment in mind.

2.9.2 ER #9: Storage Volume - Tolerance = +/- 1 ft^3

The tolerance of the storage was decided in order to provide the space needed but to not reduce the space under the bench that would account for leg room if the bench was being used as a desk.

2.10 ER #10: Temperature Resistance

2.10.1 ER #10: Temperature Resistance - Target = 50°F

The temperature resistance was calculated with the ambient temperature and temperature of fluids used during the experiments conducted by Dr. Becker and his team.

2.10.2 ER #10: Temperature Resistance - Tolerance = +/- 50°F

The tolerance for the temperature was decided to ensure the materials selected in the design of the bench would be able to withstand a drastic change in temperature and remain in tact.

2.11 ER #11: Liquid Drained

2.11.1 ER #11: Liquid Drained - Target = 80%

This engineering requirement was recently added. Dr. Becker suggested that our team should add a

drainage component to the bench. Our team responded by designing a trough component to the side. Our team decided that by reducing 80% of the maximum spills that occur, Dr. Becker would be satisfied and able to continue his work.

2.11.2 ER #11: Liquid Drained - Tolerance = +/- 10%

A tolerance of 10% was decided because if our team can eliminate at least 70 percent of spillage, Dr. Becker could easily wipe up the remaining spillage contained within the cleanroom hood.

3 Testing Procedures (TPs)

This section discusses the testing procedures for each respective ER. All the testing will be completed by the end of the week beginning March 30th in order to make necessary changes if need be. All tests will be conducted on Friday's in order to have our client, or one of his advisors around to supervise the tests. Numerous tests will be conducted for all testing procedures, to verify that the system is reliable and robust. The team has a goal of 100 percent client satisfaction and will ensure the system will perform as intended by Dr. Becker.

3.1 Testing Procedure 1: Project Cost

3.1.1 Testing Procedure 1: Objective

This test will be executed by examining the bill of materials once the final product has been completed. This will possibly change after all testing procedures have been completed. This corresponds to ER1 (Cost Target).

3.1.2 Testing Procedure 1: Resources Required

This will require the final product to be completed with an updated bill of materials. This requires a Bill of Materials approval from Dr. Becker and Dr. Oman.

3.1.3 Testing Procedure 1: Schedule

This test will be in two cycles, after the final product is completed, and after all testing procedures are completed. For the first cycle, the week of March 23rd and for the second cycle (if necessary), the week of March 30th.

3.2 Testing Procedure 2: Portable Bench Specifications

3.2.1 Testing Procedure 2: Objective

For this test, the specs of the bench will be analyzed. This includes tabletop thickness, bench height, and storage volume. This testing procedure corresponds to ER7 (Tabletop Thickness), ER8 (Bench Height), and ER9 (Storage Volume). Volume specifically will use the devices required by Dr. Becker to be stored underneath to make sure everything fits.

3.2.2 Testing Procedure 2: Resources Required

SolidWorks drawings of the bench will be the first check. This has already been completed. After the product has been finished, a tape measure will be used to ensure that the tabletop thickness and bench height are correct. For the storage volume, the necessary devices needed to be stored underneath will be

used. Also, it will require Dr. Becker to supervise and make sure that the devices fit in locations that he approves of.

3.2.3 Testing Procedure 2: Schedule

SolidWorks drawings have already been completed for the bench and everything has been checked multiple times. Hands on testing will begin the week of March 23rd.

3.3 Testing Procedure 3: Transporting Portable Bench

3.3.1 Testing Procedure 3: Objective

For this test, the team will be transporting the bench around the Wettaw Building on campus to test the bench fitting through doorways, and the wheels giving the necessary shock absorption. This corresponds to ER3 (Fitting Through Doorway) and ER5 (Shock Absorption).

3.3.2 Testing Procedure 3: Resources Required

An escort from Dr. Becker or one of his lab assistants is required.

3.3.3 Testing Procedure 3: Schedule

SolidWorks testing has already been completed. Material testing will be conducted the week of March 23rd.

3.4 Testing Procedure 4: Temperature Resistance

3.4.1 Testing Procedure 4: Objective

For this test, the team will be running some of the components used with the bench and testing how the material responds to this. This corresponds to ER10 (Temperature Resistance).

3.4.2 Testing Procedure 4: Resources Required

The Hot Plate and Generator used with the medical devices will be required for this test. Additionally, an extremely cold day in Flagstaff will be required for testing its out-door temperature resistance. To test the cold-temperature resistance, other testing procedures will be applied to the portable medical bench while outside in the cold. These testing procedures will be the ones testing ER4 (Tabletop Yield Strength), ER5 (Shock Absorption), and ER6 (Tabletop Deflection).

3.4.3 Testing Procedure 4: Schedule

This test will be completed the week of March 23rd.

3.5 Testing Procedure 5: Liquid Drainage/ Deterioration

3.5.1 Testing Procedure 5: Objective

For this test, the team will make sure that liquid spilled on the tabletop will both drain and not deteriorate

the tabletop itself. The team will make sure that the drainage system (the gutter tray and pipe) effectively drains 80%+ of the two liter spill. This corresponds to ER11 (Liquid Drained).

3.5.2 Testing Procedure 5: Resources Required

The blood-viscosity substitute liquid recommended and provided by Dr. Becker or one of his lab assistants is required. The cleaning fluid used in Dr. Becker's lab will also be required and provided by his lab assistants. This will also require the gutter tray and pipe to be completed.

3.5.3 Testing Procedure 5: Schedule

This will take place the week of March 23rd.

3.6 Testing Procedure 6: Weight

3.6.1 Testing Procedure 6: Objective

For this test, the team will measure the weight of the completed portable medical bench to ensure that it is an acceptable weight. This corresponds to ER2 (Overall Weight).

3.6.2 Testing Procedure 6: Resources Required

The resources required for this testing procedure are SolidWorks for a simulated weight measurement, and an industrial scale from 98c. Dr. Becker's approval is required.

3.6.3 Testing Procedure 6: Schedule

The SolidWorks Model has been evaluated. Testing for the overall weight of the device will take place the week of March 30th.

3.7 Testing Procedure 7: Tabletop

3.7.1 Testing Procedure 7: Objective

This test will check the tabletop yield strength and the tabletop deflection. These two tests correspond to ER4 (Tabletop Yield Strength) and ER6 (Tabletop Deflection).

3.7.2 Testing Procedure 7: Resources Required

SolidWorks analysis was already conducted for the design. The next step of the test will require the entire assembly of the portable bench to be completed. This will happen the week of March 23rd. The team will need to bring the completed device to the Wettaw Building on campus and load the tabletop with the cleanroom hood and the cleanroom filter. Measurement will be taken for the tabletop deflection with a tape measure.

3.7.3 Testing Procedure 7: Schedule

The test will be conducted the week of March 30th.