Introduction

The purpose of this document is to explain the processes that we went through to test out certain configurations of our prototypes along with some searchable keywords for further explanations. Some of these tests ended early as we found no purpose in continuing them, while others continued for extended amounts of tests. Each section will have an explanation of the process used to test along with any changes that we may have made with the lens or the settings used. It will be sectioned off by the prototype tested with and should be used to search for keywords and file names.

3D Printed Prototype

Because of the significant amount of noise created from the 3D printed models, we decided to never actually use this as one of our testing devices since we couldn't differentiate between noise and actual data.

Metal Device

1- 10 Bean Range tests

This test was the first real test that we ran using our new metal testing device. While we had no luck using the 3D printed material, this was our first attempt at eliminating the outside noise. The tests are broken up into "Lens 1" and "Lens 2" tests. Using the IQ data tool from Acconeer we tested from 1 bean adding an additional bean per test all the way up to 10 (see the README in the lens folder). We also included some examples to show what the signal looked like without any beans in the device. This test was replicated for each of our chosen bean types.

The data for 1-10 Bean range tests can be found in the git in Documentation/Test Documentation/Metal Device Testing/1-10 Bean Range Tests. Additional README files can be found in these describing our testing process.

README - The readme is included in the folder to give an idea of the process that we used for testing the beans.

Used Settings - Each Lens testing folder contains the settings that we used for testing with the Acconeer tool. The “profile” setting changes the transmitted pulse length with profile 1 being the shortest pulse length.

No Beans - Alongside testing of different bean types, we include a test with no beans to show that the signal clearly shows when the device is not filled with any beans even when following the same steps as the actual bean tests.

Weight testing - This test was done after our initial 1 - 10 tests. Using varying bean amounts, we tested to find a good weight that did not fully attenuate our signal or eliminate our clear max amplitude peaks. This test was done using “Profile 2” on our Acconeer tool to find a reasonable weight that we could test at that would clearly define a max amplitude. There are two images in each test, one is the initial picture after adding the beans, while the next is after we shake the beans. This was done using various beans at different moisture levels as labeled.

Lens 1 - Flat Lens

Beans Tested and their moisture levels

1. Comicovel 7.6%
2. Sweet Marias Guatemala Antigua Hunapu 7.8%
3. Tailored Pulped 8.8%

Unusual Signals - A couple of tests gave us very unusual results compared to similar bean amounts. An overhead picture was taken of these and recorded for reference.

Lens 2 - Fresnel Lens

Our original metal testing device was not made to fit lens 2, so we did not continue the tests with this lens, but we did want a good idea with how the signals looked using it.

Beans Tested and their moisture levels

1. Comicovel 7.6%

Large Amount Bean Testing V1

“Settings 1” tests were conducted using profile 1 with approximately 50 beans per test. There is an example of the amount of beans used in the folder along with a readme explaining that we would be turning the device rather than shaking to see if this gave more consistent results.

There is also a screenshot with the settings that we used with the Acconeer tool for this test. Just like the tests before, there is also a no beans test recorded for reference.

The data for this test can be found in the git Documentation/Test Documentation/Metal Device Testing/Large Amount Bean Testing (V1). There is an additional README that can be found in this folder as well explaining the process.

Seeing Reflector - These are the modified settings that we used for this test that showed us a good signal and was drastically affected by the use of our corner reflector.

Beans Tested and their moisture levels

1. Comicovel 7.6%
    a. Conducted one test while spinning the device a quarter turn in between screenshots.
2. Sweet Marias Guatemala Antigua Hunapu 7.8%
    a. Ran one test with quarter turns in between screenshots (test with spins old), mixed up the beans and tested again with quarter turns in between screenshots (test with spins new).
3. Tailored Pulped 8.8%
    a. Ran one test with quarter turns in between screenshots (test with spins old), mixed up the beans and tested again with quarter turns in between screenshots (test with spins new).

Large Amount Bean Testing V2

By this point, we finally had a good test program that used the IQ data from the Acconeer tool, but put it into a numeric value that we could easily record onto a CSV and compare against other tests. For this test, rather than spinning the device and taking the values at different turns, we would take 4 values at different time intervals **without mixing**, then mix the beans and repeat this a total of 4 values per test for 4 tests (16 values per bean type). As always, refer to the README in the folder for more information. We ran this test for two different days, retesting some of the beans we had already tested to see if days later in a different test setting we would get similar or different results.

The main value we are testing for in these tests was the peak amplitude from each reading, then after x amount of tests, we would find the average of those peak amplitudes and compare them against different beans to see if we can reliably tell which bean was which from the amplitude average.

Data from these tests can be found in “PeakAmplitudeTestNoSpin.xlsx”

Beans Tested and their moisture levels

1. Comicovel 7.6%
2. Sweet Marias Guatemala Antigua Hunapu 7.8%
3. *Tailored Pulped(OLD) 8.8% Both Tailored Pulped Old and New are the same, just different bags so we tested and found they were slightly different so we relabled them.
4. *Tailored Pulped(NEW) 8.9%
5. Sweet Marias India Monsoon Malabar 12.2%
6. Sweet marias Yemen Mokha sanani 11.4%
7. Sweet Marias Guatemala San Diego Buena 7.9%
8. Sweet Maria's Rwanda Rulindo Tumba 9.7%
9. Sweet Marias Ethiopiques 8.8%
10. Sweet Marias Yemen Mokha Peabery 10.4%

*Both Tailored Pulped Old and New are the same, just different bags so we tested and found they were slightly different so we relabeled them and tested again to see if the small moisture difference would make a noticeable difference in values.

Large Amount Permittivity Testing

This test was done using a modified program that found the average for us using many scans over a time period and taking the average of those scans. This test was not fully completed because we found a lot of the data to be unreliable since our values could be so drastically different from one test to another. The settings used can also be found in this folder along with the README. For this test we ended up finding that the flat lens was more reliable for this testing prototype since it was specially sized for this lens and focused more on those tests.

Data from these tests can be found in “PermativityTesting.xlsx” and was found using “ConsistentAmplitudeV1.py” which can be found in the git. We continued to modify this program to try and get more reliable results.

Beans Tested and their moisture levels

1. Sweet marias Yemen Mokha sanani 11.4%
2. Sweet marias Guatemala Antigua Hunapu 7.8%
3. Sweet Marias Guatemala San Diego Buena 7.9%
4. Sweet Maria's Rwanda Rulindo Tumba 9.7%
    a. We stopped part way through this test because we could see that our average amplitudes were all over the place, so this data was not going to end up being usable.

Real and Imag Test V1

The real and imaginary Test was our final test using our First Metal testing device. We decided that we just needed more data to be able to tell if we were getting usable data or not. We chose 3 beans of varying moisture content so that if possible, we could clearly see the difference in the signal values that they produced. Because of some of the varying values from the tests before, we modified the program to get both the real and imaginary parts of the IQ data to see if we could use more than one value to differentiate the type of beans easier. The testing plan was as follows.

1. Start with an empty testing device for calibration and start the program.
2. When calibration is complete, fill the testing device with our chosen amount (5 grams).
3. Continue with the program by pressing enter and waiting for the program to get all the required data.
4. Once the first scan is complete, shake up the device and then press enter again.
5. Continue steps 3 and 4 until all 10 scans are completed, then remove the beans and restart from step one with another 5 grams from the same bean type.

Beans Tested and their moisture levels

1. Sweet marias Guatemala Antigua Hunapu 7.8%
2. Sweet Maria's Rulindo Tumba 9.7%
3. Sweet marias Yemen Mokha sanani 11.4%

Data from these tests can be found in the git in “Real_and_Imag_testV1.xlsx” and the program used was “ConsistentAmplitudeV6”.

Thin Metal Device

This test was completed using profile 1 on the Acconeer tool. We broke it up into 2 main tests using the Fresnel lens, the flat lens, and the parabolic lens. The first test was testing the waves produced by 1-10 beans like the test before, and the second was adding a large amount of beas to our testing device.

The data for these tests can be found in the git in Documentation/Test Documentation/Thin Metal Device Testing. For additional information, see the README file inside this folder.

The coffee that we tested with this device was as follows

1. Sweet Maria's Rwanda Rulindo Tumba 9.7%

2. Sweet Marias Ethiopiques 8.8%
3. Comicovel 7.6%
4. Tailored Pulped 8.8%

Medium Metal Device

This test was broken into two sections “2 gram testing” and “3 gram testing” which was just the amount of beans that we used for these particular tests along with “Final Testing” which was the final test that we ran with green beans.

These tests were run following the “Proceduere_README” which can be found in the “Medium Metal Device Testing” folder. The complete data for Final Testing can be found in Software/Data Collection/Datasets on the git.

Beans Tested and their moisture levels

1. Sweet marias Guatemala Antigua Hunapu 7.8%
2. Sweet Maria's Rulindo Tumba 9.7%
3. Sweet marias Yemen Mokha sanani 11.4%

New Testing device

The purpose of this test plan is to evaluate the complete COATL mmWave RADAR system designed for differentiating between different roasts from the same coffee bean using I/Q data collected via the XM125 radar. This includes verification of both hardware and software functionality, reliability of the data collection pipeline. The testing procedure begins with structured data collection using our new 3D printer inspired testing apparatus. Data is collected using Yemen Mokha Sanani green coffee beans roasted to three different levels: light roast, medium roast and dark roast. A total of 50 series of scans per variety are performed, with 3,300 I/Q measurements per series, producing a dataset of approximately 165,000 data Points.

Refer to the Developer’s Manual in Section 12 for a complete list of all required hard-ware, tools, and software packages. Follow the instructions for hardware assembly and software environment setup prior to initiating any data collection or machine learning operations.

1. Read the Developer’s Manual and User’s Manual in Section 12 to understand

hardware assembly and software operation.
2. Choose one of the three coffee roast varieties.
3. Fill and level the provided testing container.
4. Run the “FullAverageScan (Coffee Roast).py” script.
5. Follow all printed prompts while turning to the set measured steps on the bottom of the testing container in between each prompt.
• Important: At the start of each test, place the testing container with the star as the start point. This will ensure that you finish the required number of turns for the test with the same positioning each time.
8. Complete all 50 scans, then remove and store the beans in a separate container.
9. Repeat until 5 runs of the program are completed per roast.
10. The I/Q data will be exported to a CSV file within the same directory as the program file. Successive runs will append the I/Q data to the same CSV file Automatically.

Equipment used

1. 6 x .5 inch A270 Hex bolts
2. 3D printed bean holder stand
3. Copper tape
4. 4 x .25 inch philips screws
5. 4 x 2.25 x .125 inch Plexi-glass
6. 6 x 6 x .125 inches Plexi-glass
7. Acconeer Radar with lens and USB
8. 4x 2.5mm standoff hex screws with standoffs
9. 5x .25 inch width L brackets
10. 43 inches of metal strut (will need to be cut to size)
    a. 15 inches x 1
    b. 7 inches x 4