

# CREATE Competition: Automated Ream Opener (Analysis & Logical Design)

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## *Activity Report*

**Abstract**—The Center for Disability Services mailing center, which processes enormous amounts of mail per day supporting official New York State mailing operations, has partnered with students to develop a system that assists disabled workers. The center uses an estimated 50,000 – 100,000 pieces of paper per day. This paper is manually opened from reams of paper containing 500 sheets each, therefore, approximately 100-200 reams of paper must be opened per day. The center would like to hire people with disabilities to open the reams of paper, but this is difficult due to physical dexterity issues and the large number of paper cuts the disabled workers often suffer when trying to do this job. The goal of this project is to develop a system that automatically opens reams of paper in a safe and effective way.

**Index Terms**—Arduino, NEMA, automated ream opener

## 1 THE PROBLEM

MAILING centers typically require large quantities of paper to meet their daily demands. As such, reams of paper must be opened safely and efficiently in a proportionally high demand. The Center for Disability Services would like to develop a system which meets these requirements particularly as a tool to assist disabled workers. A viable solution would decrease time to open each ream while simultaneously being safe and accessible to disabled workers. Ideally, it would also allow the Center for Disability Services to hire additional disabled individuals specifically to operate the final system.

## 2 INSPIRATION

When doing background research on the topic, there was no automated system that opened

a ream of paper. There were implementations that operated on paper, however. Of these, most relevant was an automated letter opener and an Arduino based paper cutter. When considering the former, it was worth noting how the letters were opened precisely without damaging the inside contents. This is a similar amount of space between the outside sheet and interior paper of a ream, leading to the conclusion that a blade of high precision could open the outside sheet without cutting any interior papers. Of the latter, the Arduino based paper cutter used a NEMA stepper motor to move a blade left and right perpendicular through a sheet of paper, thereby making equal cuts of length specified by the user. This design led to an epiphany regarding the use of a stepper motor to cut across potentially each of the four sides of the ream to separate the outside layer.

## 3 DESIGN CONSTRAINTS

There are limitations placed on a potential implementation. Most evidently, testing will be a primary focus and is somewhat limited due to the lack of readily available access to reams of paper. Additionally, funds are limited and restrain the amount of trial-and-error in terms

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of system designing. Finally, there is a deadline of completion by April 2023.

- **Testing:** Although available in high capacity at the Center for Disability Services mailing center, it is limiting to consider scheduling, travel, etc to perform frequent tests.
- **Cost:** The Center for Disability Services has allocated a balance of one thousand dollars to build the desired system.
- **Time:** The design should be complete and in use well before the start of the CREATE design competition in April.

## 4 PROPOSED SOLUTION

The proposed device is a preliminary prototype that reflects the designers aptitude towards testing. Focusing on this notion the following engineering diagram has been developed. An individual should take heed that the inspiration from the letter opener is the driving concept for this implementation.

### 4.1 Engineering Diagram

CREATE SEAL TEAM 6

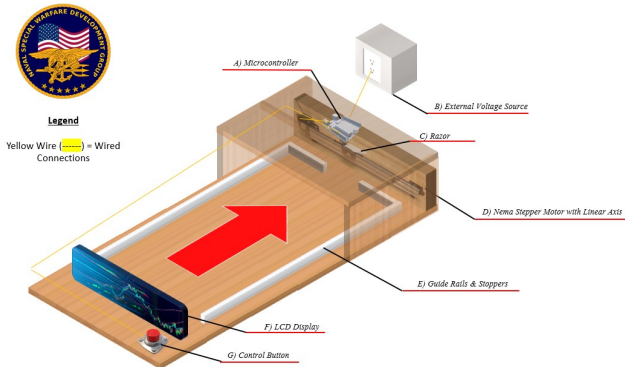


Figure 1. Annotated diagram of the proposed solution.

Physically speaking the device is quite simple in nature and requires minimal overhead to implement. The design is centered around a linear axis rail operated by a NEMA stepper motor. This contraption is capable of controlled uniform movement and as such when a razor blade is attached to the sliding linear cart it will ideally make clean lacerations to the paper ream cover. A user interacts with the system

via a button press that controls the operation of the linear rail. Along the base of the apparatus there are guiding protuberances that orient the ream in the most optimal setting. These "stoppers" ensure that only the cover of the ream will be slit, thereby leaving the contents unperturbed.

## 4.2 System Requirements

### 4.2.1 System User

The user that will interact with the system is an employee from the Center for Disability Services mailing center. All that will be asked of this individual is the ability to lift and push a ream of paper into its proper setting as well as the ability to push a button. If both of these qualities are satisfied one will have no issue operating the proposed solution.

### 4.2.2 Functional Requirements

Following are the most important functional requirements.

- 1) **Paper Ream Cutting Ability:** The system should have the ability to slit the desired ends of the paper ream in order to make the paper ream opening easy.
- 2) **Safety:** Since the users of the system are physically disabled, its a mandatory requirement of the system to be completely safe to use.
- 3) **Ease of Use:** Since the users of the system are physically disabled, its a mandatory requirement of the system to be very easy to use.

### 4.2.3 Non-Functional Requirements

Following are the most important non-functional requirements of the system.

- 1) **Capacity:** The system should have the ability to open 200 reams of paper a day.
- 2) **Ability to work with different ream size:** It is a desired quality of the system to be able to work with different size of paper reams.
- 3) **Complete Package Opening:** Ideally the system should be able to completely open the paper ream although cutting the ends of the paper ream is sufficient.

### 4.3 Justification

The belt driven actuator design was chosen mainly because of its ease of use and paper ream opening ability. The current design is easier to use than the moving arm package opener because it is more compact and will potentially contain a single button to control the blade. The idea of a moving arm package opener design was built around two arms that go into the flaps of the paper ream and then move along the y axis to tear the paper ream. The moving arm package opener design was safer to use because it did not contain the a cutting blade but it would not be easy to use and would be very less compact. Based on these results our team decided to go with the belt driven actuator design.

	Criteria 1	Criteria 2	Criteria 3	
CRITERIA DESCRIPTION	Safety	Ease of Use	Ream Opening Ability	
OPTIONS	Criteria 1 SCORES	Criteria 2 SCORES	Criteria 3 SCORES	TOTAL SCORE
Belt Driven Actuator with Blade	3	5	4	12
Moving Arm Package Opener	4	2	4	10

Figure 2. Decision Matrix

### 4.4 Ethical Concerns

One of the most important ethical concerns that our design addresses is user safety. Since our design contains a blade that moves along the x axis to open the ream of paper, the danger of a user getting a cut increases dramatically. In order to mitigate potential harm caused by the system the belt driven actuator with blade will be put into a wooden box such that the only thing that can be put in to the box is just the ream of paper. Moreover, the stepper motors that control the motion will be controlled by a button. This will ensure that the stepper motors

does not cause the blade to move without user input.

## 5 INITIAL PROTOTYPE

Our initial prototype consists of a wooden box with a belt driven actuator to which a blade is attached. The belt driven actuator allows the blade to move along the x axis. The belt driven actuator is controlled by a stepper motor, which allows movement in the positive and negative x axis. In order to ensure the safety of the user, the control of the stepper motor will be done by a button outside the wooden casing. The user will place the paper ream inside the apparatus, the stoppers will restrict the user from pushing the paper ream too close to the blade. After placing the paper ream , the user will push the button for the actuator to start and the blades will make a cut to the specific side of the paper ream. The user can switch the side of the paper ream to apply cuts on different sides of the paper ream to make the package easier to open. After applying the cuts the user can take the paper ream and dump the contents. One prospective engineering problem that might cause delays is finding the optimal distance for which to stop the paper ream, such that the blade does not cause damage to the paper inside the ream. One solution to the problem is experimenting with the reams and through trial and error finding the specific distance that will allow for the package to be cut without harming the paper inside.