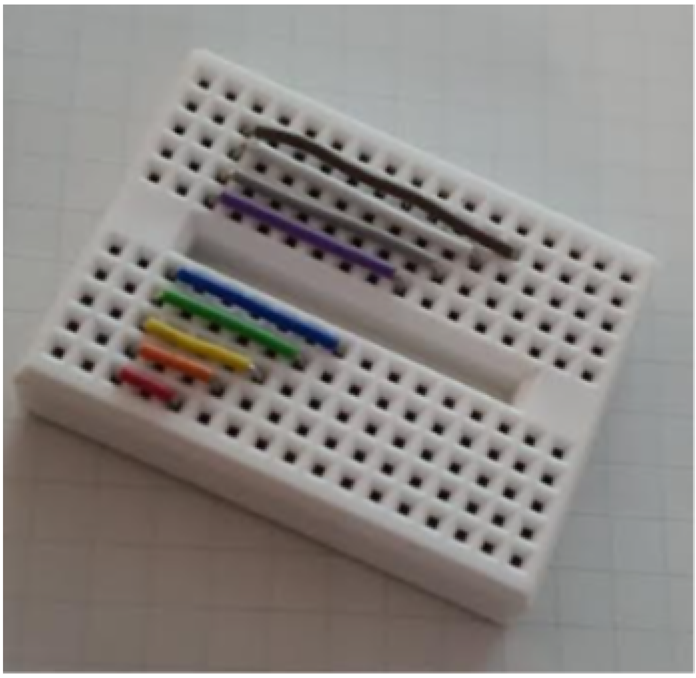
DELIVERABLE 2 : JUMPER CUTTING/STRIPPING MACHINE



Example of a bread-board with jumpers that have been cut, stripped out of their sleeve and bent

Date : 01/24/2023

Group N° : 12

Names : BOULAY Florian - HEID Clara - MARTY Virgile - VÉRAN Benoît - VINCENT Bastien

1. Context

Our group decided to carry out this project using the AGILE method. This seemed ideal to us because our client is not a professional and his needs can change over time. Moreover, our project is practical because it can be separated into four sub-projects which can fit with the cycles of the AGILE method. We are currently in the first AGILE cycle:

Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
preparatory phase		First Agile cycle			Second Agile cycle		System assembly and delivery	

To be more efficients, we have formed two groups in order to work on two subsystems at the same time.

Virgile; Clara; Bastien	Cutting System
Benoît; Florian	Distribution System

At the end of this first cycle, our goal is to be as advanced as possible on these two subsystems in order to use them with the next two subsystems. However, they are not yet integrated in the global system of the "Jumper Machine". Indeed, there will certainly be prototypes that we will have to modify during our last AGILE phase.

Thus, the purpose of this deliverable is to present the functioning of the machine as we perceive it. Then we will see the design choices and the reasoning that led us to these solutions. Finally, we will make a brief conclusion on the progress of the prototypes and take a step back towards the next steps of the project.

2. THE SYSTEM

Our project consists in making a jumper cutting and stripping machine, ordered by Frédéric Mantegazza. This machine should be used in schools (above all Ense3) for learning and research purposes. Its main functions will be to cut and strip wires in order to manufacture jumpers for electrical devices such as breadboards.

Although we have only focused on the distribution and the cutting part yet, we have still thought about the global functioning of the system to be able to orient ourselves in certain design choices. What we are presenting in this deliverable is not necessarily complete and definitive but it allows us to project ourselves into the future of the project.

To manufacture our jumpers, we are using a single-core cable of AWG 23. The AWG standard defines the inner diameter of the electric conductor, in our case .575 mm. However, the diameter of the sheath can vary, and the one of our reel is 1.3 mm. This reel was ordered with the customer because the characteristics correspond to his expectations and the gauge allows a good insertion in the prototyping breadboards. Thus, we are going to use this reel as a reference for sizing our entire system until the end of the project.

Figure n°1 : AWG 23 Reel

As you can see on the following figure, our project can be separated into several functional blocks that will meet the requirements of our client. We have already explained these functions in the first deliverable.

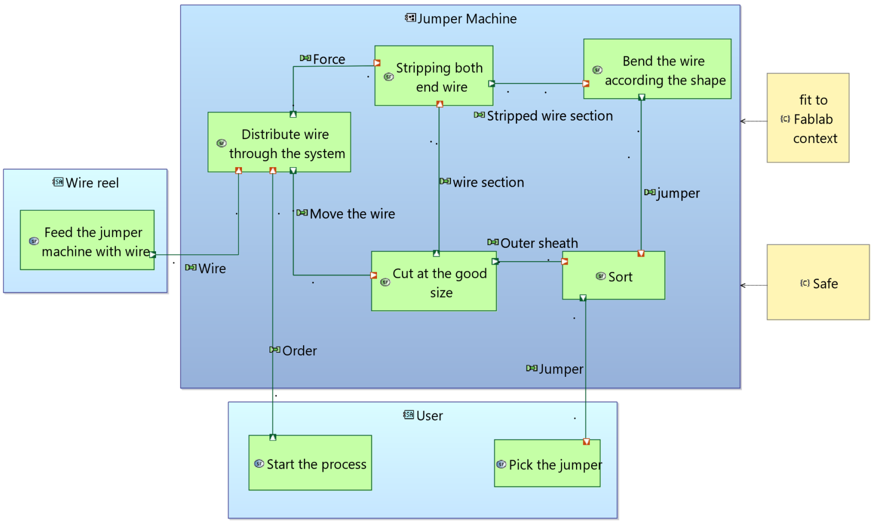


Figure n°2 : System Analysis

Currently, thanks to this system analysis, we have a general idea of how a jumper will be manufactured. However, the bending phase is still under consideration, but it is not a priority step for the customer.

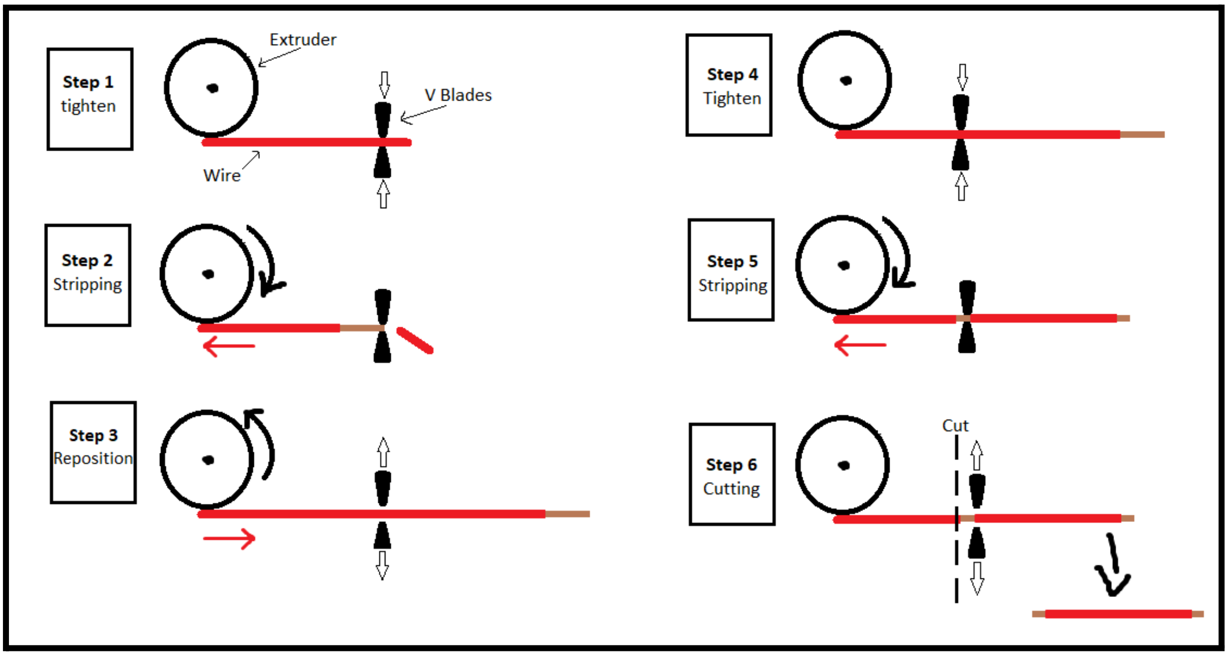


Figure n°3 : Jumper building stage

First of all, the wire is stripped to twice the length of a leg, then the machine positions the wire so that the V-blades can grip the sheath upstream. Secondly, the sheath is pulled until the same length of wire is stripped at both ends. Then the wire is cut and an unbent jumper is obtained. This process has the advantage of not requiring the use of several pairs of blades at the same time. And it can be used for several different jumper lengths.

As we can see, the manufacturing of a jumper will require a precise synchronization of all our functional blocks. This will be an element to take into account to during our final phase of the AGILE method.

3. CUTTING SYSTEM

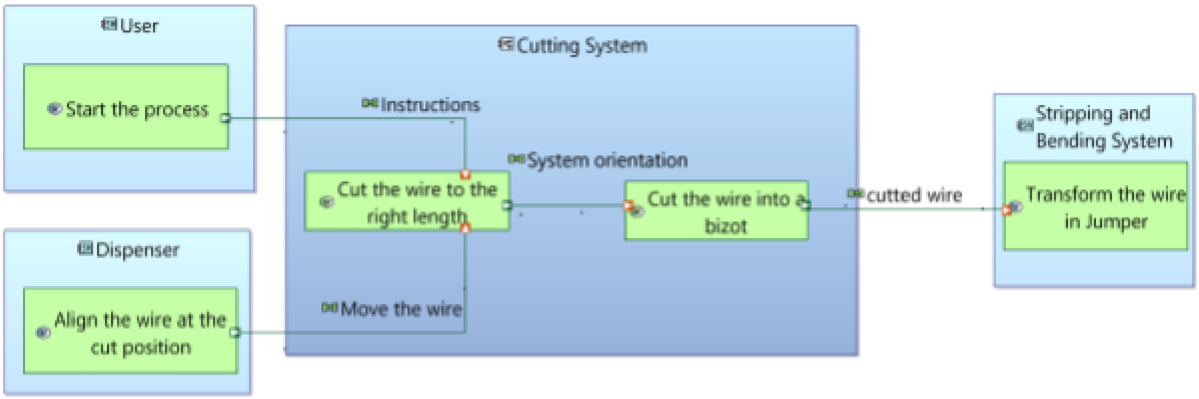


Figure n°4 : System analysis, cutting part

As far as the cutting system is concerned, there are two simultaneous actions in the first instance. The system must follow the instructions given by the operator while ensuring that the wire is correctly positioned. This step is essential because it allows the wire to be cut to the right length. Here we only focus on the cutting part and not on the wire feeding part. The biggest challenge here is to succeed in cutting the wire into a pledge. Indeed, to cut the wire properly, the two blades must be constantly glued to each other so that the wire does not twist between the two blades.

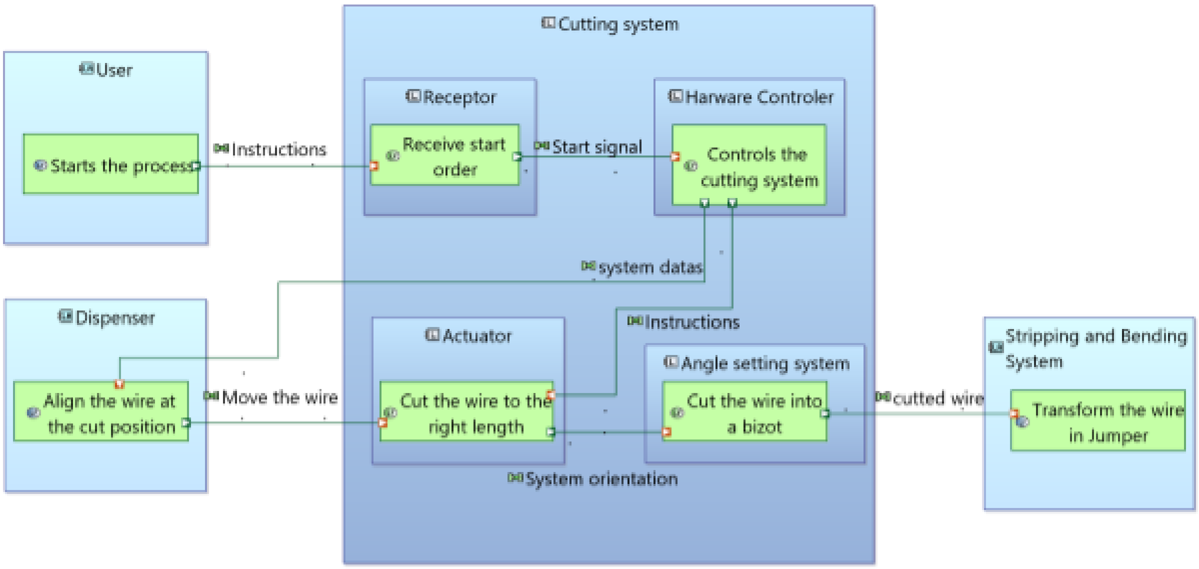


Figure n°5: Logical architecture, cutting part

For the translation of the blades, we first thought of using a crank system. But such a system is very cumbersome and complicated to control. Indeed we need great precision to cut the wire well. Then we thought of a rack and pinion system, but we thought it was not precise enough. We therefore turned to a cam system that would transform a motor rotation movement into translation via a translation guide. We spent a long time looking at how to ensure the correct translational guidance with the cam. Indeed, it is necessary to avoid the bowing effect at all costs.

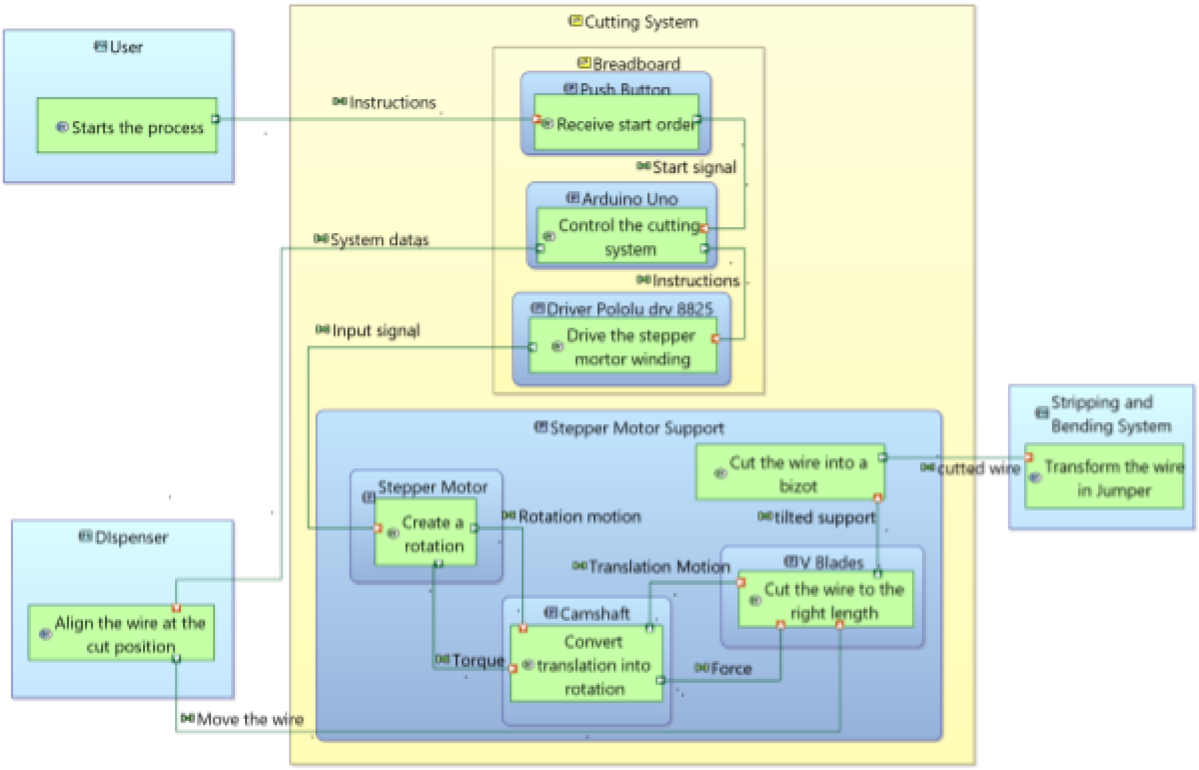


Figure N°6: architecture system

As far as the cutting part is concerned, we were based on the following architectures:

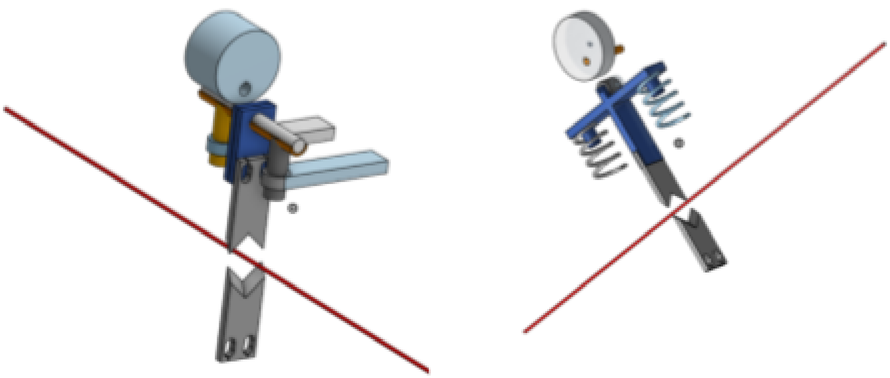


Figure N°7: first ideas for modelling the cutting part

We opted for a cam system in order to be able to control the translation of the blade with a stepper motor. The cutting function is closely linked to the stripping function, so we need to be able to control the cutting depth of the blade.

In order to cut the wire core at a bevel, the whole system must be oriented at 45 degrees. One of the blades remains fixed, the wire will then be pushed as close as possible to the cutting edge of the lower blade and the cam actuates the upper blade to cut the wire. The springs in the system allow the blade to return to the upper position. Both of these designs were not chosen as they would result in an overhang on the blades.

In order to press the blades against each other to cut the thread properly, we turned to the system created by the group that cuts sutures and we adopted their architecture. We then proceeded in several steps. First of all, we transferred from Github to Onshape the parts of the group that makes suture cutting . (https://github.com/TomGosnik/FairEmbo-Project/tree/main/Documentation). We then had the whole suture system. The challenge was then to find a way to arrange the cutting system at 45° in order to cut the thread in pledge. To do this we modeled the plate below which would pass over the thread guide system.

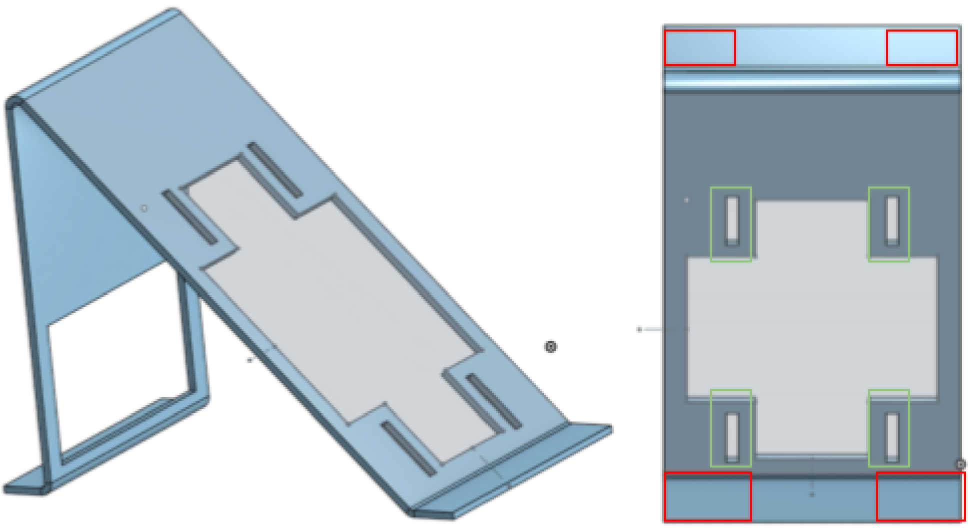


Figure N°8: Cutting system support plate

As can be seen from the CAD model, there are 4 notches on the plate (shown in green). These notches allow the cutting plate to translate in order to adjust the cutting height.

So we printed the parts of the suture group on a 3D printer. Then we laser cut the two plates (support and cutting plate). The support plate then had to be bent. For the translational guidance of the blades, we cut two 4 cm pieces of steel tube with a diameter of 8 mm. Finally, the motor and the individual parts were mounted on the cutting plate.

We would like to point out that when modeling the support plate, we had a lot of trouble using the sheet metal module. Therefore, the plate has very wide feet that could be reduced to a minimum width (shown in red). The problem is that these feet prevent the guide system from being placed under the support plate. We are considering either redesigning the part on Onshape or raising the wire distribution part. Moreover, during the assembly the bent plate broke when we handled it. So we can already try to use an 8mm plate instead of 5mm.

Here is the rendering of our prototype and the different parts we printed and cut out. Like the suture unit, we used a NEMA 17 motor which rotates the cam and thus enables the thread to be cut.

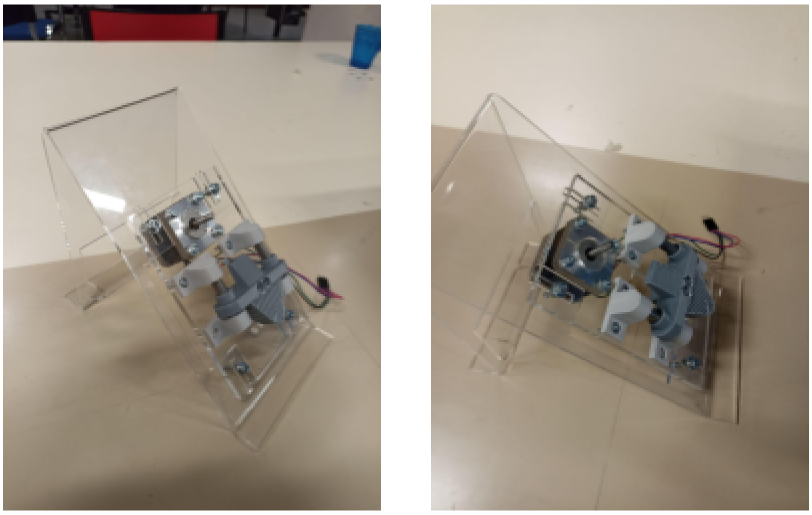


Figure N°9: cutting part's prototype

4. DISTRIBUTION SYSTEM

The distribution part of the system has the role of moving the wire through the other functional blocks. It must allow the wire to be moved precisely while exerting a force strong enough to perform the stripping steps.

As our system is not integrated into the final assembly, we consider for the moment that it must only be turned on and able to pull the wire. To meet the customer's safety requirement. Our subsystem must have an emergency stop of the machine in case of a wire issue.

The wire is rigid and wound around a spool, it may not be straight when unwinding. This is why we have made a system to straighten it.

All these reasonings are synthesized in the following logical architecture:

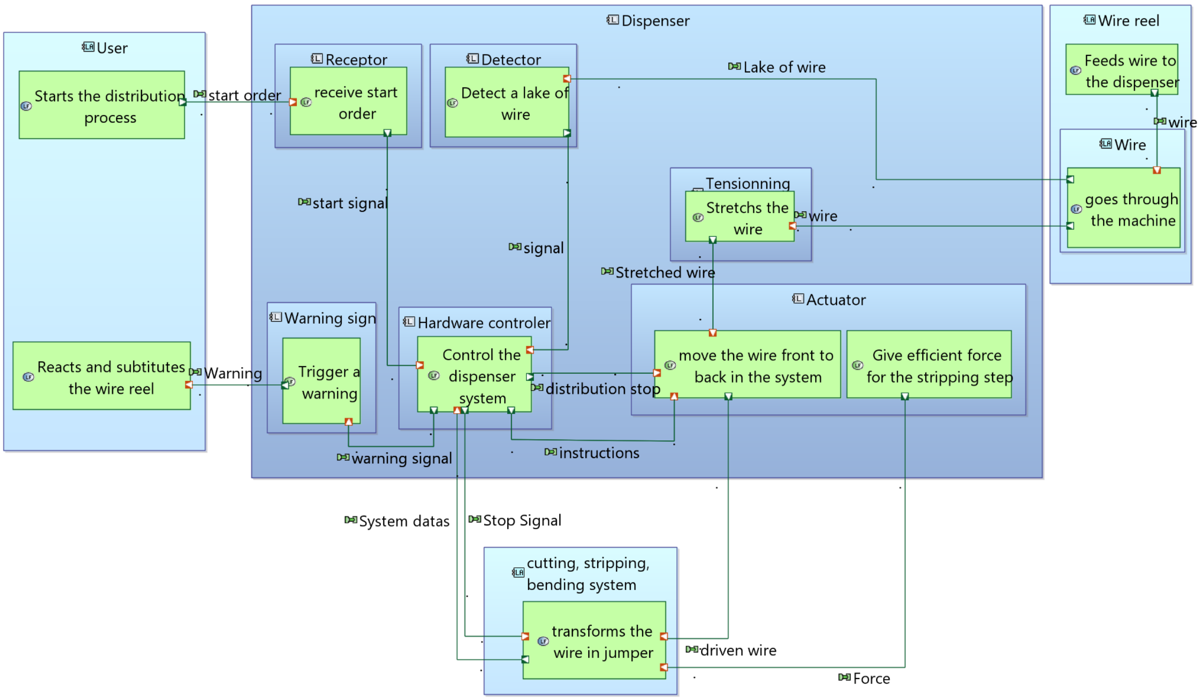


Figure n°10 : Logical architecture

For the implementation of the physical system, we will control the whole system with an arduino UNO board for the moment (maybe a MEGA board at the end). It is a programmable board dedicated to prototyping, so it is ideal in our situation.

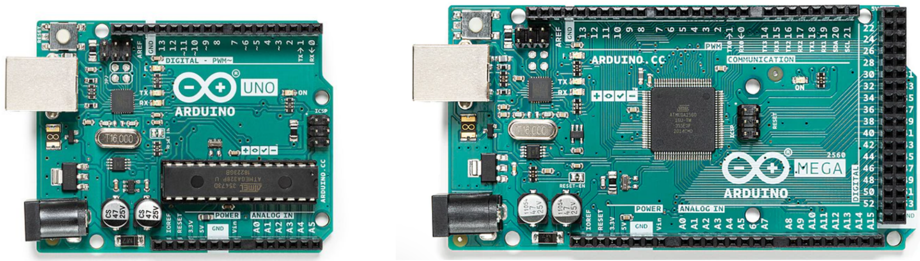
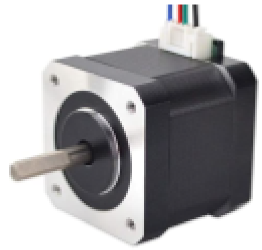


Figure n°11 : Arduino UNO and Mega card



For the actuator, we chose a stepper motor because it is precise in its movements. Moreover, the NEMA 17 standard is easy to access because it is widely used in DIY communities. We have chosen a model that can provide a torque of 45 Ncm to allow for efficient stripping and driving through the machine.

Figure n°12 : Stepper motor Nema 17

The stepper motor implies an interface with the arduino board called "driver". We had by default a driver from POLOLU model DRV8825. It is a standard model that can go up to a current of 1.5A (enough for our motor). This driver is equipped with an "Enable" mode that can act as an emergency stop for us. And a "Sleep" mode for extended standby. However, this last one can heat up on long periods of use and can cause unpleasant noises on the motor. It is therefore possible that we will change by the end of the project for TMC2208 drivers, quieter, less hot but with a less good step resolution.

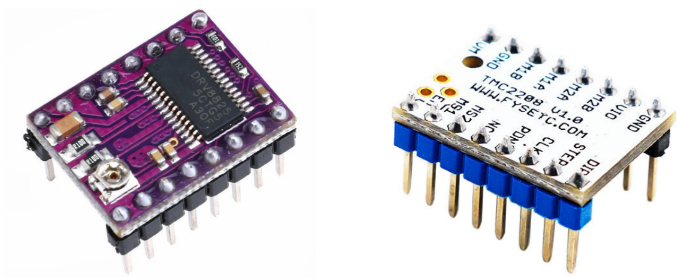


Figure n°13 : Driver drv8825 and TMC2208

The element between the wire and the motor is a 3D printer extruder. It has the advantage of being accessible and adapted to the NEMA 17 standard. The wire is pressed against a grooved bearing by a toothed roller. It is this roller that transmits the motion. We also had a dual drive device that provides a better grip on the cable. However, this option is not considered necessary because the current extruder already pulls the wire effectively.

Figure n°14 : Extruder Redrex Ender 3

We could have used a "CNC shield" to facilitate the management of the movements between all the motors of our machine. However, this shield would occupy all the pins of the arduino board. This is not possible in our case because we also need to implement sensors and a man-machine interface. Hence the fact that we do not retain this solution.

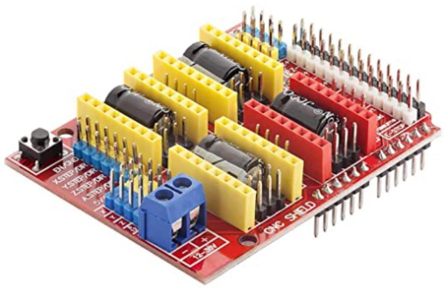


Figure n°15 : CNC shield

The detection of a lack of wire or any other issue is done by a limit switch which will be closed as long as the wire compresses its leg. On the other hand, if the wire is missing, the switch goes to open mode and sends a signal to both the Arduino and the "Enable" pin of the driver.

Figure n°16 : limit switch from Omron

To straighten the wire at the exit of the spool, we have decided to implement a system of tension rollers through which the wire will pass. For this, we have chosen to use the design of Jiripraus [1]. It consists of two interlocking and adjustable supports, this gives us the prototype V0.

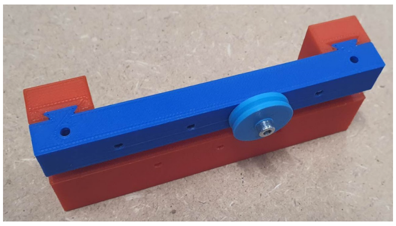


Figure n°17 : Proto V0

Many defects appear, after the test:

- no place for the wire shortage sensor, incorporating it into the structure should save us space
- not suitable for AWG 23
- the supports were blocked because of a lack of clearance

So we have decide to make a V1 including a place for the sensor and changing the side rollers to allow the wire to be guided in the structure, it results that:

- the interlocking structures were too fragile and broke
- the wire was not high enough to exit in front of the extruder
- the sensor location was too small
- the height adjustment system was not practical

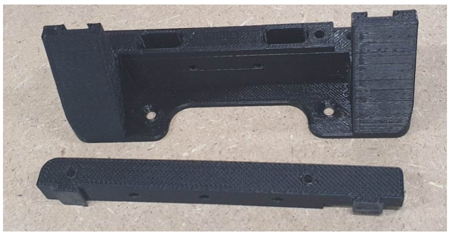


Figure n°18 : Proto V1

We realize a V2 having a higher support, a much wider base, changing the system of adjustment in height by a system of tightening, and by changing the place of the sensor. During the tests, the whole was functional but the sensor behaved badly.

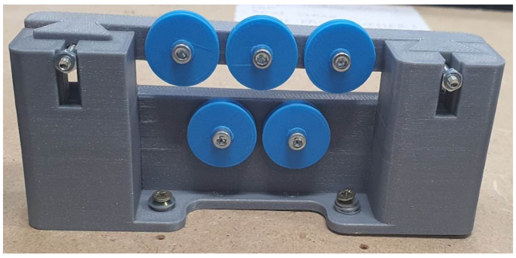


Figure n°19 : Proto V2

We then decided to make a set of small parts in FDM to test the best placement before integrating it into the support. This results in a V3, the tensioning system that we consider as completed.

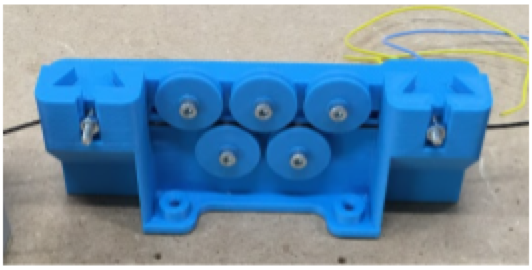


Figure n°20 : Proto V3

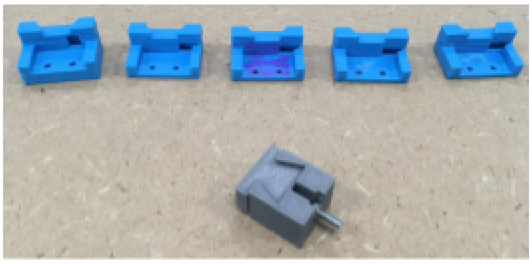


Figure n°21 : multiple trials

All these design choices lead us to the following system architecture:

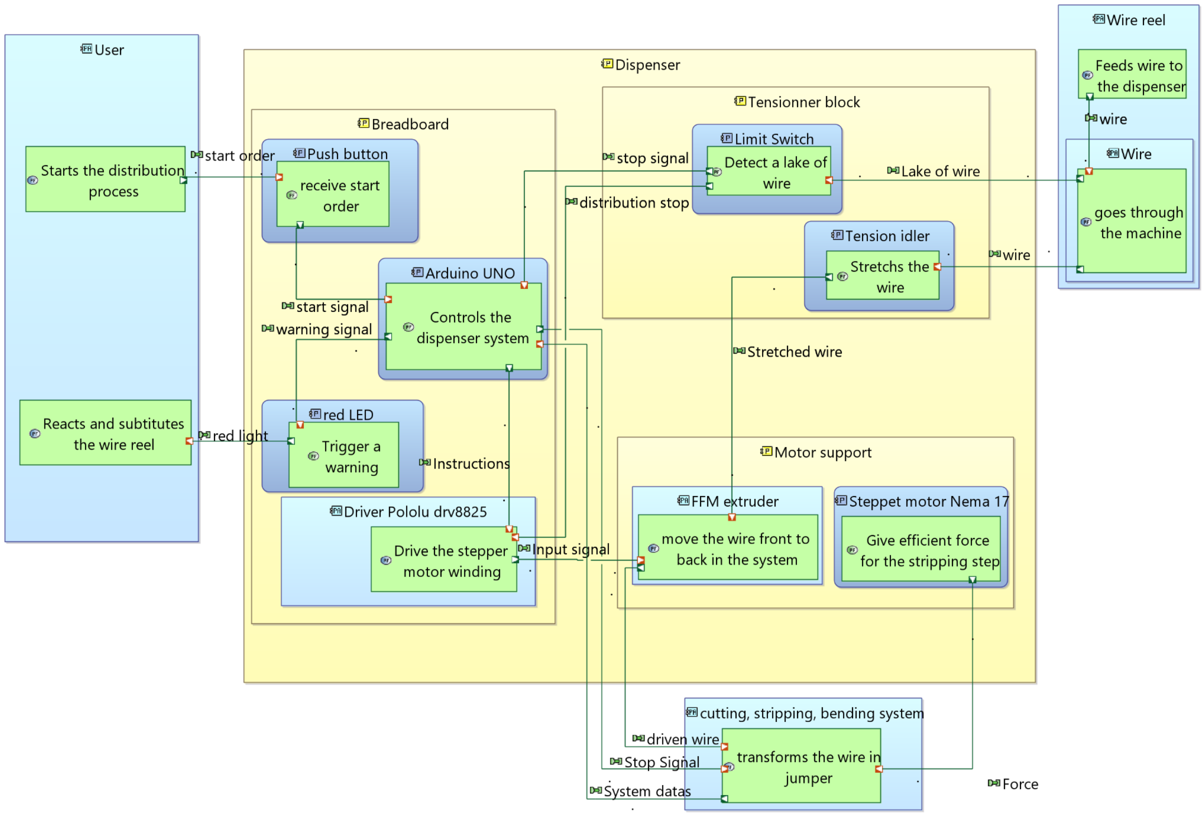


Figure n°22 : Physical architecture of the distribution system

The electrical connection diagram for the distribution part is available in the appendix. We also provide a grafcet representing the expected behavior of the distribution subsystem for the end of this AGILE cycle.

5. WHAT’S NEXT ?

Due to the partial period, the project was delayed. As a result, both teams have not been able to perform the specification validation tests for this deliverable. However, we aim to complete them before the January 31st presentation.

- For the cutting part, we still have to machine the cam and put the bearing on the bearing support. The support plate also needs to be redone as it has been broken and its mounting brackets are too wide.
- For the distribution part, we have to do all the programming.

We plan to continue the first cycle AGILE until February 4th, closing it with a customer meeting. The cutting part being more behind, it is possible to extend on the second cycle.

The cost analysis indicates that we are within the client's budget (300€). It will be necessary to foresee that from February the GiNova platform will be taken for the first year students on Friday. And that at the beginning of April, resources will be difficult to access GiNova because of the end of the first year ISR project.

After that, the whole group is going to focus on the stripping and bending parts for the next two months.

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6. Appendix

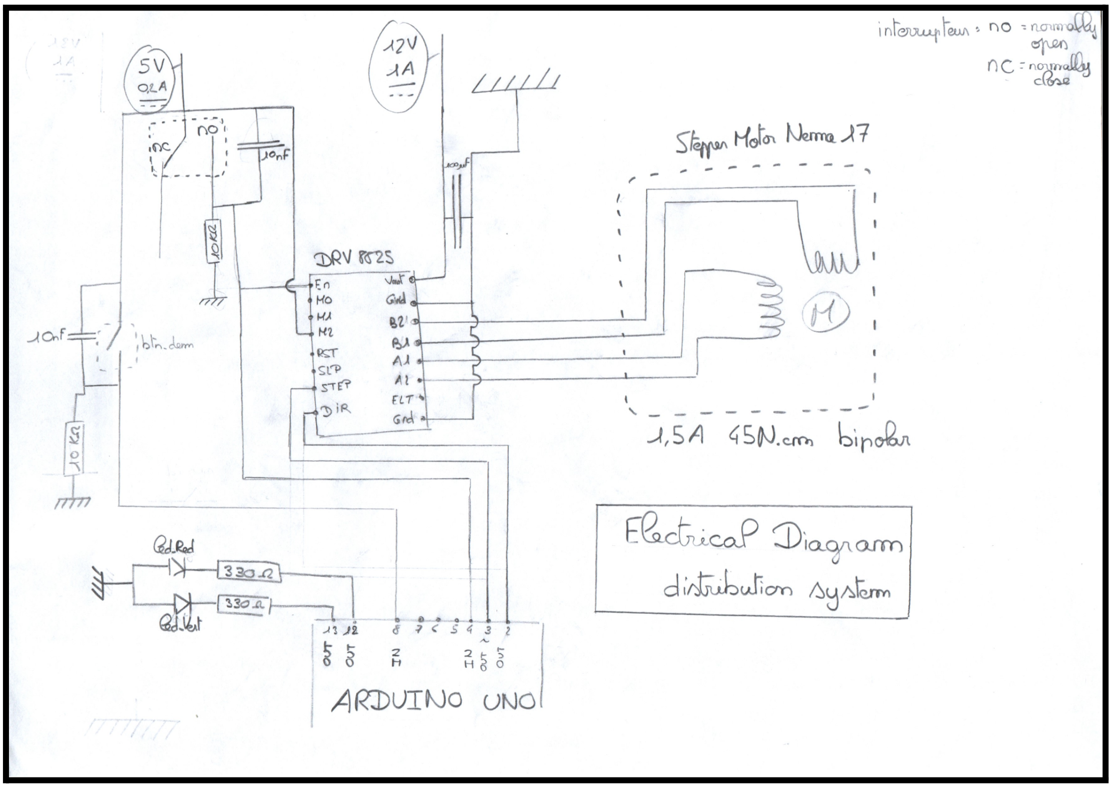

Figure n°23 : Electrical diagram of the distribution system

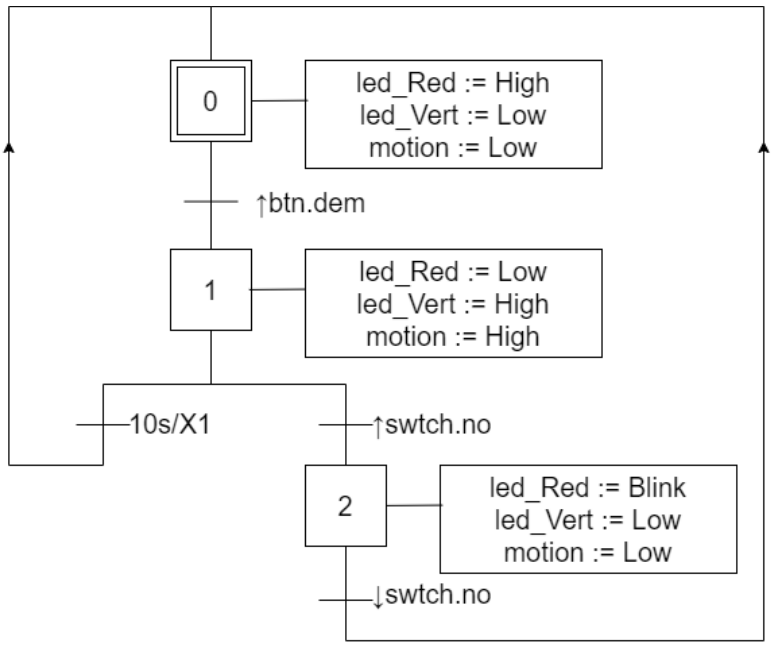

Figure n°24 : Grafcet of the distribution system

BIBLIOGRAPHY

[1] Spring Making / Wire Bending Machine, Autodesk instructables, accessed 24/01/2023, open source website,

https://www.instructables.com/Spring-Making-Wire-Bending-Machine/