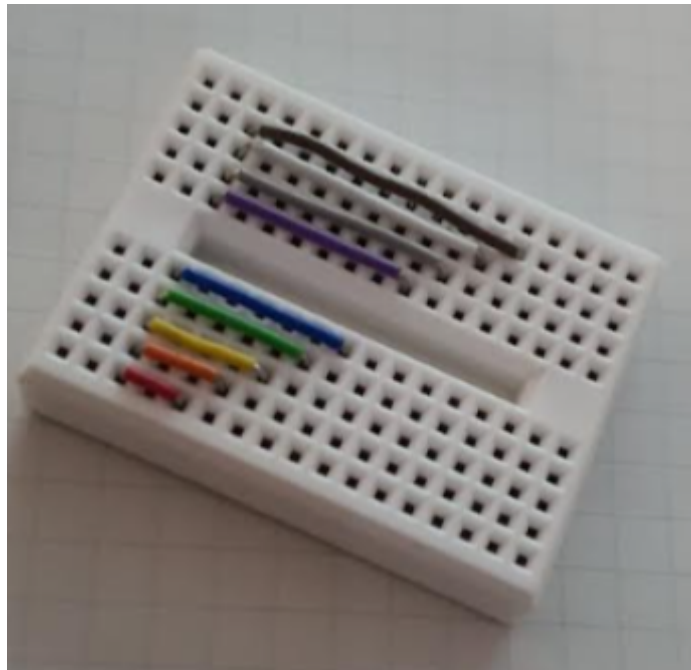


LIVRABLE 1 : JUMPER CUTTING/STRIPPING MACHINE



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

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Groupe N  : 12

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1. CONTEXT OF THE STUDY

Our project focuses on a jumper cutting and stripping machine, ordered by Fr d ric Mantegazza. This machine should be used in schools (above all Ense3) for learning and research purposes. Its main functions will be to cut jumpers for electrical devices such as breadboards and strip the jumpers out of their protective wire sleeve.

The people who will interact with the machine will mostly be students and professors. They will also be the ones to repair the machine if it ever gets broken. Indeed, our client wants us to create a maintenance and instructions manual. Also, users should be able to interact with the machine through an interface to give the machine clear instructions. The machine won't have to be sustainable in a harsh environment, however it must handle temperatures between 0 C and 30 C. The machine also has to interact with the jumpers : it must roll them out of the coil of wire, stretch them, cut them, strip them and bend them. In order to do so, the machine will be powered by a battery or an external power supply.

For this project, we have a maximum budget of 300 euros. Considering that we have many pieces to buy, this is a tight budget. We must indeed buy blades to cut the jumpers, tensioning rollers to keep the jumpers still, and maybe cutting pliers. We might also have to buy raw material such as plexiglass boards or wooden boards to build the housing of the machine. The other devices such as motors and the Arduino card should be found in GINOVA.

It is important to know that such machines already exist on the market. They are extremely performant : they do all the mentioned functions : cutting, stripping and bending the wire, and they do it neatly and fastly. The only issue is that they are expensive : for instance, the cheapest models for strip and cut wire cost around 800   [1].

2. PROBLEM STATEMENT

The main purpose of this machine is to allow students and researchers to work faster. Indeed, cutting jumpers, stripping them and bending them takes time. According to the client, the main issue with doing these tasks by hand is the inaccuracies of the jumper's length and the jumpers not being bent correctly. Indeed, the corners of the jumper are usually not straight but curved toward its center. This curve makes it difficult to place the jumpers on the breadboard.

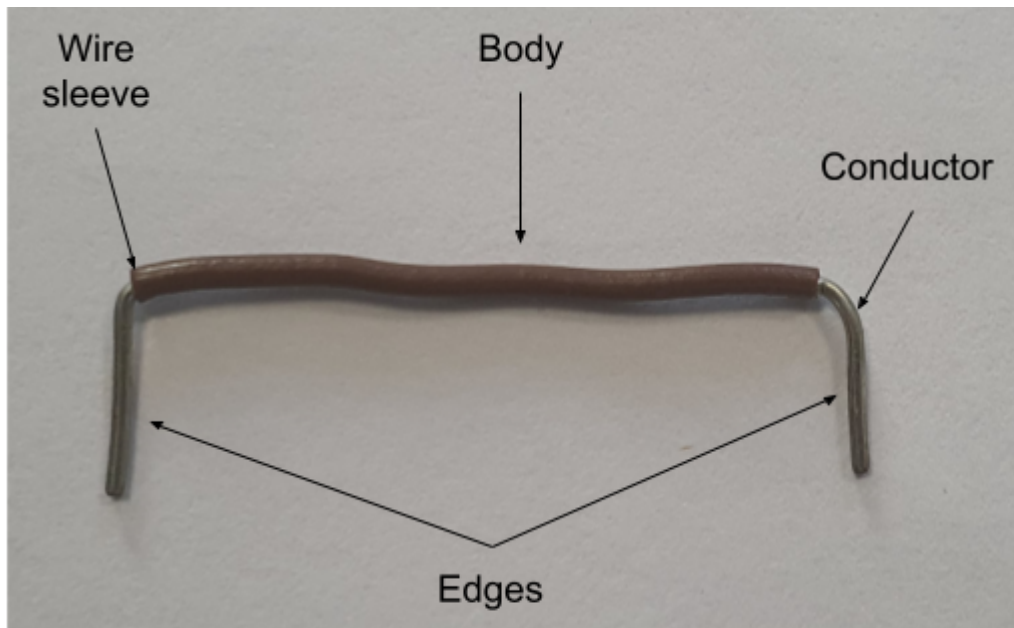
So the first challenge is to straighten and harden the corners of the jumpers. Then, the jumper's length is also difficult to get right by hand. If the jumper is too long it will bend or create knots with the other jumpers, whereas if it is too short, it won't fit in the dedicated space. Also when the jumper's length is not right, the electrical contacts are not made or badly made.

3. MAIN OBJECTIVE OF THE PROJECT

In order to best meet the customer's needs, we felt it was more efficient to ask him directly what he wanted from our machine. To do this, we drew up a first set of specifications and sent them to him. This was followed by several email exchanges and corrections to the specifications. We were also able to prioritize the functions of the machine from the most important to the least important with the customer. We also integrated a method of verification for each function (visual method, on software, by measurement, etc). To date, here are our main objectives.

First of all, the machine must distribute rigid wire. It must therefore be fed with wire, tension the wire and make it circulate in the system. The tensioned wire must not deviate from its initial axis by more than 1 millimeter.

Then, the machine must cut the wire to the right length and in bizot (45 degree angle). The length of wire to be cut ranges from 5.08 to 50.8 mm with a pitch of 2.54 mm with a tolerance of 0.5 mm. Here is the nomenclature of a jumper to make it clearer :



Nomenclature of a jumper

As for the removal of the sleeve, it must be done on the left and right parts of the cut wire on a length of 6.5 mm on each side with a tolerance of 0.5 mm. This step must be done with care in order not to damage the conductors. We have also thought of a sorting system in order to differentiate between the waste of the sleeve and the waste of the conductor wire.

For the bending part of the machine, the edges of the wires must be bent at 90° with a tolerance of 5°, and above all they must not modify the initial geometry of the wire, that is to say that the wire must remain straight.

Then, for the operation of the machine, the customer would like it to be powered by different sources (nomadic mode, 12v DC) and to withstand the temperature conditions of a laboratory. Moreover, the machine must also respect a rate of 1 jumper in 10 seconds. It must be reliable, i.e. it must produce at least 10 jumpers in a row that comply with the specifications mentioned above. But the machine must also be dismountable and mountable with simple tools in one hour maximum.

As far as safety is concerned, the customer would like the machine to stop completely in less than one second with a simple manipulation. Also, if the instructions are not followed, the machine should not start. Moreover, during its operation no moving part of the system should be reachable by the user.

Finally, for the spatial dimensions, the system must not exceed the dimensions L50*W30*H30 cm and must not weigh more than 15 Kg.

4. DELIVERY

The Client expects us to create a working prototype that, at a minimum, would validate the functionality of such a system. The project started this year with our group, so we don't have any bedrock. The client plans to keep the project going (at least for the next year), so our work will be the bedrock for the next groups that will take over. The client doesn't expect us to have a complete functional system. He asked us to prioritize the cutting and stripping of the wire with a minimum of electronic automation. The bending part can be done by a manual device for this year, but should also be automated in the long run.

Moreover, the project will have to be open source at the end, so it will be necessary to keep a clear documentation of what has been achieved to make it reproducible and improvable by people outside the project. A user manual and a maintenance manual are also expected at the end of our project.

The client has no particular expectations regarding the project's promotional video, so it will be made to meet the school's requirements.

5. STATE OF THE ART

Since a few decades, human beings have been using wires, especially jumpers, for electronic systems and often need to cut and strip them. That's why they have created both wire cutter and wire stripper, then he wanted to do both those tasks with only one tool. Today, there are machines which can automatically cut and strip wires. They can either be big industrial machines or homemade ones depending on making rate, quantity, ... It's also possible for some machines to bend wires in order to make jumpers.

Using wire stripper or special blades can be considered as the main way to get stripped wires even though a carbon-dioxide laser is a good solution as well. However, a carbon-dioxide laser is very expensive thus outside the budget. The last solution to strip a wire we thought about consisted in using chemicals to dissolve the wire sleeve but we have quickly forgotten this solution because of its dangerousness.

About bending, there are many existing solutions and not only the basic one by using a plier but also, for example, an interesting and uncommon way with a hot wire. On the Internet, most bending machines work with a spinning part (linked to a stepper) and an offset axis.

A wire cutting machine “typically feeds the wire in on a reel, marks the wire using an inkjet or hot stamp printing mechanism, cuts the wire, and then coils the finished product on another reel or stacks it in a guide channel” [2].

A wire cutting/stripping machine usually has a rotating blade that follows the input cable and strips or cuts away the insulation.

However, such tools are expensive, and can’t be afforded by small workshops. For example, the Model WS-212 wire stripping machine by Bluerock Tools costs \$ 1,299.00. Moreover the machine weighs 90 kilograms which is not convenient to be carried. The main issue with old wire cutting machines is the fact that they are not accurate or reliable. They tend to waste material which is an important issue when you are doing a project for the school of the environment.

Before the appearance of the first machines for cutting and stripping electrical wires, these tasks had to be done manually. Thanks to the particular shape of its blades, the "classic" cutting pliers can easily cut wires of various diameters.



Cutting pliers

For the stripping pliers, there are more or less sophisticated models. A calibrated wire stripper is very interesting for stripping small diameter wires, but its range of action is limited by its size. Indeed, the more it is possible to use it for different wires, the more it will be cumbersome. For this reason, it is sometimes interesting to have a second stripper at one's disposal to strip wires with a larger diameter.



Calibrated wire stripper and stripping pliers

Stripping a wire is based on the principle of two blades that partially cut a sleeve that surrounds the electrical wires. Then pull to detach a piece of the sleeve. However, it may be interesting to be inspired by the principle of a foil cutter. That is to say, to have a device equipped with four rotating circular blades that can cut the sleeve around the wires completely.

The use of blades to cut and strip wires is certainly the most common because of its simplicity, its low risk of injury but especially its very low cost compared to other devices.



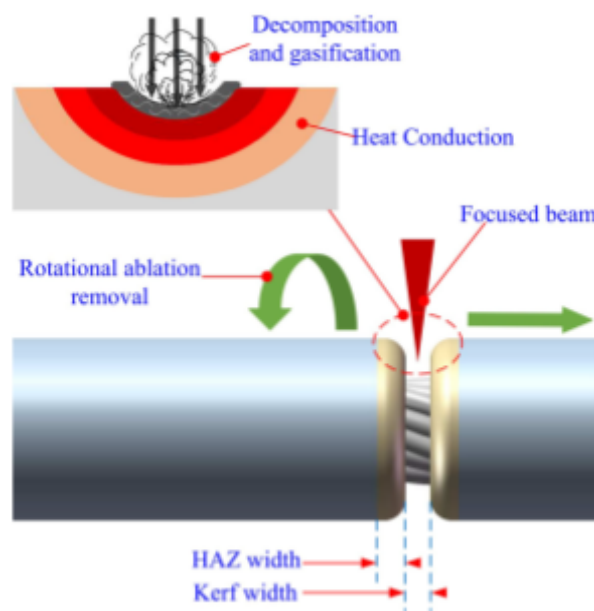
Wire foil cutter

It is possible to perform these cutting and stripping tasks automatically with machines made by professionals [3] and usually sold at high prices. However, many individuals wish to have such machines to make their own jumpers. That's why there are DIY machines [4] with tutorials available online so you can make them yourself. All of these machines work in much the same way. The wire first passes through a tensioning system which also allows to straighten it. It's then pulled by rollers which, according to their direction of rotation, make

the wire advance or retreat. Finally, these machines use two V-shaped blades capable of cutting and stripping the wire. The whole thing is often managed by an Arduino type board that controls stepper motors. Finally, the use of such machines allows to cut and strip wires much faster than with pliers. It is especially possible to manufacture some of them for a lower cost.

V-blade technology is not the only technology that can be used for wire stripping. In fact, some individuals have already built their own machines and used a laser to strip the wires.

You might wonder why should a laser be considered for this purpose when the equipment is significantly more expensive than the competing methods? The answer lies in its easy integration with electromechanical equipment, high controllability, non-contact process and no cutting force on the workpiece. Previous researches have proved that laser means has absolute advantages over traditional ways of mechanical wire stripping. [5]



Laser wire stripping process

Currently, carbon dioxide lasers are used on stripping machines because of their ability to selectively remove only the insulation without damaging the wire. The absorption coefficient of non-metal material for this kind of laser wavelength is high and the absorption coefficient of metal material for this kind of laser wavelength is low, so the metal layer will not be damaged.

Laser wire stripping has been effectively applied as a production process in the aerospace, medical and data communications fields. There are specific advantages of using a laser over other methods but the emphasis varies from application to application.

Advantages :

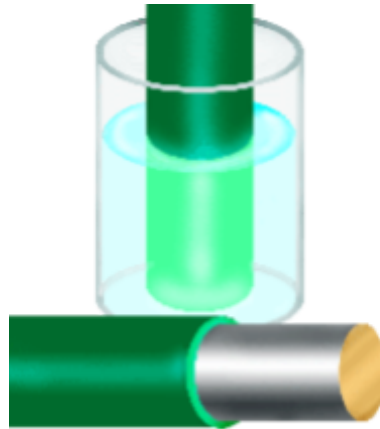
- Selectively removes insulation with no conductor damage.
- Near perfect process yield.
- Lowest rework costs.
- Provides excellent wire integrity, significantly increasing product life and reliability.
- Can be automated, reducing labor costs.

Lasers have become valuable tools in manufacturing. Laser wire stripping is now performing production requirements very satisfactorily. The companies requiring wire stripping can now use lasers for this purpose and have various processes that cover all insulation materials presently in use.

Drawbacks :

- High component costs.
- If not fully automated, need for protection for users (closed carter and protective eyewear).
- Need for a ventilation system to avoid accumulation of toxic fumes.

In the 2000s, NASA developed a manufacturing standard for wire stripping using chemical agents [6] . This method can only be used for single-conductor wires, but it is effective and allows a clean stripping without sleeve residues. However, the use of such chemical agents remains dangerous even if it seems to be possible to buy professional chemical pots [7] that enable the user to strip wires by using the method with chemical agents.



*Wire preparation
chemical stripping*

In order to bend the wires in the least complex way possible, one would simply use pliers to bend the stripped ends into the desired jumper shape. The disadvantage of this method is that it is not very fast, it can be a pain for smaller wires and it does not allow a good regularity of the jumper shape. On the other hand, it is possible to consider 3D printing a bending die allowing to deposit the wires according to the corresponding size, then to press on the edges in order to bend them. This method could also be semi-automated or even totally automated by considering two dies (female and male) that would perform the bending and would overcome some of the shortcomings of the entirely manual method.



3D printed bending die

The most commonly used solution for bending wires is to use a part controlled by a stepper motor and equipped with an eccentric and extruded cylinder. There are many machines with different designs. Indeed, some are arranged horizontally [8] and others vertically [9] . It does not seem that either of these operating modes offers any particular advantages. The majority of the machines only allow folding. However, there are some machines that are able to perform all three tasks at once [10] .

The last possible method is probably one of the least used, but it is quite possible to bend wires using an electrically heated wire [11] . It works in much the same way as the bending die, but the effort required to bend the wire is reduced. The main disadvantage of this technique is obviously the risk of burning.

6. WORKPLAN

From the beginning of the project, we had in mind to share the work between us by "Functional Block" of the project (cut, strip, fold, feed) to allow us to advance in parallel and thus to be more efficient. Moreover, our objective was to get as close as possible to the **customer's expectations** by regularly exchanging with him on our progress or our questions. That's why the **AGILE method** seemed to be adapted in our case.

We are going to apply it by separating ourselves into two groups (2 and 3 people) who will each take care of one of the functional blocks during a design cycle and which will then be concluded by a **customer feedback**. Once this feedback is done, we start a new design cycle, either to make adjustments or to start a new functional block. Moreover, this method offers us the advantage of being quite **flexible** because if we are short of time, we can decide to "amputate" the system of certain functions (the priorities having been defined with the customer).

As things stand now, and taking into account that we don't only have the PDP in our schedule. We hope to complete at least 2 cycles before we reach the phase where we will integrate all our functional blocks into the complete system (assembly phase).

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

Agile cycles of our project

Our goal is to send at least one email to the client every 2 weeks to allow him to **be involved in our progress**.

For now, we have done all the preparatory phase to be able to divide the work and understand the ins and outs of the project. Now, we will split up and start the first Agile cycle in anticipation of a meeting with the client just before the Christmas vacations.

With regard to document management, we have a drive because the project is not subject to industrial confidentiality. And we have decided on a **title nomenclature** as follows:



Title nomenclature of our project's deliverables

Nevertheless, we make sure that the latest version of a document is on chamilo.

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Picture's link :

- [cutting pliers](#)
- [calibrated wire stripper](#)
- [stripping pliers](#)
- [wire foil cutter](#)
- [wire preparation chemical stripping](#)