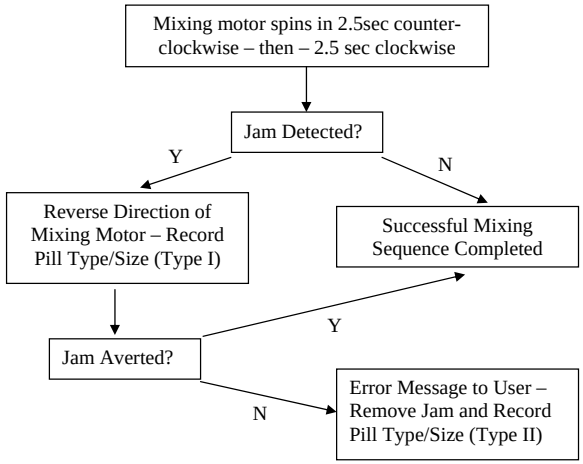
Experimental Validation of Additional Components:

Mixing Flapper Material – Dispensing/Mixing Motors – Delivery Slide:
The first mixing flapper was constructed of .011" thickness Plexiglas. It proved to be too rigid to effectively mix the pills without damaging the pills and causing jams. To address this issue, we replaced the flapper with a material that is less rigid but still will agitate the pills adequately. The rubber material from a floor squeegee was selected as it should not damage the pills but is still capable of agitating them.

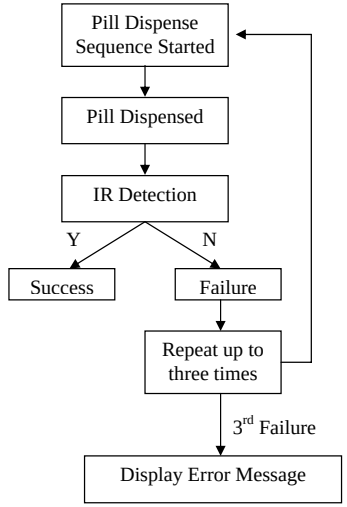
To test the effectiveness of this new material in conjunction with the motors and delivery slide, we will load the pill containers with 30 pills each, a monthly dosage, then we will complete the dispensing process for each pill 10 times. The dispensing process starts by mixing the pills for 2.5 seconds in the counterclockwise direction, then for 2.5 seconds in the clockwise direction. The dispensing motor then turns, dropping the pill onto the delivery slide, and finally, the initial mixing process is repeated. For each dispensing process we will record any jams or pill damage that occur, also we will be noting any problems associated with the delivery slide (pills that get stuck or do not slide to the dispensing dish). After the testing has been completed the data will be compiled into graphic format for easy interpretation.



Mixing Motor Testing Diagram

This testing sequence will be completed for various types and sizes of pills at least 10 times for each pill type and size.

Sensors – Implementation and Validation:
A variety of sensors will be added to the device to increase the accuracy and safety of the dispensing system. Infrared reflective sensors will be added near each of the dispensing drums to ensure that a pill has been dispensed. The program will keep track of the dispensing timing and the feedback from the sensor to determine if a pill has not dropped from the dispensing drum. If the program determines that a pill has not dropped, the mixing and dispensing process will be repeated. After three failed dispensing attempts the program will alert the user of the problem and instruct them to take the specified medication from the pill holder. The instructions will include a pictorial representation of the pill holders to aid the user in determining which pill to take.



Sensor Programming Sequence

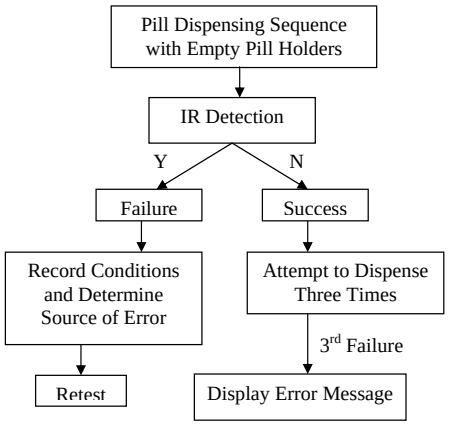
To test this set of sensors, a pill container will be purposely not loaded as instructed when entering the medication information. Then, the test subject will attempt to dispense a pill from the empty pill holder. The user will note that the device attempts to dispense the pill three times and then displays the appropriate error message. This test will be performed on each of the pill container sensors at least three times.

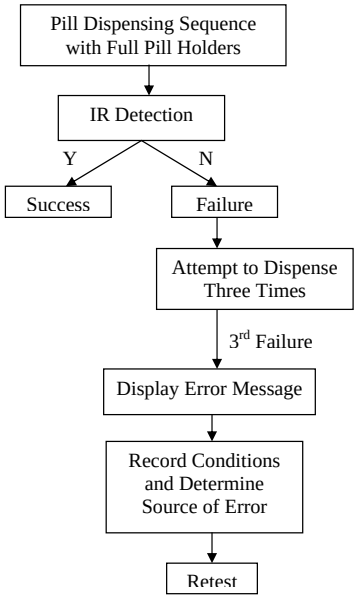
A current sensor will be added in series with the mixing motor power supply line. The sensor will detect any pill jams by detecting a spike in the current draw of the mixing motor. Initial tests have showed that under high load the current draw of the mixing motors is more than 150mA, whereas with only the flappers attached the current draw is

approximately 80 – 90 mA. When the program receives input from the sensor indicated that the current draw has exceeded an undetermined threshold it will reverse the direction of the mixing motor. If the sensor indicates that there is a jam in both directions an error message will be displayed on the screen to alert the user of the problem. The error message will instruct the user to open the device and remove the jammed pill. It will also display all the medications that should be taken at the particular dosage when the error occurred and ask the user to verify all medications are present.

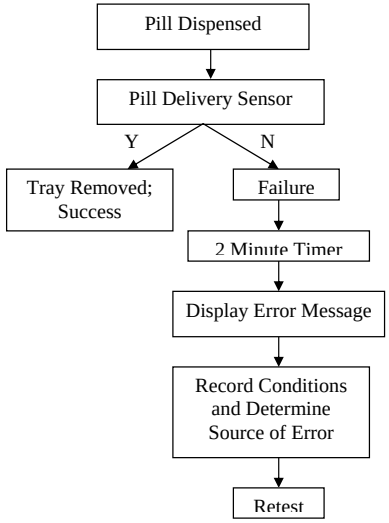
To test this sensor we will obstruct the mixing flappers a hard object to ensure that the current draw of the attached mixing motors has exceeded the threshold. We will note that the motor reverses direction each time the flapper is obstructed. This will be repeated, testing each direction, 10 times; in addition, a complete blockage will also be simulated, where the motor is unable to move in either direction, to ensure that the program displays the appropriate error message.

The final sensor that will be added is the pill dish removal sensor. This sensor also is an infrared reflective sensor that will be placed near the front of the enclosure to determine if the pill dish has been removed from the device. To validate the effectiveness of the sensor the pill tray will be purposely not removed after medication has been dispensed. After a time limit of 2 minutes has been exceeded without the removal of the dispensing dish the program will sound an audible alarm that indicates the dish has not been removed after medication has been dispensed. The dish will also be removed prior to medication dispensing to ensure that the program recognizes the absence of the dispensing dish and informs the user that it cannot dispense the medication until the dish is replaced. In the case where the dispensing dish is removed during the medication dispensing process the program will alert the user that errors are probable and it will display the medication that should be taken at this time.





Pill Dispense Sensor Testing Diagrams (Top – Empty, Bottom – Pills Present)



Pill Tray Sensor Testing Sequence

Human Interface Testing:
The software will first be updated to include patient scheduling, the pill database/barcode scanner, alarm system, dosage tracking, and biometric identification system. After it is updated the entire package will be tested to ensure its functionality, usability, and consistency. The testing will also attempt to reveal any bugs in the software. To test the patient scheduling and dosage tracking components a new patient will be entered into the system, then the patient's medication and schedule will be added. A week of use will expose any errors in the scheduling system and dosage dispensing. To test the reminder alarm, the test subject will purposely miss a scheduled dose to determine how the software and alarm component will respond. The alarm should sound after a pre-determined time has passed without the user retrieving the appropriate medication.

- New patient entered – medication and schedule entered as prompted by device
- Week of regular use according to medication schedule
- Reminder alarm testing
  - Subject will purposely miss a scheduled dosage
  - Device should alert user of missed dosage and sound audible alarm after specified time limit
- If alarm does not sound, the software will be investigated and the source of the error will be fixed

This alarm testing phase will be carried out at least five separate times during the week to ensure the alarm functions as designed. This one week testing process will be completed for three weeks with three different test subjects. The following parameters will be recorded for each testing phase:

- Patient identification entry errors – difficulty with LCD touch screen and/or program interface
- Barcode errors – barcodes that will not scan, or scan incorrectly
- Medication barcode/database lookup errors – medication displays incorrectly
- Biometric identification errors – does the device recognize the user when his/her fingerprint is scanned
- Dispensing errors – any medication that is dispensed at the wrong time or not dispensed at all
- Alarm functionality – the alarm should sound after the user misses a scheduled dose
- Other – any other errors or undesirable occurrences

Human Subjects Accessibility Testing:

The Accessible Medication Dispensing Device validation will require a small human subjects test. The goal of the test is to ensure that the device meets the accessible design requirements and safely dispenses the appropriate medication at the correct time. Part of the accessible design requirements are that the device is simple to use for elderly and disabled individuals. To ensure this requirement is met, we will take the AMDD to Meriter Heights Senior Community where we will seek people that best match the proposed five clients. Then we will ask the volunteers to operate the device and record their experience. The volunteers will be read some simple instructions on how to operate the device and given a short demographics survey to determine their age, sex, and any physical limitations or disabilities. They will attempt to enter medication information, dispense medication, and comment on the overall appearance and ergonomics of the device. After each user completes their test, they will be given a survey and asked to rank the following criteria – device setup, ease of use, visual clarity, aesthetics, desirability – on a 1 to 10 scale. These criteria were chosen because they address the overall design specifications and accessible design considerations; however, device setup, easy of use, and visual clarity will be weighted twice as much as the aesthetics and desirability feedback. The results of the surveys will be tabulated for the final paper and presentation. The testing will also be recorded via video camera for documentation and verification purposes. We expect to receive positive feedback on the device; however, we realize that some people may find the LCD difficult to read at various offset angles.