



REFITTING  
MACHINE

DESIGN AND ENGINEERING OF SIMPLE  
PARTS NEEDED FOR MACHINERY  
REVAMPING



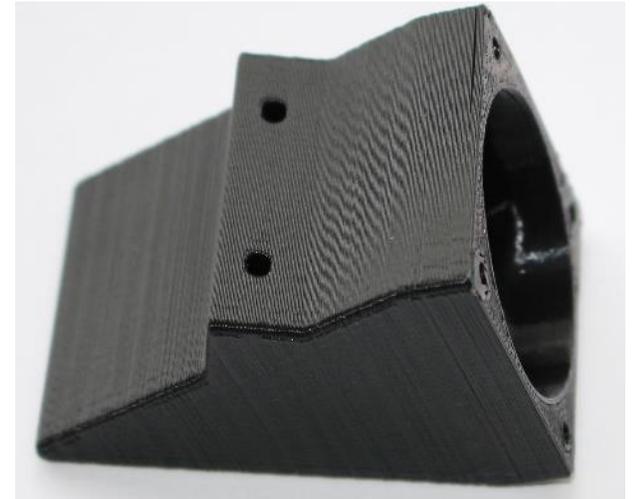
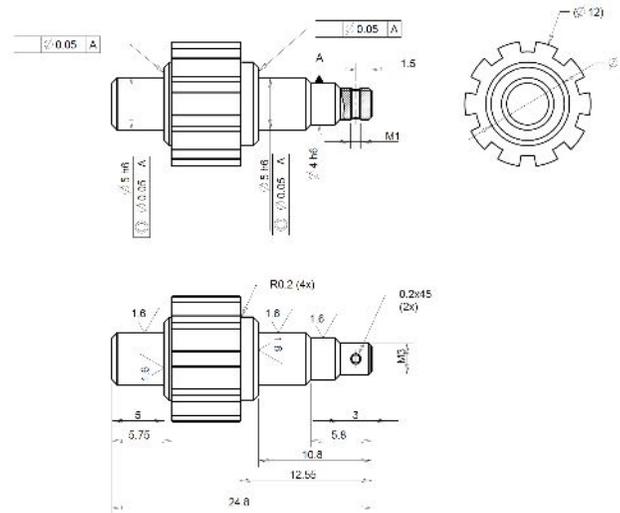
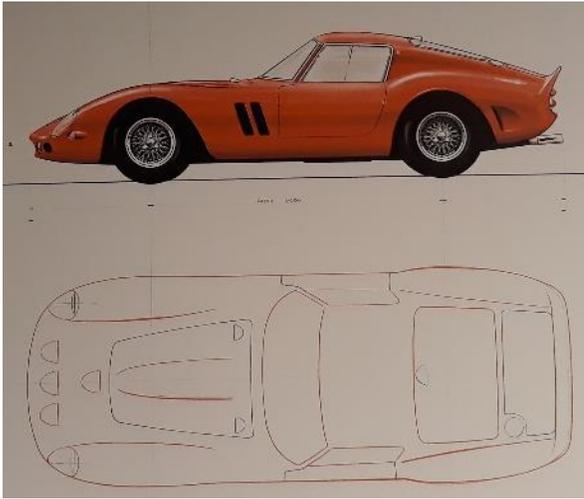
Co-funded by the  
Erasmus+ Programme  
of the European Union

## Aims and objectives

CHAPTER AIM:	To equip learners with the basic knowledge needed to design simple parts for machinery revamping
COMPETENCES:	<ul style="list-style-type: none"><li>• Ability to design a simple part</li><li>• Ability to 3D model a simple part</li></ul>
LEARNING OUTCOMES:	<ul style="list-style-type: none"><li>• Understanding the design and engineering process applied to simple parts</li><li>• Knowledge on 3D modelling a simple part</li></ul>
NUMBER OF HOURS:	4

# Lecture Outline

1. Introduction
2. The design process
3. Design tools and resources
4. Case-study
5. Conclusions



# Introduction

—

# Introduction

- **Design & Engineering** is the process of translating an idea or a need into the detailed information from which a part can be manufactured.
- **Machinery revamping** is a technique aiming at regenerating or modernizing existing equipment while at the same time conserving most of its functional parts.
- In this chapter we will consider only **simple parts** that a maker can design and fabricate by hobby 3D printing and CNC machining and/or other accessible technologies.

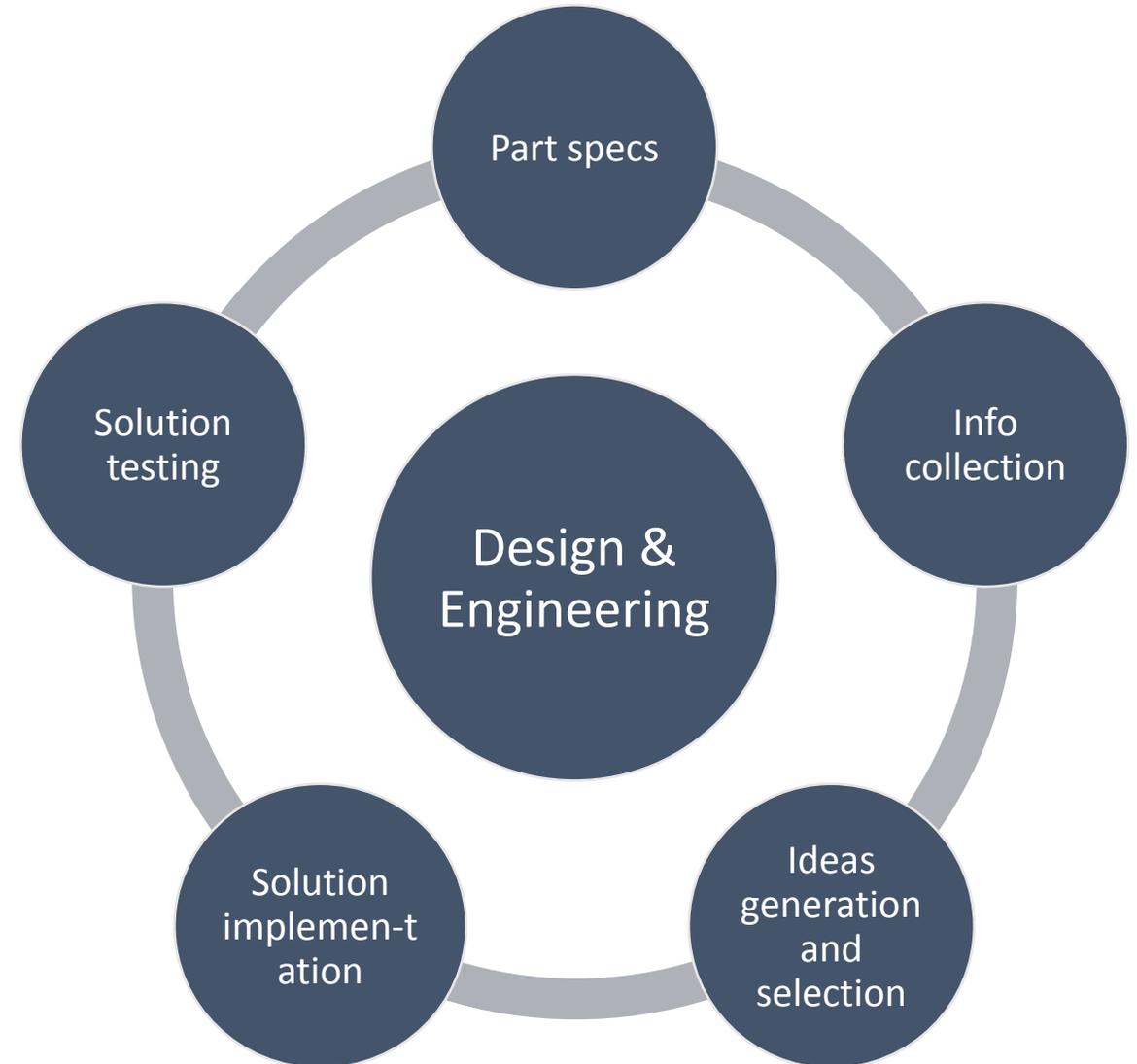


# The Design Process

—

# Simple parts design & engineering process

- Design & engineering is, basically, a process of problem solving consisting of several steps. It starts with the definition of the problem to be solved (for example, the specifications of a part needed for a particular application), involves some research (such as existing and possible solutions), some thinking to come up with ideas on how to solve the problem followed by the selection of the most suitable one. Testing the selected solution is also a part of the process.
- If the tested solution proves not to be satisfactory, the last three steps must be done again, until the right solution is found.



# Define the requirements for the part

There are many requirements that must be considered in the design process in order to obtain a proper part.

Some examples are as follow:

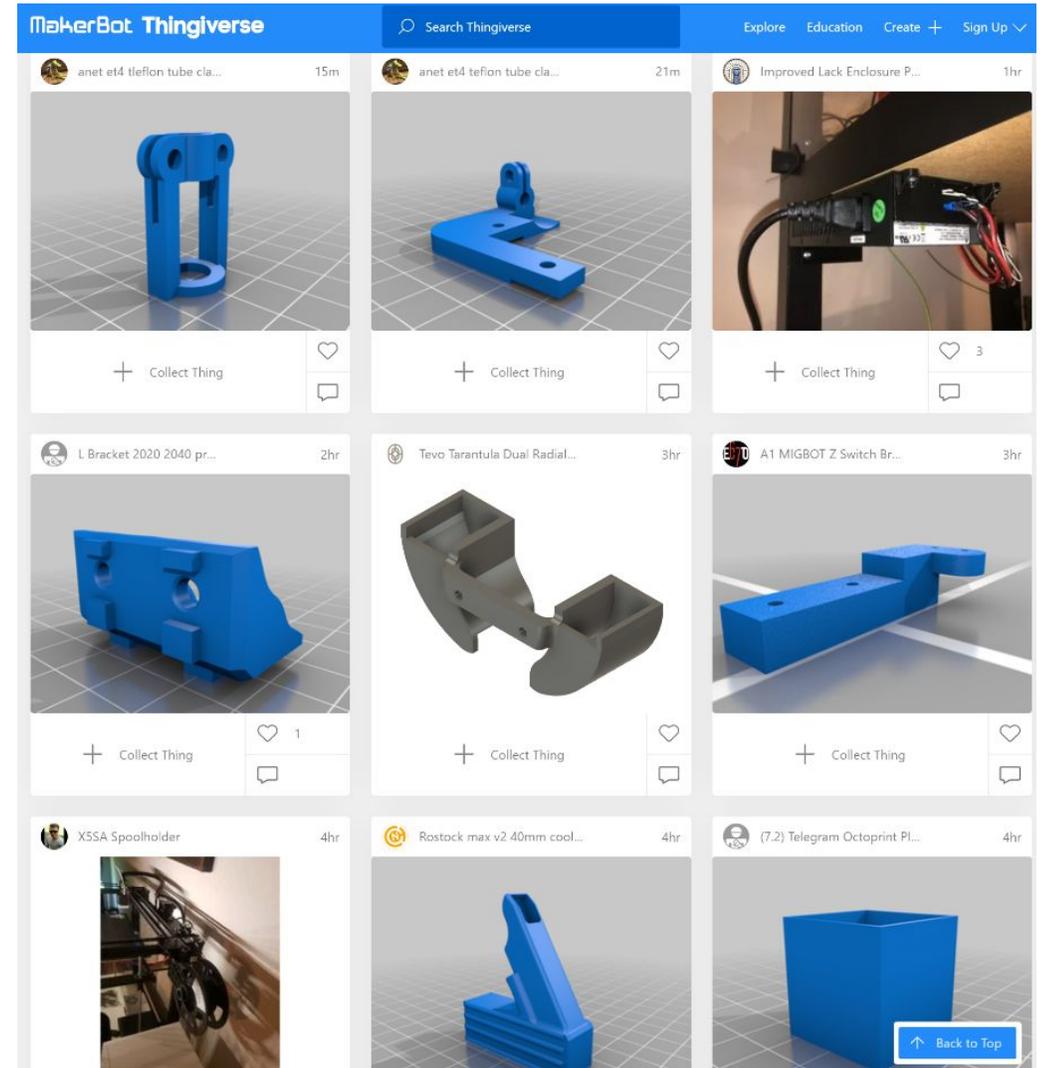
- Desired functional characteristics
- Geometry and dimensions
- Physical characteristics: weight; melting point; elasticity; transparency, etc.
- Interface - to allow part's connection with other components
- Performance characteristics: strength; accuracy; permeability, etc.
- Manufacturing method
- Environmental requirements: indoors/outdoors use; operating temperature range; corrosion resistance, etc.
- Material and Cost



# Collect information

Before going further in the design process, one needs to collect information related to the part. **Some important actions could be:**

- Check out existing online communities and forums, like [www.grabcad.com](http://www.grabcad.com) , [www.tinkercad.com/](http://www.tinkercad.com/), etc. or online 3D models repositories, like [www.thingiverse.com](http://www.thingiverse.com), to see if some comparable parts were already designed/made by someone. Analysing these examples could provide learning, useful information and inspiration.
- Study catalogs, technical documentation, etc. related to the components that may affect your design (electronics, bolts, nuts, bearings etc.). If possible, measure and analyze the existing components that may interact with the part to be designed.
- Talk with people that have experience with similar projects or activities. If possible, discuss with members of local makerspaces.



# Select and test a solution

- Usually, more than one solution can exist so generating and analyzing several possible variants could lead to a better part. For example, by considering various manufacturing technologies and materials one can arrive to different solutions and select the best one among these.
- The selection criteria for a simple part design idea could be as follows:
  - The availability of technology for part manufacturing
  - The time needed to obtain the part
  - The availability of required materials and components
  - The total cost
- Testing a part could range from a simple check if it fits or not to destructive tests to determine its strength. The testing requirements depend on the application, on the effects of a potential failure, etc.



# Design tools and resources

—

# Introduction

The main tools and resources needed for design and engineering of simple parts are as follows:

- a computer
- a Computer Aided Design (CAD) software
- Information resources:
  - Characteristics of specific off-the-shelf components
  - Technical information
  - Tutorials, learning materials
  - 3D model repositories
  - Online communities, specific forums

## 3D models repositories

Name	Link
Thingiverse	<a href="http://www.thingiverse.com">www.thingiverse.com</a>
MyMiniFactory	<a href="http://www.myminifactory.com">www.myminifactory.com</a>
Cults	<a href="https://cults3d.com">https://cults3d.com</a>
Pinshape	<a href="https://pinshape.com/">https://pinshape.com/</a>
YouMagine	<a href="http://www.youmagine.com">www.youmagine.com</a>
SetkchFab	<a href="https://sketchfab.com/">https://sketchfab.com/</a>
Yeggi	<a href="http://www.yeggi.com">www.yeggi.com</a>
CGTrader	<a href="http://www.cgtrader.com">hwww.cgtrader.com</a>
STL Finder	<a href="http://www.stlfinder.com">www.stlfinder.com</a>

# Computer Aid Design (CAD)

There are many different CAD software tools available, from free software for beginners to very expensive industrial grade software. Some of them are shown in the below table.

Name	Link	Level	Free/paid
<b>TinkerCAD</b>	<a href="http://www.tinkercad.com/">www.tinkercad.com/</a>	Beginner	Free
<b>Blender</b>	<a href="http://www.blender.org/">www.blender.org/</a>	Intermediate	Free
<b>FreeCAD</b>	<a href="http://www.freecadweb.org/">www.freecadweb.org/</a>	Intermediate	Free
<b>OpenSCAD</b>	<a href="http://www.openscad.org/">www.openscad.org/</a>	Intermediate	Free
<b>Onshape</b>	<a href="https://www.onshape.com/">https://www.onshape.com/</a>	Professional	Paid*
<b>Autodesk Fusion 360</b>	<a href="http://www.autodesk.com/products/fusion-360">www.autodesk.com/products/fusion-360</a>	Industrial	Paid*
<b>SolidWorks</b>	<a href="http://www.3ds.com/">www.3ds.com/</a>	Industrial	Paid*
<b>Creo</b>	<a href="http://www.ptc.com/en/products/cad/creo">www.ptc.com/en/products/cad/creo</a>	Industrial	Paid

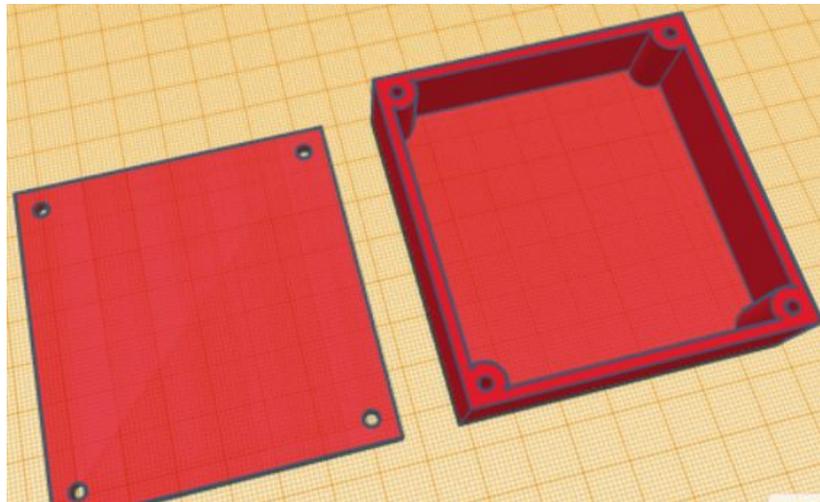
\* Free licences can be obtained by students and educators.

# TinkerCAD

TinkerCAD is a web-based software for 3D design and modeling, free and easy to use

It can be accessed on <https://www.tinkercad.com/>

TinkerCAD is a good starting point with the 3D modelling for beginners. Advanced modelers may prefer other software, like Autodesk Fusion 360 or SolidWorks but these can have a steeper learning curve.



# Autodesk Fusion 360

Autodesk Fusion 360 is a cloud-based tool for product development that integrates CAD, Computer Aided Manufacturing (CAM) and Computer-aided engineering (CAE).

It has many features, the most relevant for simple parts design being:

- freeform sculpting and modelling
- solid/parametric/mesh modelling
- simulation and testing
- machining
- 3D printing

There are several Fusion 360 tutorials available for those wanting to learn it. We recommend the course "3D CAD modelling using Autodesk Fusion 360" developed by the Erasmus+ project "Training in 3D printing to foster EU innovation & creativity" freely available in English, Romanian, Spanish, Italian, Pol

## 5. 3D CAD modelling using A360 Fusion

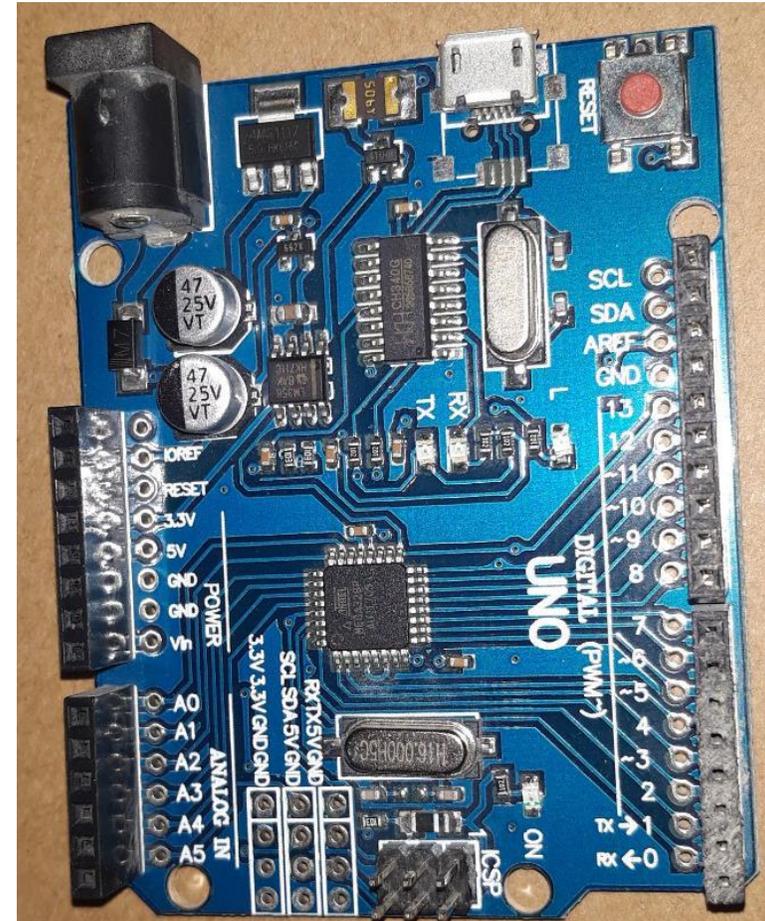


# Case study

—

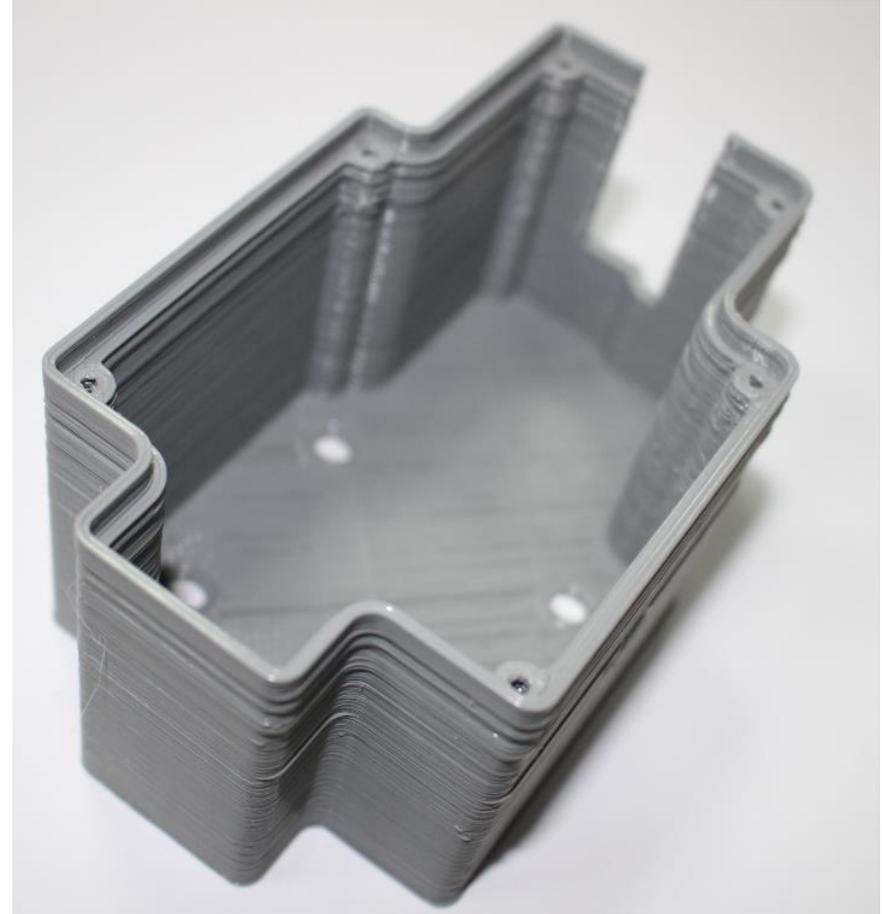
# Introduction

- In order to demonstrate how a simple part can be designed and engineered, we will design an enclosure for an Arduino Uno board
- First, we will set a list of specifications, in order to define the problem to be solved
- Next, some useful information will be gathered
- Several concepts will be generated and the most suitable one will be selected
- The selected idea will be further developed in order to clarify the design and to provide input data for 3D modelling.
- The 3D model will be created using TinkerCAD
- The .STL file needed for 3D printing will be saved from TinkerCAD



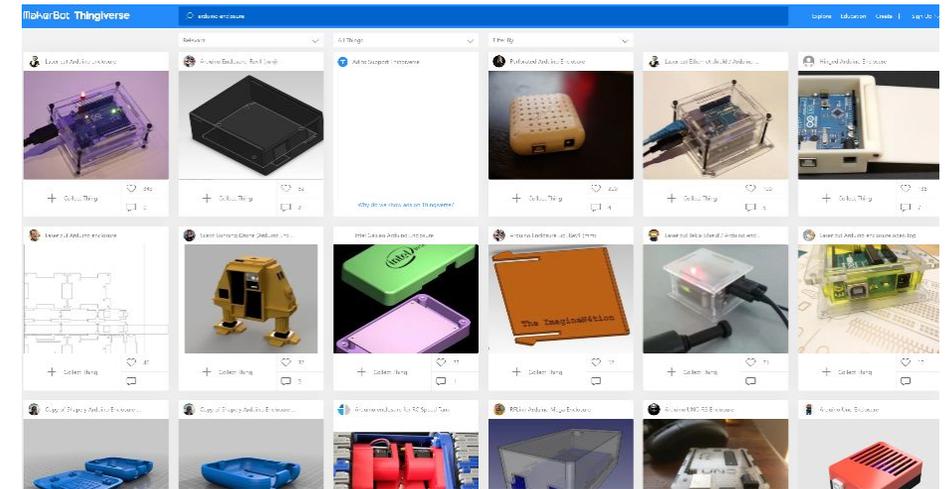
# Enclosure's specifications

- Desired functional characteristics: to safely store an Arduino Uno board
- Geometry and dimensions: suitable for holding the board
- Physical characteristics: rigid enclosure; no transparency
- Interface – only with the Arduino board
- Performance characteristics: need to protect the board from dust
- Environmental requirements: indoors use, room temperature
- Cost: not too expensive



# Gather relevant information - documentation

- A search on [www.thingiverse.com](http://www.thingiverse.com) reveals tens of different Arduino enclosures made by 3D printing or laser cutting from materials like PLA, ABS, acrylic or plywood. There are several design ideas:
  - With and without lid
  - With and without slots for plugging in cables
  - With and without cuts for ventilation
  - Bolted or snap fit cases
- We should take a look to some of the designs, analyze them, find pluses and minuses, trying to understand which are suitable for us.
- We should search information about some suitable connection solutions like bolts, screws, insert nuts, adhesives, hot gluing, etc.
- We can also check out data about the materials and manufacturing options.

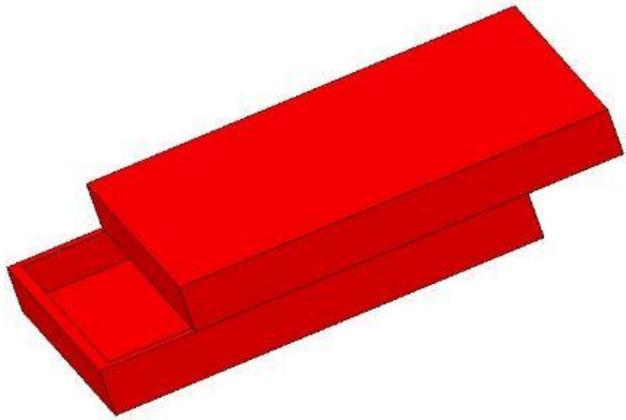




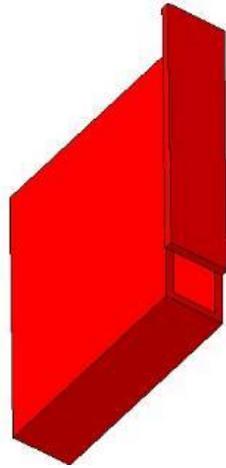
# Generating concepts, selecting the idea

- We saw during the info collection phase several concepts for an enclosure. According to our specifications we need a closed enclosure, without any opening or cut, in order to protect the board from dust.
- To be able to put the board inside the enclosure, this must be made from at least two separate parts connected in a way that allows repeated mounting/dismounting. There are several possible ways to do this, some concepts are shown in the bellow pictures. Among these, the simplest one is the variant (d), consisting of a box and a lid, so we will select it.
- There are several ways to attach the lid to the box. A simple one is to use self tapping screws and make the holes in the lid slightly bigger than the screw size and the holes in the box slightly smaller so that the screws cut mating threads into the box. We will select this method.
- The best way to manufacture the selected concept is by 3D printing. For this, we need to create the 3D printing files which include the information required for making the enclosure.

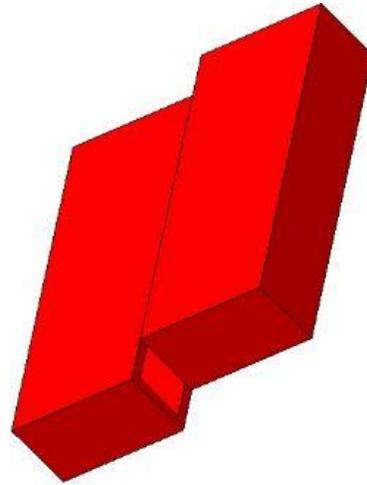
# Generating concepts, selecting the idea



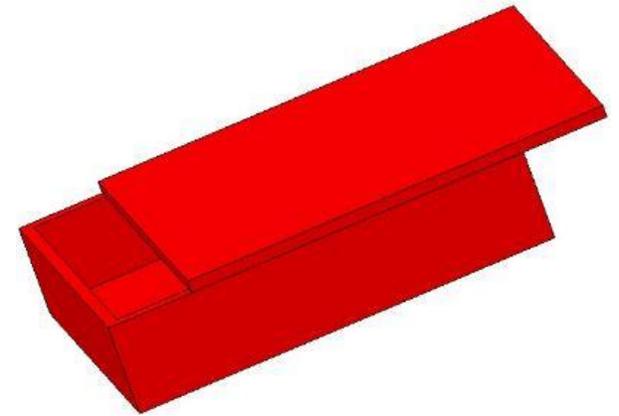
(a)



(b)



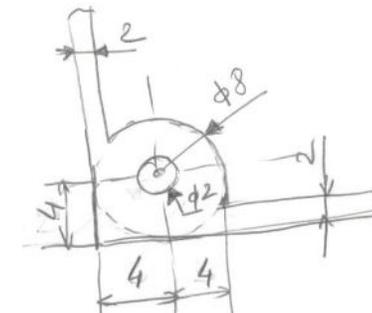
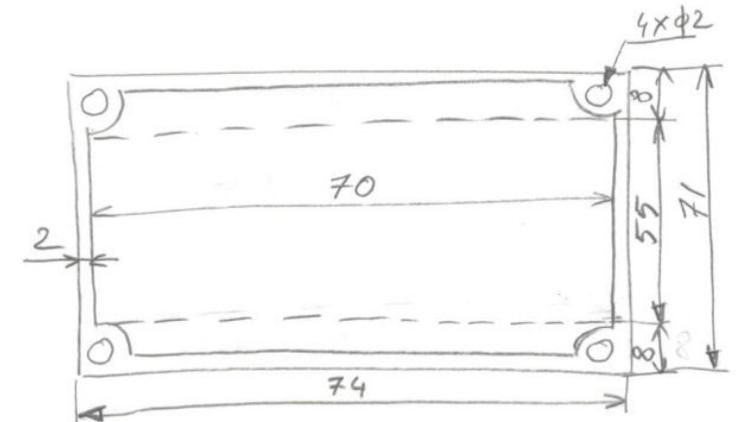
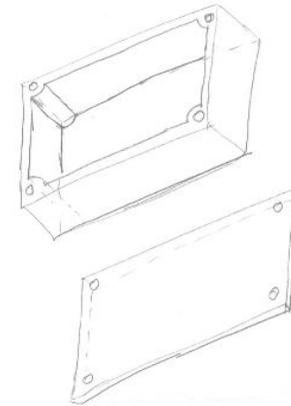
(c)



(d)

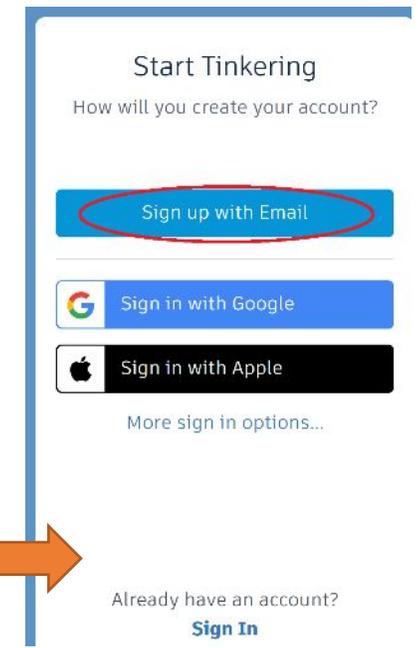
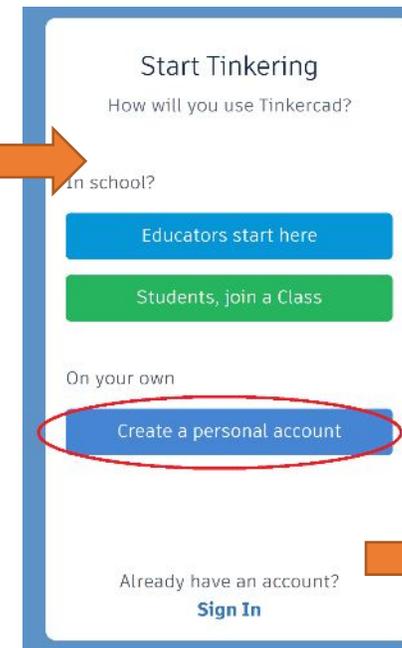
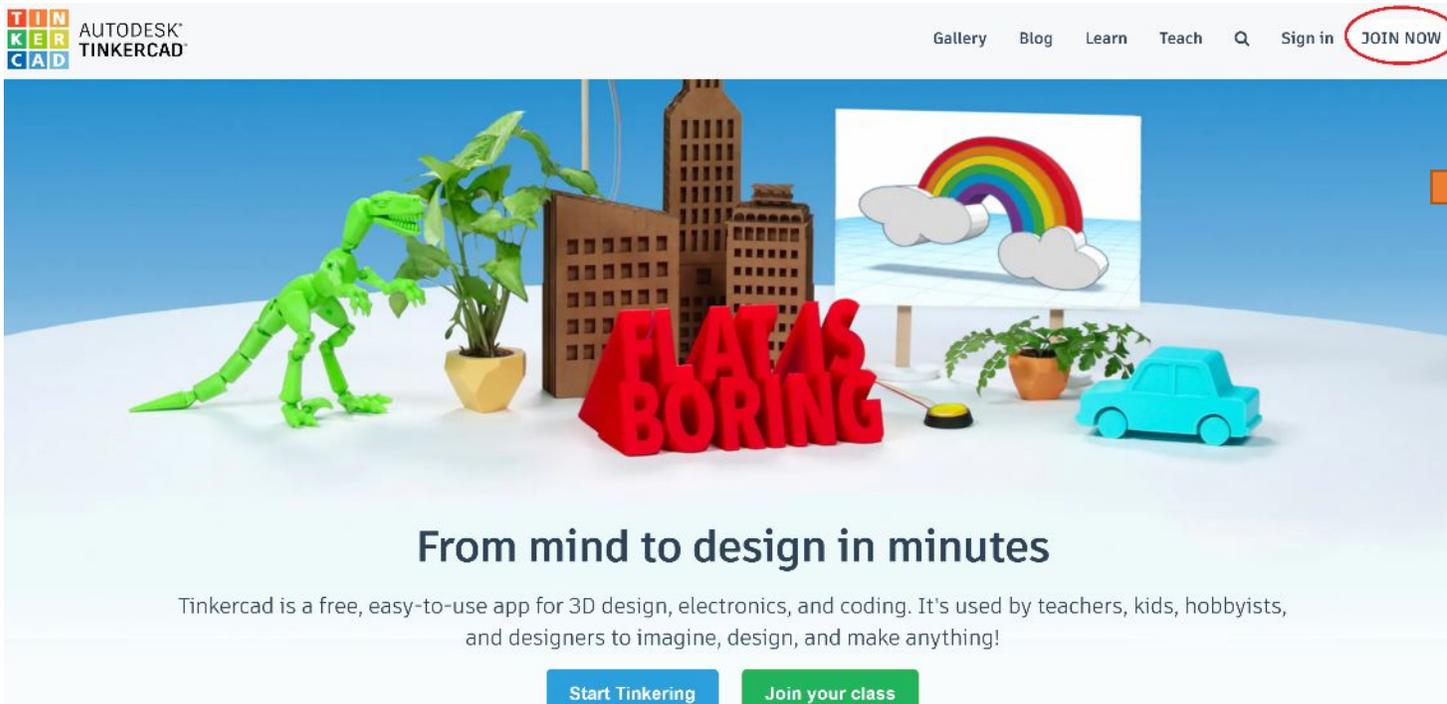
# Concept development

- The measured dimensions of the Arduino board should be rounded up to allow for some extra room in the enclosure. We will use the following dimensions for the required cavity size:
  - Length: 70 mm
  - Width: 55 mm
  - Height: 15 mm
- For connecting the lid, we will use screws having 3 mm diameter and 9 mm length. So, the holes in the lid will have 4 mm diameter while the ones in the box will have 2 mm diameter.
- Next step is to dimension the two parts. We will draw a sketch including the cavity needed by the Arduino board (70 x 55 mm) and the holes. For each hole we will allow 3 mm of material around it. The wall thickness will be 2 mm. The other dimension will simply result from the sketch.
- The height of the box will be 17 mm (15 mm the cavity height + 2 mm the basis thickness).
- We will use TinkerCAD to create a 3D model of the box and of the lid and, then, convert the 3D models in 3D print files.



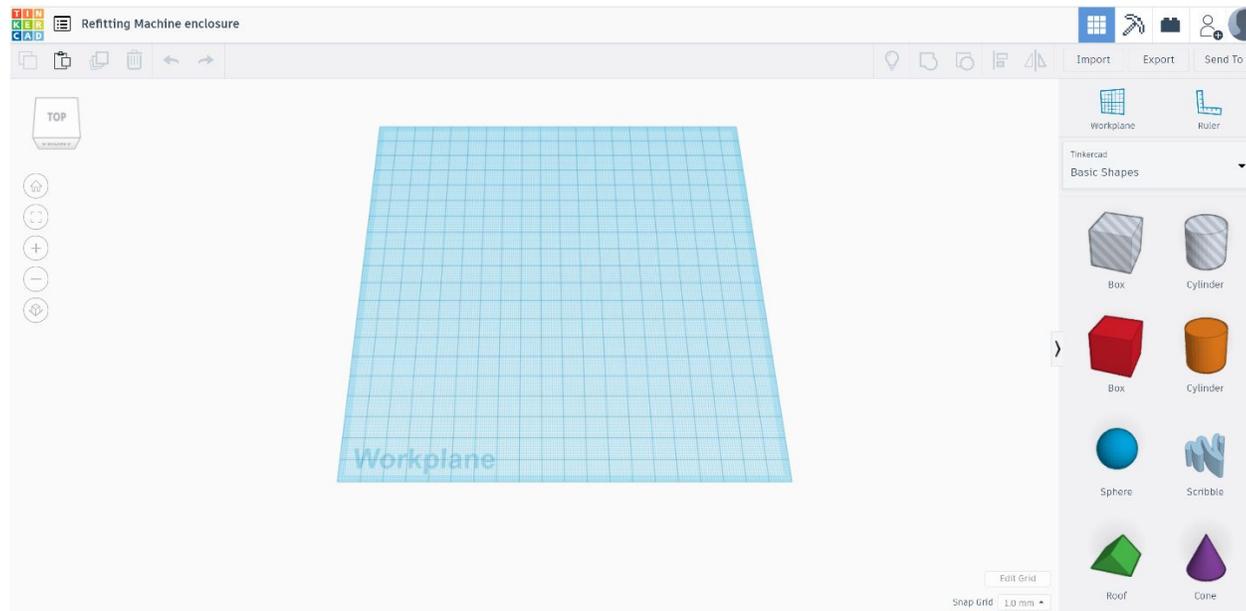
# Getting a TinkerCAD account

A TinkerCAD account is required. To obtain it, go to <https://www.tinkercad.com/dashboard>, click on "JOIN NOW" button then click on "Create a personal account" and chose how to create your account.



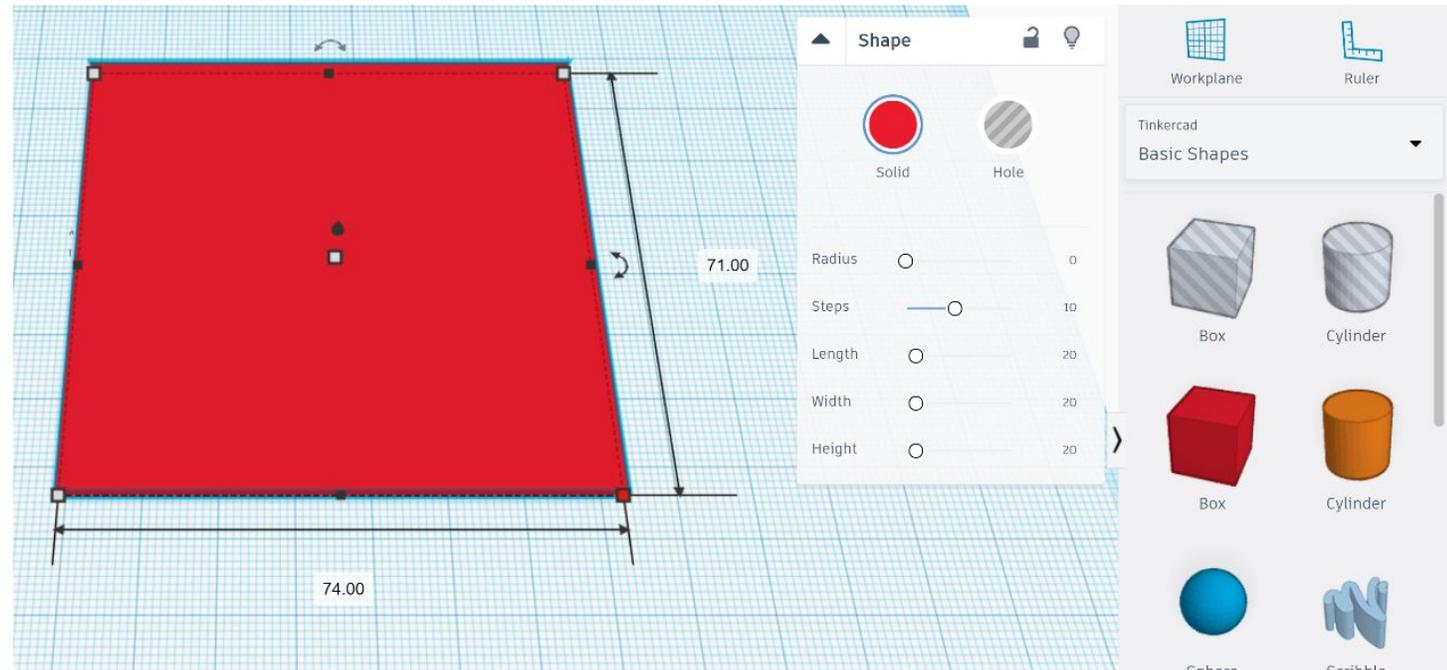
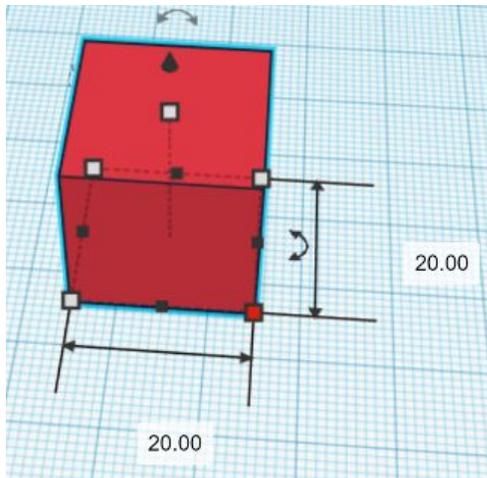
# Start working in TinkerCAD

- Login in TinkerCAD, select "*3D Designs*", click "*Create new design*" and you will see a blank workplane with several shapes on the right side and some visualization tools on the left side.
- TinkerCAD works quite simple, by dragging a shape onto the workplane, modifying it and combining it with other shapes.
- You may want to change the name of the design (top left corner) or grid properties (bottom right corner).



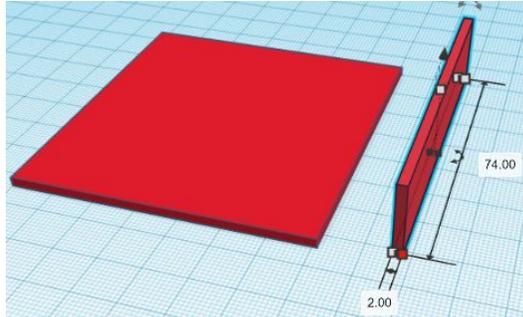
# Making the box basis

Click on "Box" shape and drag it to the middle of the workplane. Click on the white squares and the dimensions of the box should appear. Click on the dimension text and change the values to the ones of the enclosure's base (74 x 71 x 2 mm).

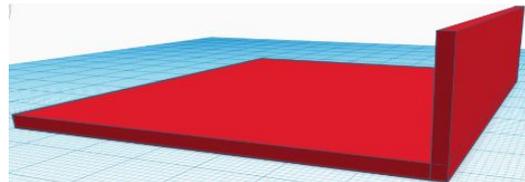


# Making the first wall

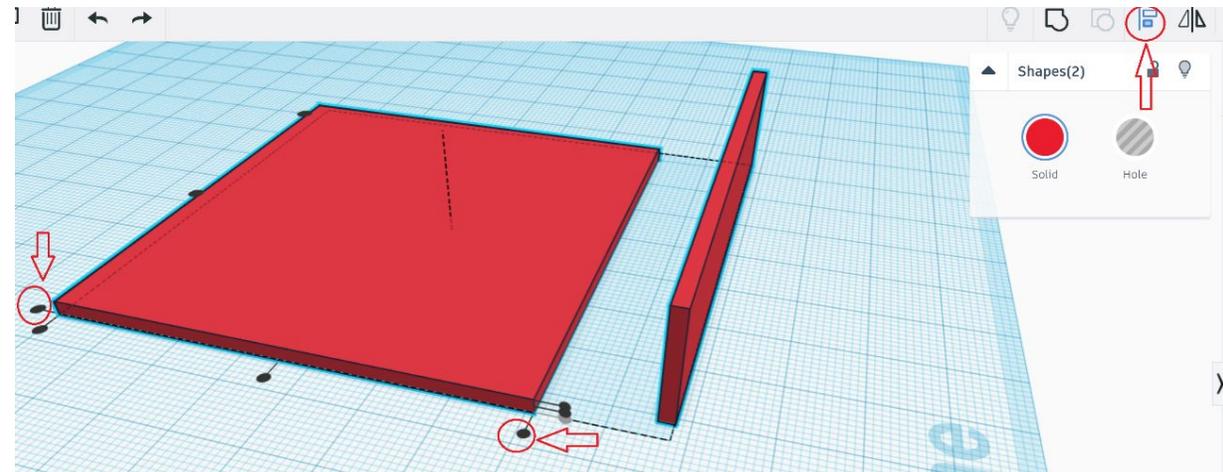
- Click on "Box" shape and drag it on the workplane. Change the dimensions to those of the first wall (74 x 2 x 17 mm).
- Select both basis and wall (left-click and drag a selection around them) then select the "Align" button (upper-right corner). Next, click on the basis (this way only the wall will move) and then click on the black dots indicated in the picture. The wall should be align with the basis now.



Wall dimensioning



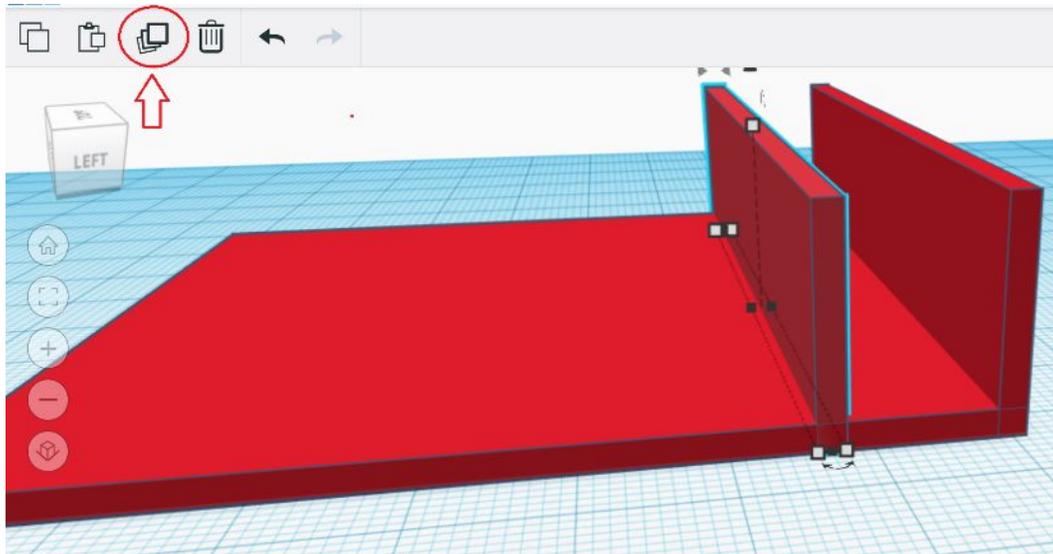
Aligned basis and wall



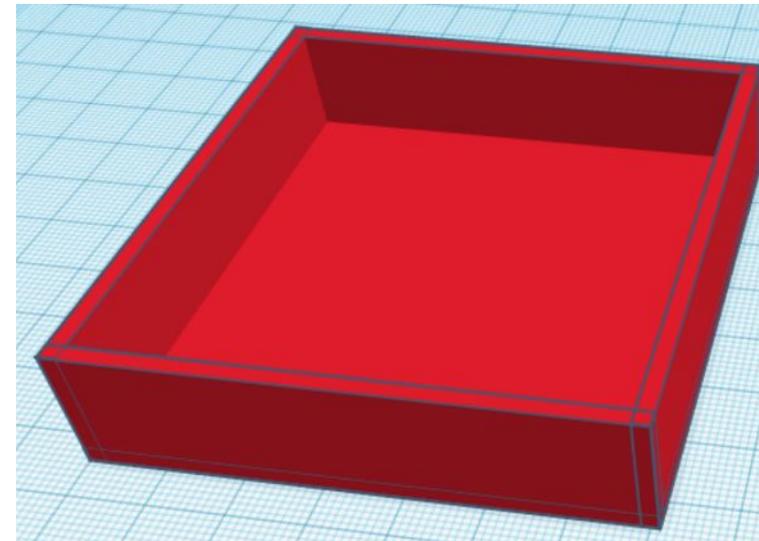
Basis and wall aligning process

# Making the rest of the walls

- Click on the first wall and then on “Duplicate” button (upper-left corner). Left-click and drag away the duplicated wall.
- Align the basis and the duplicated wall as shown previously.
- Repeat the operations to make, duplicate and align the remaining 2 walls. You should obtain something similar to the below picture.



Wall duplicating



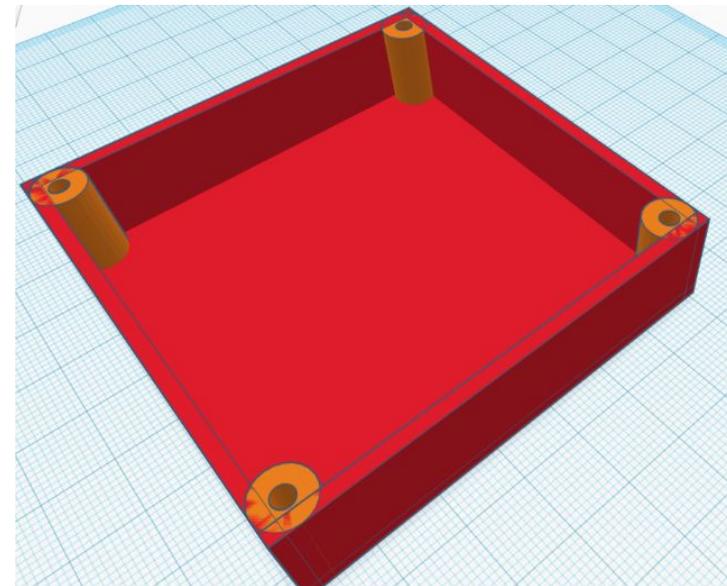
Aligned basis and walls

# Making the screw holes

- Click on “Tube” shape and drag it on the workplane. Change the dimensions to 8 x 8 x 17 mm and the wall thickness to 6 mm.
- Align the tube and the basis as shown previously.
- Duplicate and align to get other 3 three screw holes. You should obtain something similar to the below picture.



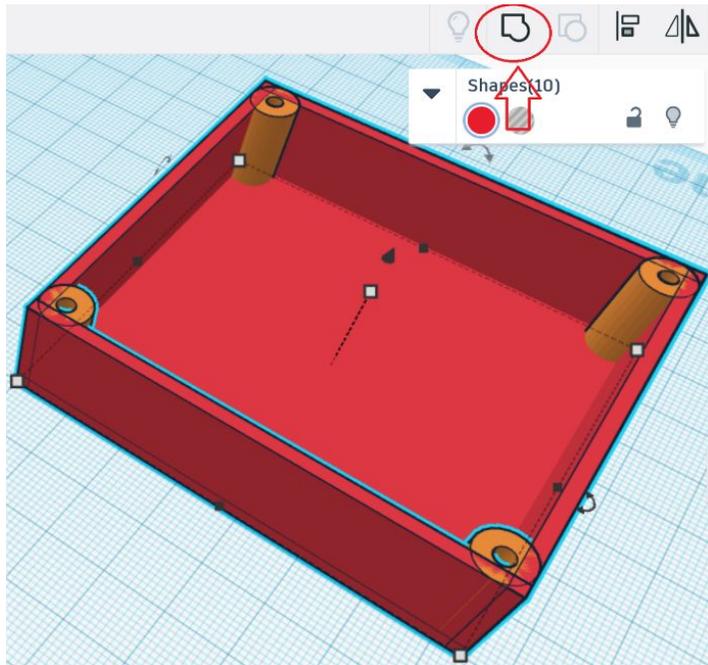
Making a tube with 2 mm inside diameter and 8 mm outside diameter



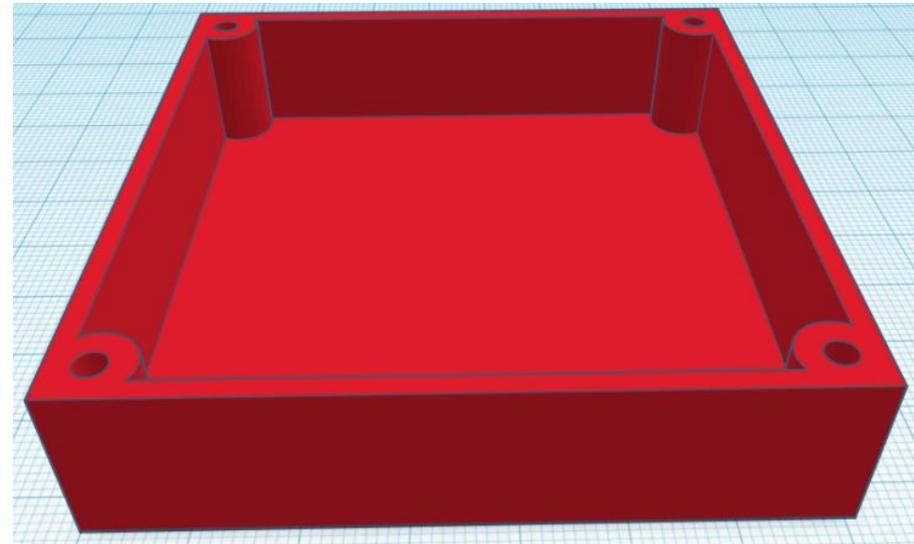
Aligned basis, tube and walls

# Making box as one single object

Select all the objects and click on "Group" button (upper-right corner). This will combine them into one object.



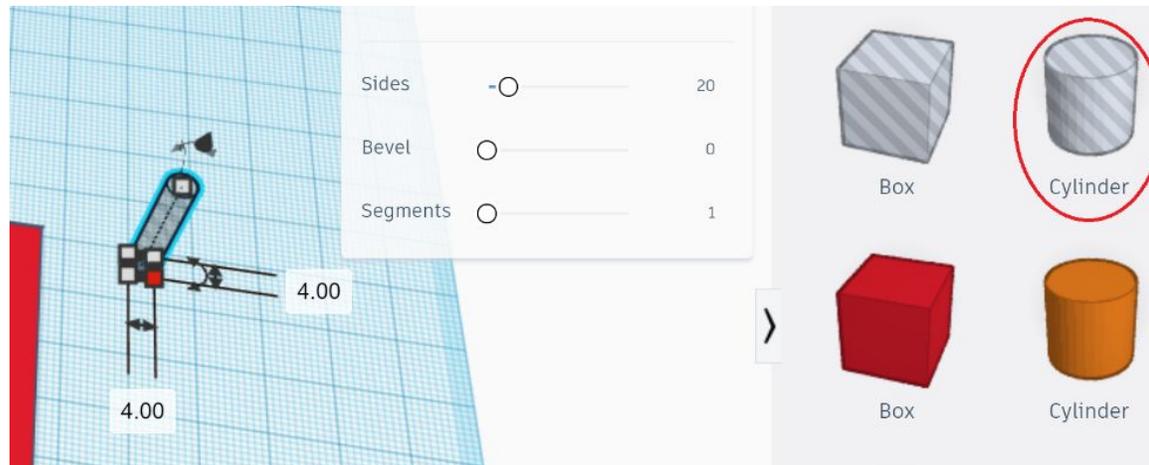
Combining all objects in a single one



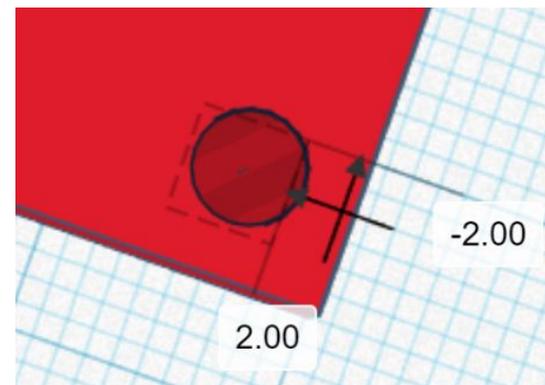
The final model of the box

# Making the lid

- Use “Box” shape to create a 74 x 71 x 2 mm plate.
- Click on the gray striped “Cylinder” shape and drag it on the workplane. The cylinder will be used to create a hole by combining it with the plate. Change the diameter to 4 mm and height to 2 mm.
- Align the cylinder with a corner of the plate. Then, click on the cylinder and begin to drag it toward the center of the plate. You should see some numbers appear showing how much you're moving the object in the two directions. Click on one of those numbers to edit it – the hole should be at 2 mm from each of the sides.



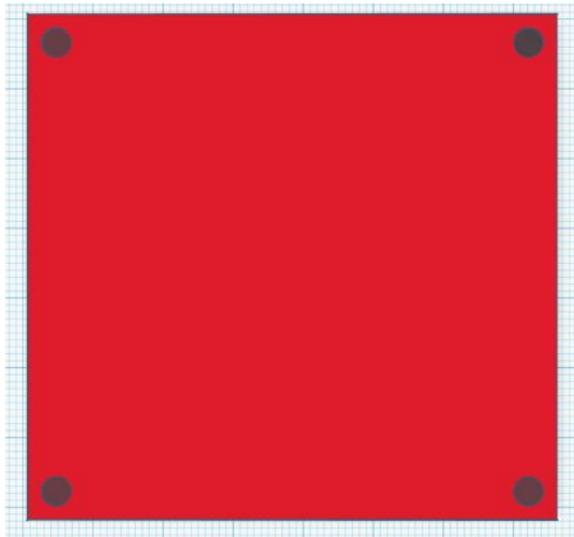
Dimensioning the cylinder



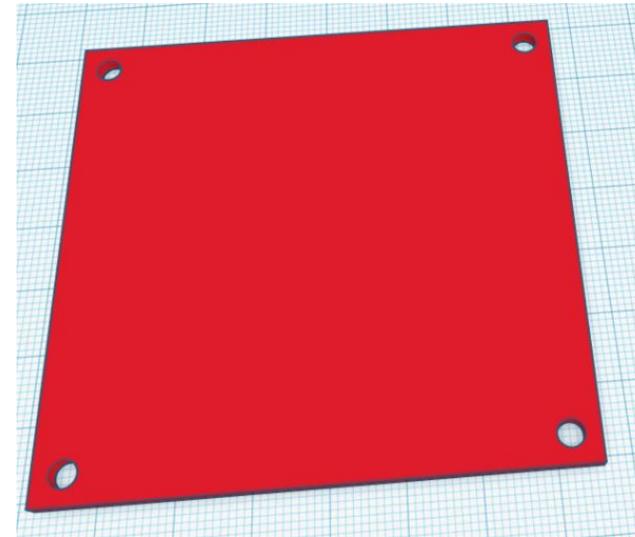
Cylinder positioning

# Completing the lid

- Duplicate the cylinder and move the duplicates in the positions corresponding to the other three holes.
- Select all the objects and click on "Group" button. This will combine them into one object and, because the used cylinders are hole shapes, they will subtract material from the plate thus creating holes. You should obtain something like in the picture below.



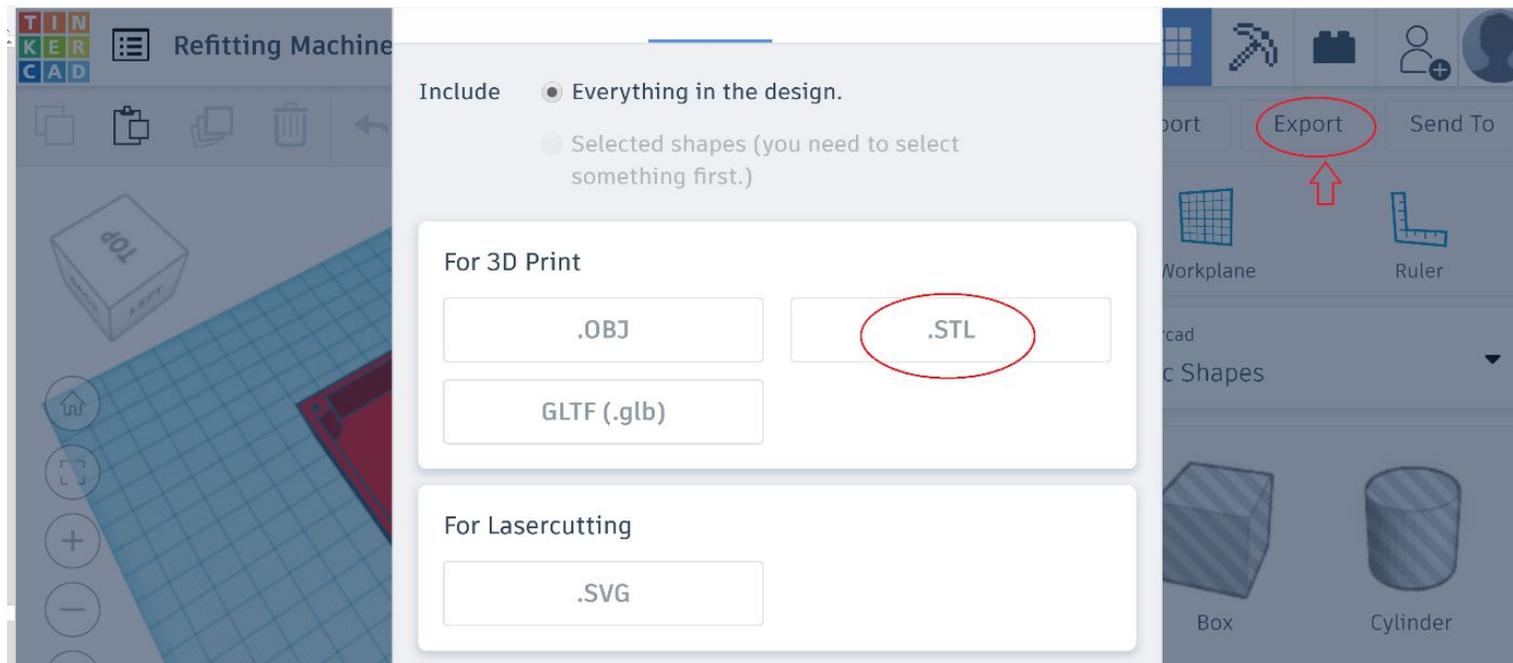
Cylinders positioning



The final model of the lid

# Creating the files for 3D printing

- In order to 3D print the models we created, these models need to be exported as .STL files.
- Click on “Export” button and then select .STL. The .STL file should be downloaded on your computer and can be used to 3D print both the box and the lid.

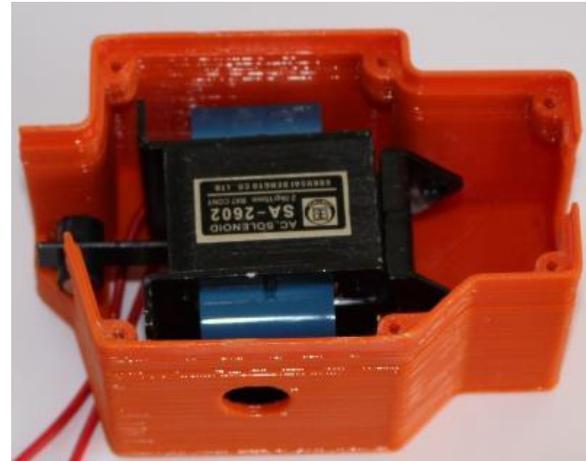
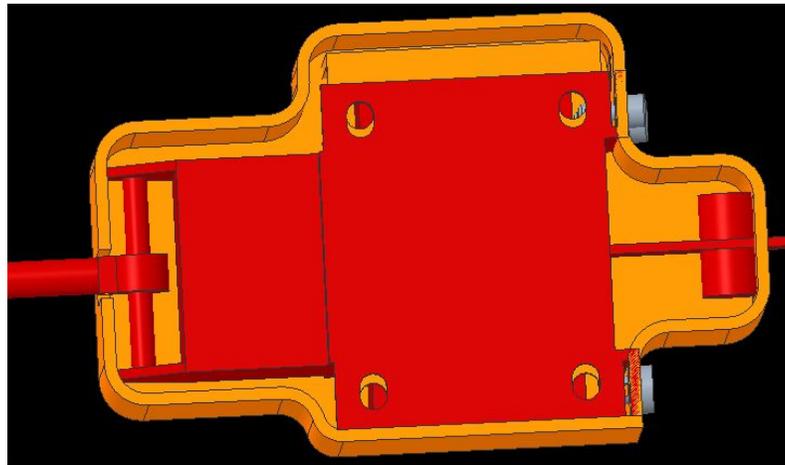


# Conclusions

—

# CONCLUSIONS

- Design and engineering is a process that makes possible the transformation of an idea in a physical part.
- The simple parts needed for machine revamping can be designed using free software, like TinkerCAD, which also create the files needed for 3D printing or laser cutting.
- Various useful tools and resources are available for those wanting to design and engineer simple parts.



# Source/References



GRABCAD – free CAD library, tutorials

<https://grabcad.com/>

Thingiverse – 3D models repository

<https://www.thingiverse.com/>

Tinkercad - a free app for 3D design

<https://www.tinkercad.com/>

3D printing course, including design and 3D modelling chapters

<https://3d-p.eu/lms/>



Tinkercad tutorial

[https://www.youtube.com/watch?time\\_continue=610&v=60xflu-lqAs&feature=emb\\_logo](https://www.youtube.com/watch?time_continue=610&v=60xflu-lqAs&feature=emb_logo)

Co-funded by the  
Erasmus+ Programme  
of the European Union



The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



REFITTING

MACHINE



REFITTING  
MACHINE

3D PRINTING FOR PRODUCTION OF  
THE PARTS NEEDED FOR MACHINERY  
REVAMPING



Co-funded by the  
Erasmus+ Programme  
of the European Union

## Aims and objectives

CHAPTER AIM:	Introduce the theme of the 3D printer as a tool not yet fully exploited.
COMPETENCES:	<ul style="list-style-type: none"><li>• Remove the misconception that 3D printing is only useful for making small objects.</li><li>• Develop critical thinking towards the typical tools of the maker world (3D printer; laser cut; Arduino; etc.).</li><li>• Illustrate projects and design research where the 3D printer product is a component and not a finished object.</li></ul>
LEARNING OUTCOMES:	Change of approach towards maker tools such as 3D printer, laser cut or Arduino for the culture of "industry 4.0".
NUMBER OF HOURS:	3

# Retrofitting vs Repair

3D printing for production of the parts needed for machinery  
revamping  
3D Printing as a versatile and adaptable tool

## INDEX:

1. Introduction
2. 3D printing
3. Case-study
4. Conclusions



CREDIT  
Software: Ultimaker CURA  
Brand: ULTIMAKER  
Link:<https://ultimaker.com/software/ultimaker-cura>



CREDIT  
Project name: BYPASS  
Design: Maya Ben David  
Image author: Ilan Amichai  
Commission: Benyamini gallery  
TEL AVIV (Israel)  
Link:<https://www.mayabendavid.com/Bypass>



CREDIT  
Project name: VALVE VENTURI  
Design: Isinnova  
Image author: Massimo Temporelli  
Link:<https://www.forbes.com/sites/amyfeldman/2020/03/19/talking-with-the-italian-engineers-who-3d-printed-respirator-parts-for-hospitals-with-coronavirus-patients-for-free/#1fef17a478f1>



CREDIT  
Project name: VALVE CHARLOTTE  
Design: Isinnova  
Image author: Isinnova  
Link:<https://www.isinnova.it/easy-co-vid19/>

# INTRODUCTION

Image source:  
[www.camozzi.com](http://www.camozzi.com)

—

# Introduction

- In most cases, technical operators and professional trainers believe that the 3D printer has no use in the field of industrial maintenance and retrofitting of machinery and / or accessories.
- The purpose of this unit is to provide information on 3D printing and printers as a tool, supported by case studies showing how their potential as a tool to create «machine-specific» parts and/or components is still unexpressed and underestimated.
- This tool is very useful for repairs, tests and also for the testing of machinery of any nature.

# 3D PRINTING

Image property  
[www.ultimaker.com](http://www.ultimaker.com)

—

# 3D Printing as a versatile and adaptable tool

- The first 3D printers appeared in the 80s and have remained an expensive and not widely used tool for many years. None of us could have imagined 10 years ago that the 3D printer would have spread worldwide thanks to affordable costs and technologies.
- Thanks to continuous research in the field and technological progress, it was possible after a very short time from the first release on the market of 3D printers to reduce prices allowing anyone to buy a printer.
- This technology allows many planners, designers and creators to think and create everything they want comfortably in their laboratories.

# Types of existing 3D printers

- 3D printers are equipment capable of producing three-dimensional objects starting from a 3D model. To manage them are used the so-called CAM programs which, very briefly, "read" the 3D model that an operator has created with a CAD program and "translate" it through a whole series of settings, into information that our 3D printer uses to "build "Our piece.
- There are different types of 3D printers with characteristics and standards often linked to the manufacturers of these devices. To use them often, the manufacturers offer CAM software and customized apps, luckily, however, the most popular print file format is the "STL (Standard Tessellation Language)" format recognized by almost all 3D printers and this allows us to draw on many resources and open-source 3D models available on industry websites and forums.
- In conclusion, we can say that there are numerous types of 3D printers on the market that are recognized based on the production process and the basic material for printing, but the most common are the following:



FFF - FDM - CFF (Fused  
Deposition)



SLA (Stereolitografia)



SLS (Selective Laser Sintering)



MJF (Multi Jet Fusion)



SLM (Selective Laser Melting)



MJ (Material Jetting)



LOM (Laminated Object  
Manufacturing)



EBM (Electron Beam Melting)

# Fused Deposition (FFF; FDM; CFF)

The first type of 3D printing we want to talk about is the FUSED DEPOSITION, a printer type based on the fusion of thermoplastic materials, supplied in the form of filament, with a section ranging from 1mm up to almost 1cm. This type of printer is used for the production of prototypes or pieces with a short life cycle if used in a production process. This however is not necessarily a limit because being these models fairly cheap they have allowed many designers and makers to test and experiment pieces without worrying about the "failure".



Ultimaker S5

# Characteristics

- Materials: Thermoplastic filament (PLA, ABS, PET, PETG, TPU).
- Dimensional Accuracy:  $\pm 0.5\%$  (lower limit  $\pm 0.5$  mm).
- Strengths: Good surface finish; Numerous Colors and Materials available; The pieces made are suitable for both prototyping and for some non-commercial functional applications; It is the most popular and cheapest 3D printing technology.
- Weaknesses: Printer not sustainable because it is often not repairable; Due to the printing process, the printer is not suitable for making pieces with complex details; In most cases post-processing is required to have a smooth finish on the piece.



[Ultimaker S5](#)

# Stereolithography (SLA)

The second type of 3D printing we want to talk about is the STEREO LITHOGRAPHY, a printer type in which a light source selectively polymerizes the photopolymer resin present in a tank. Selective solidification takes place in the construction area by creating the piece layer by layer. This type of printer is also used for the production of prototypes but also for dental applications, support for hearing aids and molds for the production of mass-produced parts.



[formlabs FORM2](#)

# Characteristics

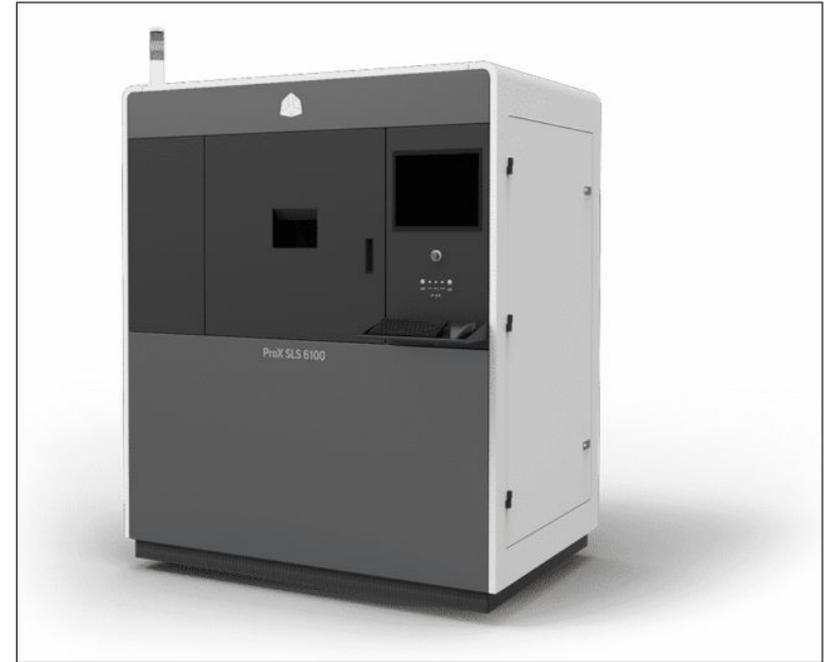
- Materials: Photopolymer resin (Standard; Castable; Transparent; High Temperature).
- Dimensional Accuracy:  $\pm 0.5\%$  (lower limit  $\pm 0.15$  mm).
- Strengths: Excellent surface finish and does not require post-production; Ability to print objects with detailed and complex elements.
- Weaknesses: Low print speed due to the type of process; Printer not sustainable because it is often not repairable.



[formlabs FORM2](#)

# Selective Laser Sintering (SLS)

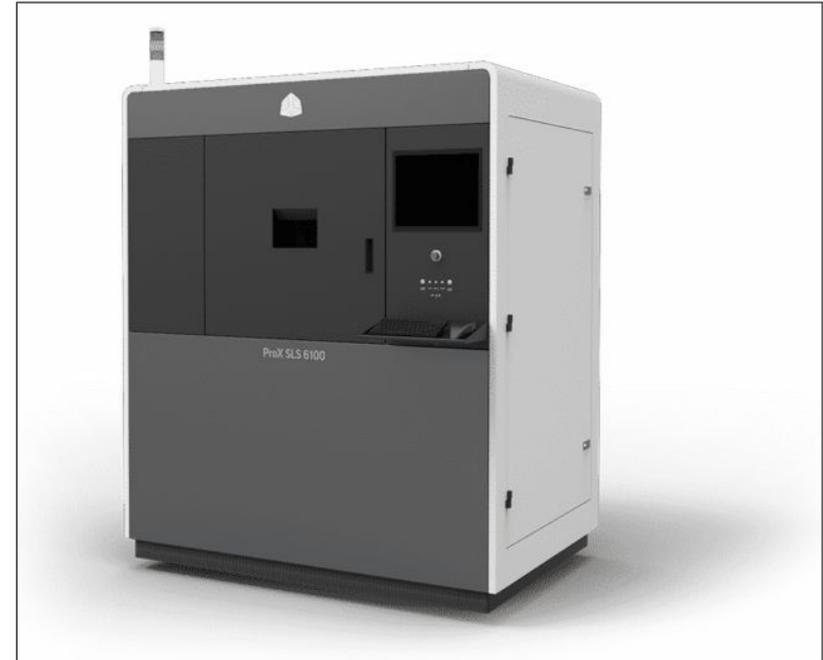
The SLS 3D printer (Selective Laser Sintering) uses heating and the consequent fusion of thermoplastic materials or metal powders. This technology offers an alternative production model to traditional manufacturing, because it guarantees precision, durability and repeatability of the parts produced. This feature makes these pieces suitable for both prototyping and end use in a production process. The limit of this printer is the economic one given the high cost, a limit that can be easily overcome in a co-working concept typical of new professionals.



[3D Systems 3D ProX 6100](#)

# Characteristics

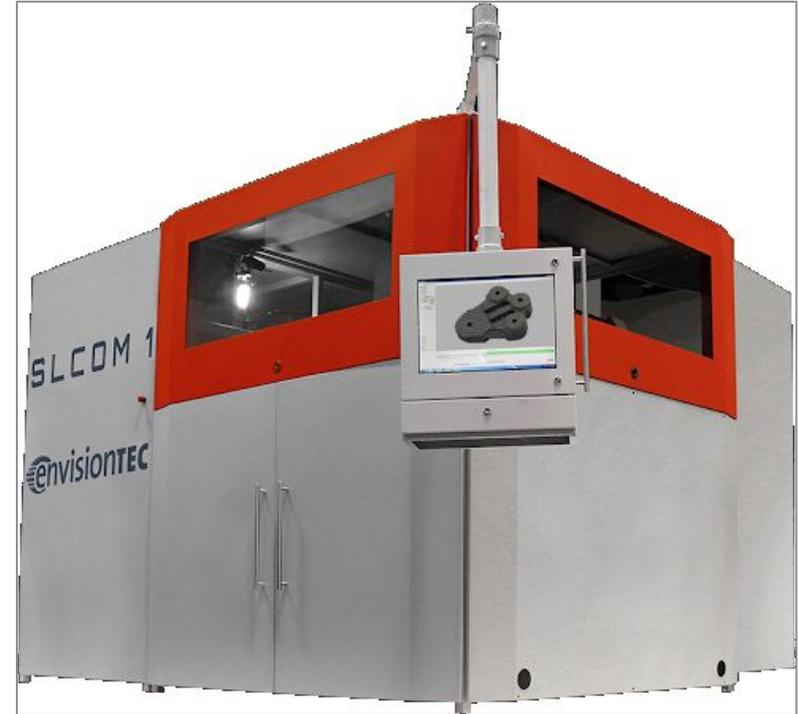
- Materials: Thermoplastic powder (Nylon 6, Nylon 11, Nylon 12).
- Dimensional Accuracy:  $\pm 0.3\%$  (lower limit  $\pm 0.3$  mm).
- Strengths: The printer has good sustainability because it is robust and repairable in its components; Excellent surface finish and does not require post-production; Ability to print any type of objects with detailed elements and any complexity.
- Weaknesses: High cost of the printer; It requires more time for the settings necessary for the production of a piece; The production cost of the parts is higher than other printers.



[3D Systems 3D ProX 6100](#)

# Laminated Object Manufacturing (LOM)

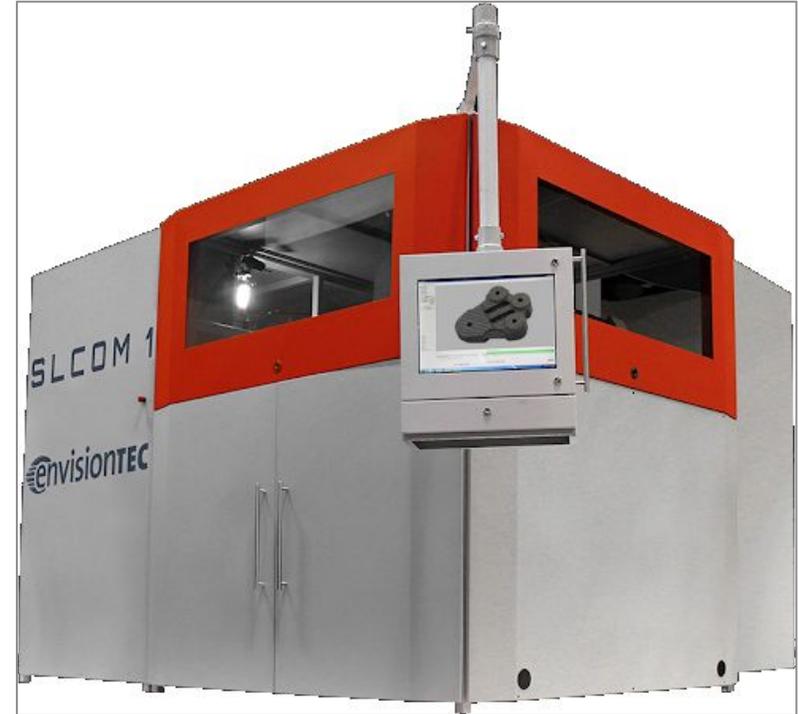
The last type of 3D printing we will talk about is Laminated Object Manufacturing (LOM) which allows you to separately create the layers that make up the finished product. In summary, the machine engraves very thin layers which are then laid on the previous layer and melted together by a precision laser. This printer can only be used in the industrial sector and has extremely high precision with great production speed. An interesting variant of this type has been developed by EnvisionTEC and is called Selective Lamination Composite Object Manufacturing (SLCOM).



[Envisiontec SLCOM1](#)

# Characteristics

- Materials: adhesive-coated paper, plastic or metal laminates.
- Dimensional Accuracy: +/- 100  $\mu\text{m}$  in X and Y - One layer thickness in Z after lamination.
- Strengths: Ability to produce large pieces; Use cheap raw materials.
- Weaknesses: High cost of the printer; Large printer usable only in the industrial sector.



Envisiontec SLCOM1

# 3D printing software

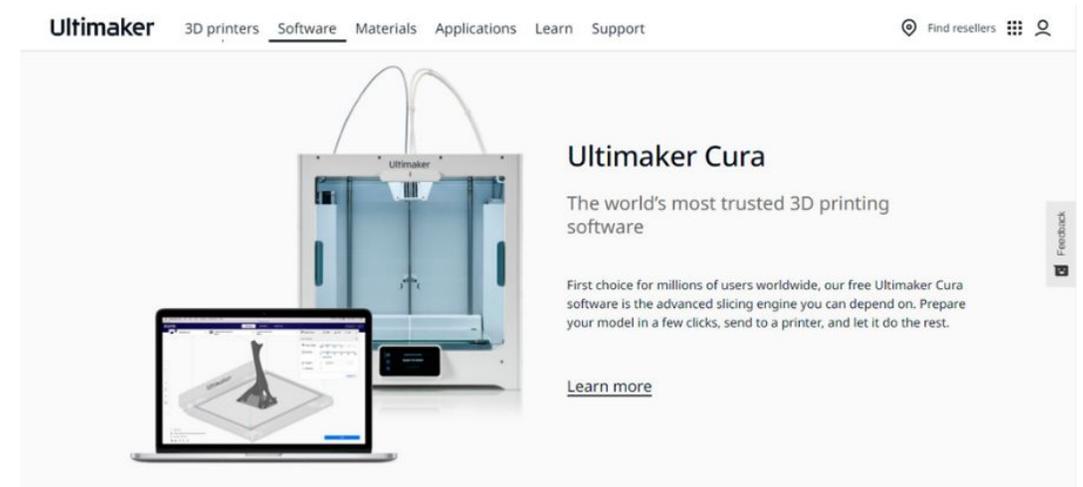
- As previously mentioned, to transform the 3D model made with CAD software (Computer Aided Design) a CAM software (Computer Aided Manufacturing) is needed, which in simple terms gives indications to the printer and tells it precisely how it should move.
- Most manufacturers also supply the standard CAM program but considering that almost all 3D printers support the file format ".STL (Standard Tessellation Language)" it doesn't matter which software is decided to use.
- In this case, however, it was decided to illustrate a CAM program by way of example, in order to provide a useful reference for those wishing to deepen the theme.

# Ultimaker CURA

The Ultimaker CURA software is an open-source CAM software for the management of the printing process, one of the most popular among 3D printers users.

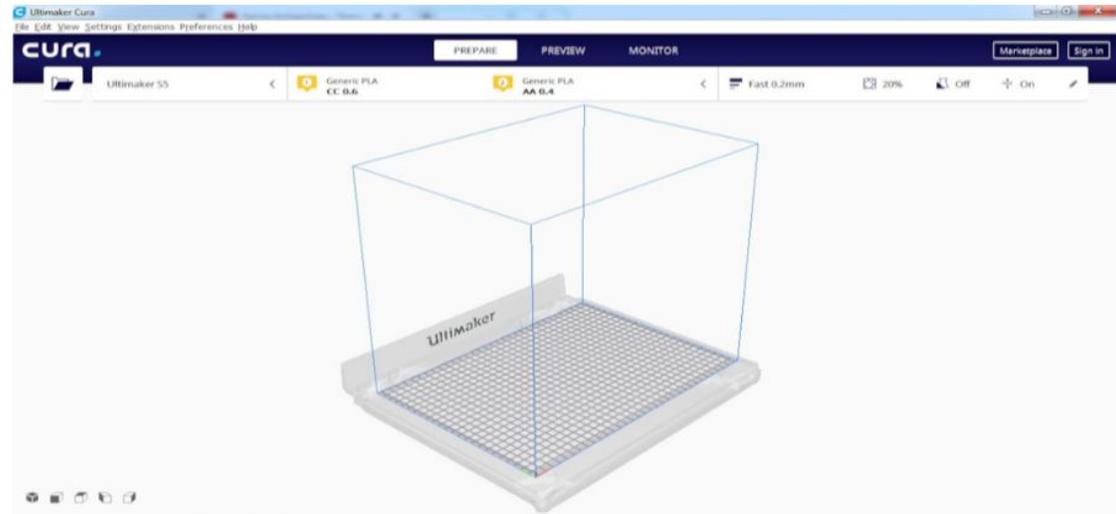
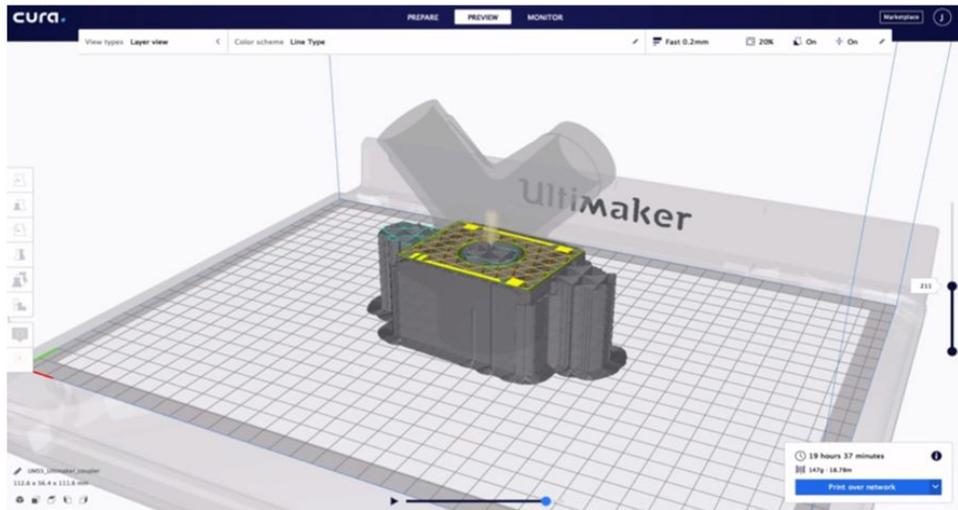
The main feature that has made Ultimaker Cura so widespread is its slicing engine created thanks to years of in-house development with the contribution of experts and private users. An open-source and very high-performance component that offers over 400 customized settings for granular control of the printing process, functions that convince anyone approaching the world of 3D printing.

Furthermore, video tutorials, monthly forum newsletters with tips and open-source resources allow anyone to easily learn the functionality of this software step by step.



The image shows a screenshot of the Ultimaker Cura website. The navigation bar at the top includes the 'Ultimaker' logo and links for '3D printers', 'Software', 'Materials', 'Applications', 'Learn', and 'Support'. On the right side of the navigation bar, there are icons for 'Find resellers', a grid icon, and a user profile icon. The main content area features a large image of an Ultimaker 3D printer with a laptop in front of it displaying the Cura software interface. To the right of the image, the text reads: 'Ultimaker Cura', 'The world's most trusted 3D printing software', and 'First choice for millions of users worldwide, our free Ultimaker Cura software is the advanced slicing engine you can depend on. Prepare your model in a few clicks, send to a printer, and let it do the rest.' Below this text is a 'Learn more' link. A vertical 'Feedback' button is located on the far right edge of the page.

# Ultimaker CURA



Brand:  
Ultimaker

Software:  
Ultimaker CURA

Sources:  
<https://ultimaker.com/>  
<https://www.youtube.com/watch?v=KDDfhqc57BI>



# CASE STUDY

BYPASS  
Design by Maya Ben David



# BYPASS

## DESCRIPTION:

- The Israeli designer Maya Ben David, starting from her passion for 3D printing, developed the BYPASS project, a system of non-standard fittings for metal pipes, such as those for water.
- Normally, water pipes have specific standard fittings (90 °, 45 ° and T angles) which allow the flow to move only in certain directions.
- With BYPASS they are designed and produced with a 3D printer, a series of non-standard fittings that allow you to create a customized water system based on how you want the water flow to proceed and the spatial characteristics of the place for which it must be built.

## QUOTE BY THE AUTHOR:

*“3D print as other technological developments reviles not only new abilities and techniques; the development process embodies new social, economical, cultural and political realities and visions. In current visions the standard which characterized modern industrial products and systems is about to change and with it our physical spaces and structures. A dedicated, semi industrial solution will take its place allowing flexibilities of systems, products and life surroundings.”*

# BYPASS



PARALLEL	REDUCING PARALLEL	TWIST TO PARALLEL	BYPASS
HALF BAGEL	MULTIANGLE QUATRO HALF BAGEL	DOUBLE REDUCING HALF BAGEL	QUATRO REDUCING HALF BAGEL
Y	TRIPOD	Y - TEE	Y- MULTIANGLE



Design:  
Maya Ben David

Commission:  
Benyamini gallery Tel Aviv

Image author:  
Ilan Amichai

Source:  
<https://www.mayabendavid.com/Bypass>

# Venturi Valve by ISINNOVA

In the midst of a pandemic emergency for COVID-19 in Lombardy, one of the most affected regions in Italy, a hospital in Brescia found itself facing a serious problem of supplies for oxygen therapy machines. All stocks of Venturi type valves were exhausted and the company that produces and holds the patent could not supply them quickly. The Venturi valve is a basic disposable component in oxygen therapy machines used in resuscitation. In this desperate situation, a series of local figures, such as the science communicator Massimo Temporelli and the engineer Cristian Fracassi of the ISINNOVA company, make something unthinkable possible in "ordinary" times. ISINNOVA in 24 hours produced more than 100 copies of the Venturi valve using 3D printing, after having reproduced the original and having tested it in the hospital. It is clear that these valves are emergency products that cannot be certified and that they can only be accepted in "extraordinary" times such as that linked to a world pandemic. In fact, these copies were not authorized by the company that owns the patent and therefore it was not possible to satisfy the many requests from hospitals and fab-labs who wanted the valve designs to be able to print them.



Project name:  
VALVE VENTURI

Design:  
ISINNOVA

Image author:  
Massimo Temporelli

Source:  
<https://www.forbes.com/sites/amyfeldman/2020/03/19/talking-with-the-italian-engineers-who-3d-printed-respirator-parts-for-hospitals-with-coronavirus-patients-for-free/#1fef17a478f1>

<https://www.3dprintingmedia.network/covid-19-3d-printed-valve-for-animation-device/>

# CHARLOTTE Valve

The project born from an idea of Dr. Renato Favero and developed by the engineer Cristian Fracassi of ISINNOVA, consists of a 3D printed fitting, which allows the use of the DECATHLON «Easybreath» snorkeling mask to replace the C-PAP masks, used for respiratory failure in sub-intensive care.

The multinational corporation DECATHLON immediately made itself available to cooperate, upon request of the Lombardy region, firstly by providing ISINNOVA with the CAD drawing of the snorkeling mask, then once it was verified that the project worked, donating 10,000 masks to the Italian government that distributed them to the regions concerned.



Project name:  
VALVE CHARLOTTE

Design:  
ISINNOVA

Image author:  
ISINNOVA

Link:  
<https://www.isinnova.it/easy-covid19/>

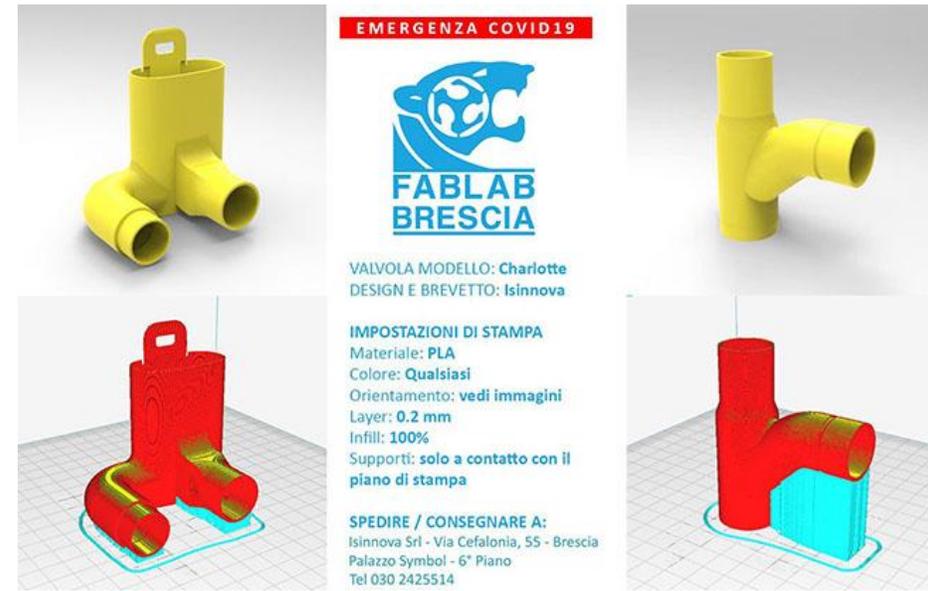
[https://www.youtube.com/watch?v=w4Csqdxkrfw&feature=emb\\_title](https://www.youtube.com/watch?v=w4Csqdxkrfw&feature=emb_title)

<https://docs.google.com/document/d/1J22le3dBZBnNDXGIJLRb38z7v7LaOjKfDeN9f0tFeKY/edit?fbclid=IwAR3cgtWvsDLuPg50Nr53VlwW2PQrT2VDkOxZ61sLiKoIJZ8DRLw1shD8U7U#>



# CHARLOTTE Valve

ISINNOVA staff dismantled the mask, studied it and developed the changes to make it work as a life support machine. Then the new ventilator fitting was designed and printed with 3D printing. The CHARLOTTE valve has been prototyped and tested on a healthy volunteer at the Brescia hospital proving to be fully functional. At this stage ISINNOVA after having patented and made the CHARLOTTE valve projects open source, decided to start a fundraiser to finance the free distribution of skills, equipment, and material for 3D printing, in those countries where the health system is not able to cope with crises such as that of COVID-19.

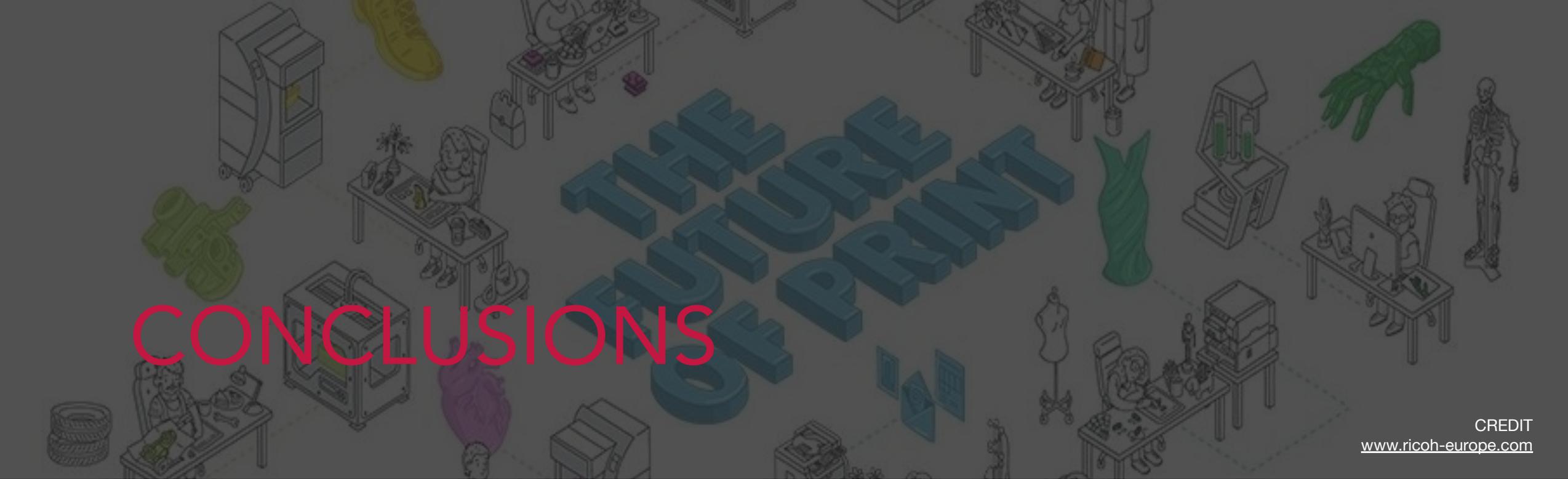


Project name:  
VALVE CHARLOTTE

Design:  
ISINNOVA

Image author:  
ISINNOVA

Sources:  
<https://www.isinnova.it/easy-covid19/>  
[https://www.youtube.com/watch?v=w4Csqdxkrfw&feature=emb\\_title](https://www.youtube.com/watch?v=w4Csqdxkrfw&feature=emb_title)  
<https://docs.google.com/document/d/1J22le3dBZBnNDXGIJLRb38z7v7LaOjKfDeN9f0tFeKY/edit?fbclid=IwAR3cgtWvsDLuPg50Nr53VlwW2PQrT2VDkQxZ61sLiKolJZ8DRLw1sHD8U7U#>



# THE FUTURE OF PRINT

## CONCLUSIONS

CREDIT  
[www.ricoh-europe.com](http://www.ricoh-europe.com)



# CONCLUSIONS

- This overview of projects has as the main purpose to make whoever looks at this research understand that the 3D printer is a tool with a very high potential not yet fully expressed in different areas.
- Repairing or replacing parts of a machine, reproducing components that we are temporarily lacking in, or even designing and manufacturing elements that modify a product to make it perform a new function; these, in a nutshell, are the skills that these case studies tell.
- In conclusion, it can be said that for the purposes of this unit is to provide information on 3D printing for technicians and repairers of different types of machines. A training course that allows technicians to use the 3D printer as a support in the production of parts and / or components.



# Source/References



Additive 3d printing

<https://make.3dexperience.3ds.com/processes/3D-printing>

Ultimaker CURA

<https://ultimaker.com/software/ultimaker-cura>

BYPASS

<https://www.mayabendavid.com/Bypass>

VALVE VENTURI

<https://www.forbes.com/sites/amyfeldman/2020/03/19/talking-with-the-italian-engineers-who-3d-printed-respirator-parts-for-hospitals-with-coronavirus-patients-for-free/#1fef17a478f1>

<https://www.3dprintingmedia.network/covid-19-3d-printed-valve-for-reanimation-device/>

VALVE CHARLOTTE

<https://www.isinnova.it/easy-covid19/>

<https://docs.google.com/document/d/1J22le3dBZBnNDXGIJLRb38z7v7LaOjKfDeN9f0tFeKY/edit?fbclid=IwAR3cgtWvsDLuPg50Nr53VlwW2PQrT2VDkQxZ61sLiKoIJZ8DRLw1shD8U7U#>



FORMLABS

<https://www.youtube.com/user/formlabs1>

Ultimaker CURA

<https://www.youtube.com/watch?v=KDDfhqc57BI>

VALVE VENTURI

<https://www.youtube.com/watch?v=WzbRXd-wrGI>

VALVE CHARLOTTE

[https://www.youtube.com/watch?v=w4Csqdxkrfw&feature=emb\\_title](https://www.youtube.com/watch?v=w4Csqdxkrfw&feature=emb_title)

Co-funded by the  
Erasmus+ Programme  
of the European Union



The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



REFITTING

MACHINE



# REFITTING MACHINE

OPEN SOURCE HARDWARE RELEVANT  
FOR MACHINERY REVAMPING



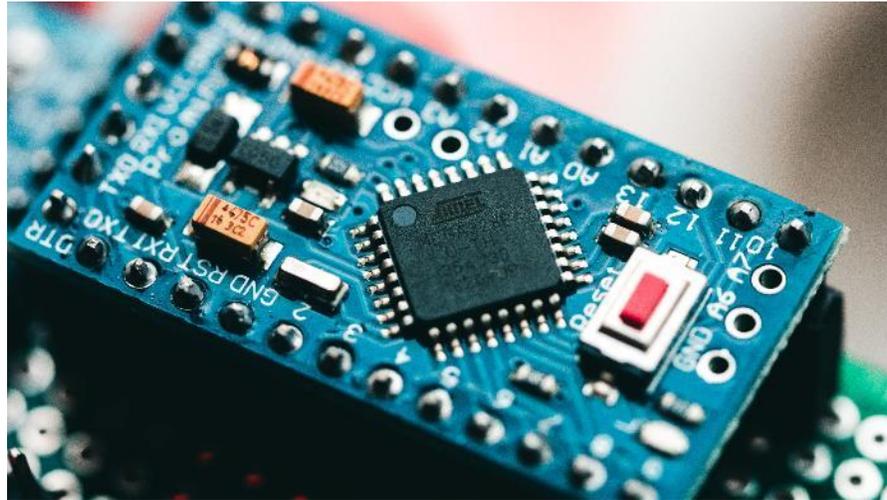
Co-funded by the  
Erasmus+ Programme  
of the European Union

## Aims and objectives

CHAPTER AIM:	Present and discuss the existing open source hardware that is relevant for machinery revamping
COMPETENCES:	<ul style="list-style-type: none"><li>• Ability to select an appropriate open source electronic hardware</li><li>• Ability to distinguish between open source and proprietary mechanical hardware</li><li>• Ability to find the information needed for building open source machineries</li></ul>
LEARNING OUTCOMES:	<ul style="list-style-type: none"><li>• Understanding the Open Source Hardware (OSHW)</li><li>• Knowledge about specific OSHW relevant for machine revamping</li></ul>
NUMBER OF HOURS:	3

# Lecture Outline

1. Introduction
2. Open-source electronics
3. Open-source mechanical hardware
4. Open-source machinery
5. Conclusions

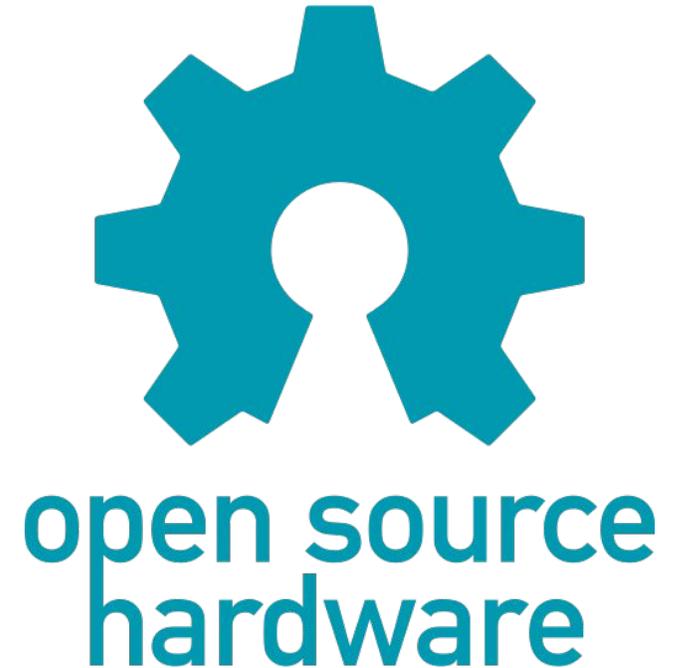


# Introduction

—

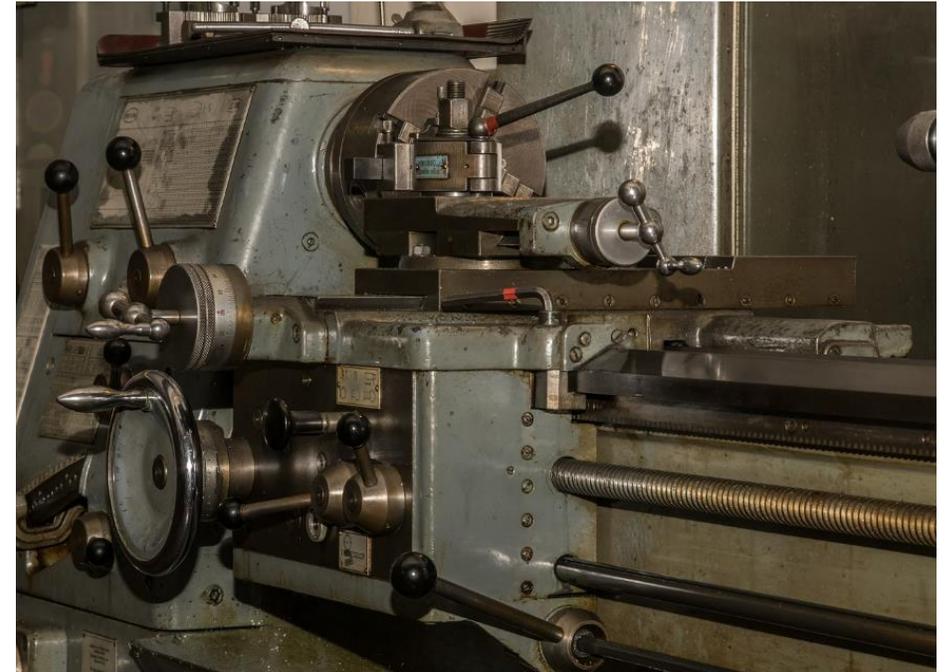
# Introduction

- According to the definition given by Open Source Hardware Association, open-source hardware (OSHW) is “hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design”.
- OSHW refers to tangible artefacts such as machines, devices, or other physical things. They may be:
  - Electronic hardware: computers, electronics, mobile phones
  - Mechanical hardware: parts, components, systems
  - Mechatronics hardware: 3D printers, laser cutters, cars, bicycles, medical equipment
- The main advantages of OSHW:
  - Can be studied by anyone and adapted to particular needs
  - Can be improved by anyone and the improvements released for others to benefit as well
  - Has the potential to accelerate the development of new devices
  - Allows users to have more free and open forums to share ideas, experiences and to support each other



# Machinery revamping

- Revamping is a technique that regenerates or modernize an existing machinery while at the same time conserving most of its functional parts.
- **Reasons for revamping:**
  - Making possible the use of obsolete machines
  - Improving the capabilities, performance level, accuracy and safety
  - Reducing operating cost
  - Obtaining a good machine at a fraction of the cost of a new one
  - Reducing waste of energy and resources by reusing existing parts
  - Environmental benefits
- **It can involve:**
  - Adding safety features
  - Changing existing components with more efficient ones
  - Adding digital features, like computer numerical control (CNC)
  - Improving software to allow optimizing operations



# OSHW relevant for machinery revamping

- Electronics: computers, microcontrollers, peripherals, electronic boards, drivers, sensors, etc.
- Mechanical: linear motion systems, various components, 3D printed parts, tools, etc.
- Machinery: 3D printers, laser cutters, machine tools, etc.

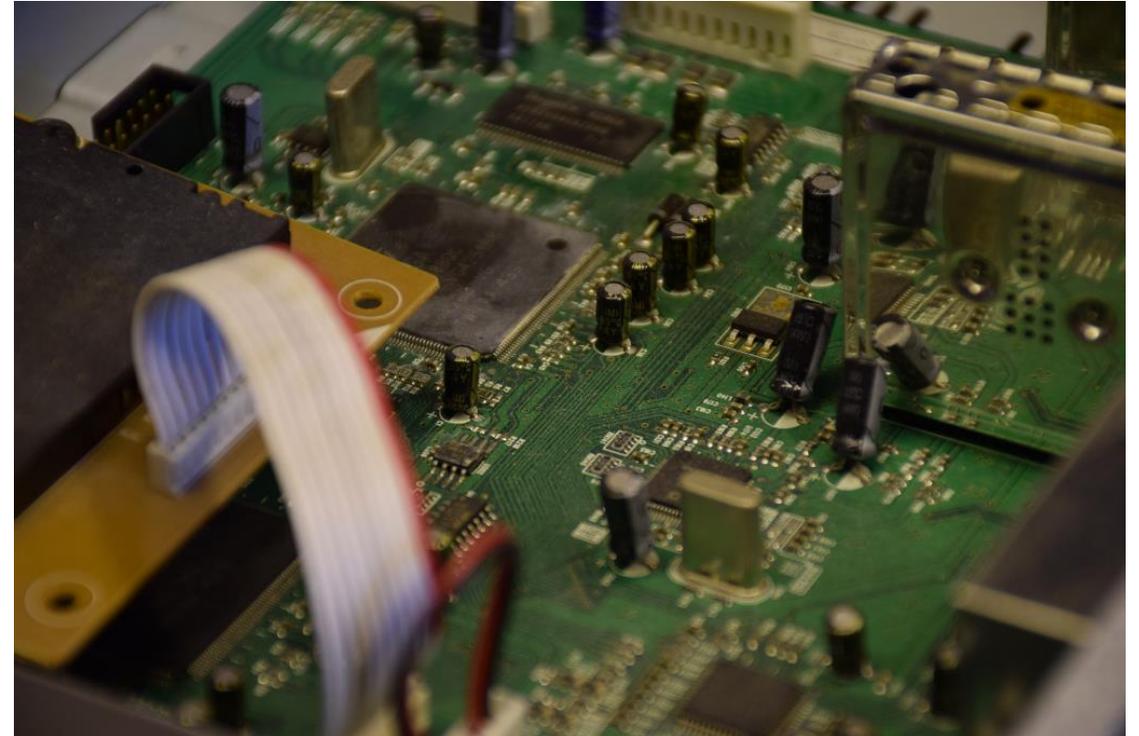


# Open source electronics

—

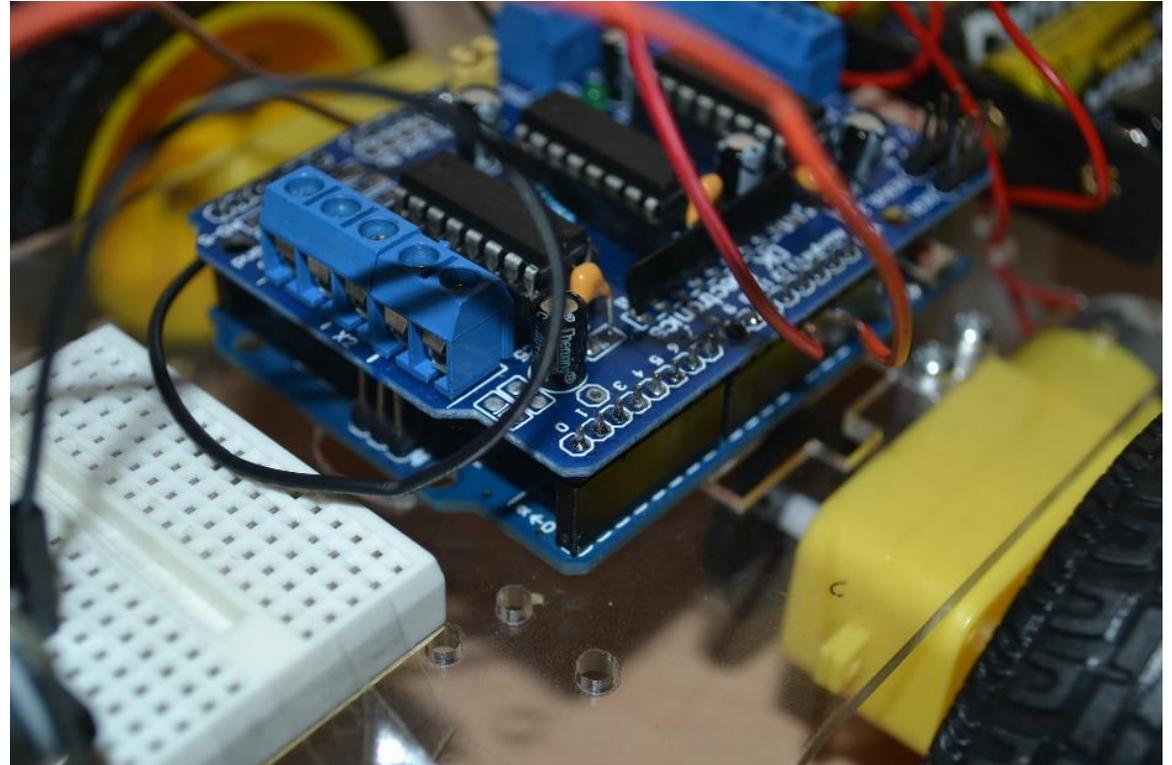
# Introduction

- There is a large variety of open-source electronics, ranging from CPUs, microcontrollers, electronic components to entire computers or systems.
- Many of these can be used for revamping machineries and, in this section, we will focus on the most used categories:
  - Arduino hardware
  - Open source computers
  - CNC controllers
  - Motor drivers



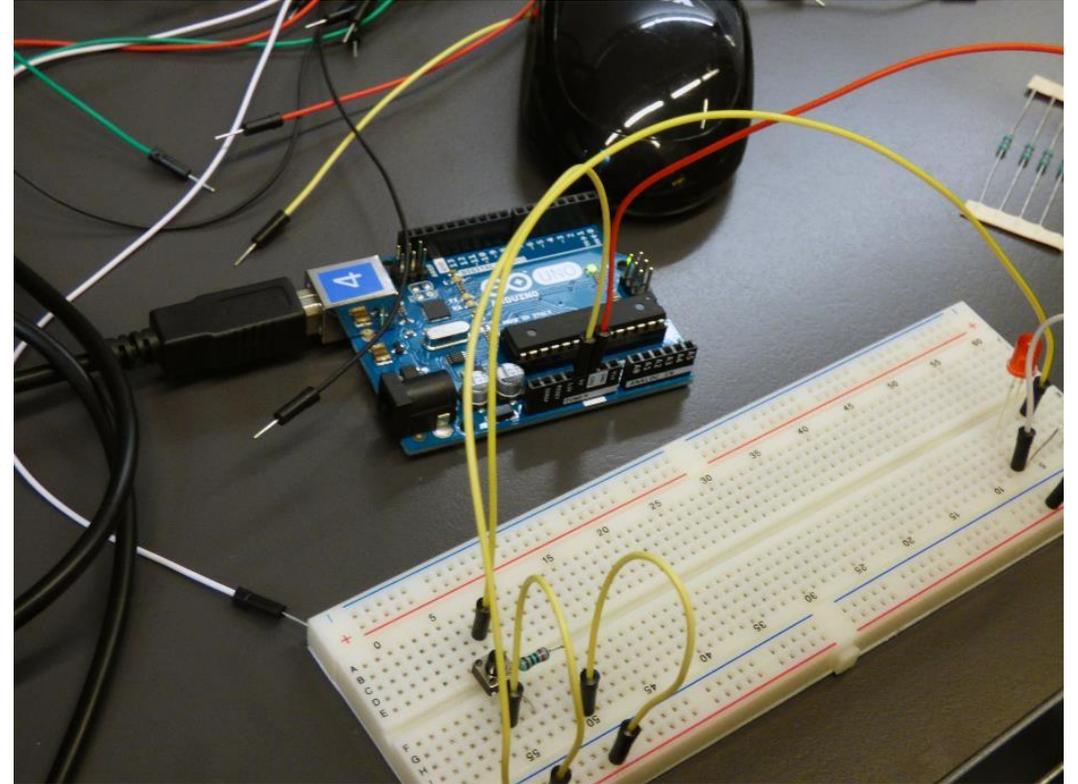
# Arduino hardware

- Arduino is an open-source electronics platform consisting of both hardware (a programmable circuit board) and software (IDE-Integrated Development Environment).
- It is the most popular and easiest to use open-source, microcontroller platform, used by makers all over the world for developing countless hardware projects.
- **Arduino hardware categories:**
  - Boards and modules
  - Shields - boards that can be plugged on Arduino to extend its capabilities
  - Accessories



# Advantages of Arduino

- Ready to use hardware
- Easy to use hardware and software
- Large availability of information, tutorials, examples, etc.
- Large community allowing to find help about everything
- Arduino hardware components are cheaper than other controller architecture





# Arduino clones

- In addition to the official microcontrollers, there are many Arduino IDE-compatible devices.
- Given the open-source nature of Arduino, unofficial doesn't mean illegitimate, anyone can make an Arduino compatible board.
- **The advantages of using clones:**
  - Cheaper
  - Suited for some specific needs
- **The disadvantages of using clones:**
  - Some clones may be of lower quality and reliability
  - While Arduino company put huge effort into their hardware and software ecosystem, the clones makers don't give back to the community.
  - By buying original Arduino, you are supporting the European economy



"Decked out" (CC BY 2.0) by [oskay](#)

# Open source computers

Some current open source computers are given below. A more extended list is available on:

[https://en.wikipedia.org/wiki/List\\_of\\_open-source\\_computing\\_hardware](https://en.wikipedia.org/wiki/List_of_open-source_computing_hardware)

- **Novena** - an open hardware computing platform  
[https://www.kosagi.com/w/index.php?title=Novena\\_Main\\_Page](https://www.kosagi.com/w/index.php?title=Novena_Main_Page)
- **MNT Reform** – an open-source notebook  
<https://mntre.com/>
- **PINEBOOK Pro** - open source ARM 64-Bit Laptop  
<https://www.pine64.org/pinebook-pro/>
- **Pi-Top** - open source laptop based on Raspberry Pi  
<https://www.pi-top.com/>
- **BeagleBoard** - a low-power open-source single-board computer  
<http://beagleboard.org/>



[MMcM](#) from Boston, USA, [Novena + Knight keyboard \(16277937833\)](#), [CC BY 2.0](#)

# Open source CNC controllers

Some current open source CNC controllers are given below.

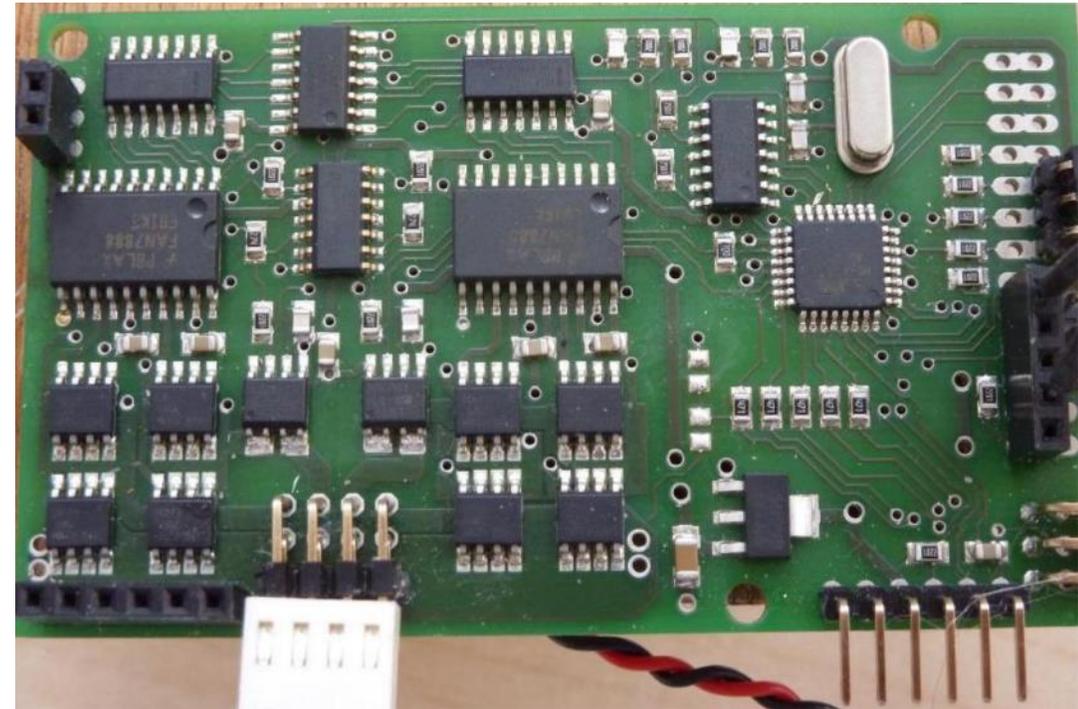
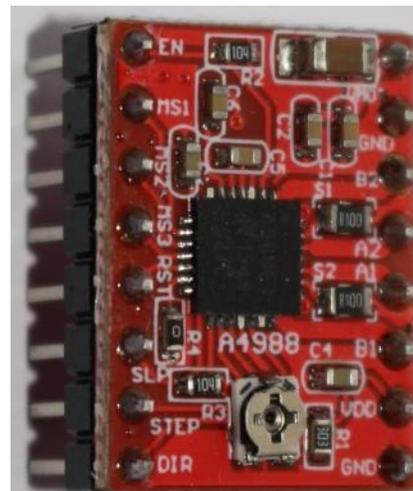
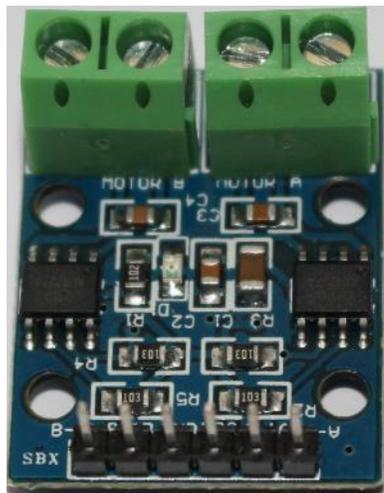
- **Buildbotics CNC Controller** – stand-alone, 4-Axis CNC controller that can drive up to 4 stepper motors and many different tools such as a CNC spindle, laser cutter or plasma torch. <https://buildbotics.com/>
- **Gradus M1 PRO GRBL CNC Controller** – a 4 driver / 3 axis CNC controller that can be used for small to medium sized CNCs, laser cutters, plotters and other machines up to 3 axes [http://www.panucatt.com/product\\_p/gm1pro.htm](http://www.panucatt.com/product_p/gm1pro.htm)
- **TinyG** - USB based CNC 6 Axis controller, with 4 motor outputs. It is designed for small CNC applications and other applications that require highly controllable motion control. <https://synthetos.com/project/tinyg>



Buildbotics CNC Controller. Source: <https://buildbotics.com/>

# Open source motor drivers/controllers

- **SOLDER Pad stepper-motor controller** – Hysteresis chopper-drive circuit for up to 6A stepper motors. Has Arduino-compatible microcontroller on-board that allows re-programming  
<http://solderpad.com/markt/stepper-motor-controller/>
- Many types of motor drivers are available from companies involved in OSHW, such as [Sparkfun](#), [Adafruit](#), [Parallax](#), etc.



SOLDER Pad stepper-motor controller. Source: <http://solderpad.com/>

# Open source mechanical hardware

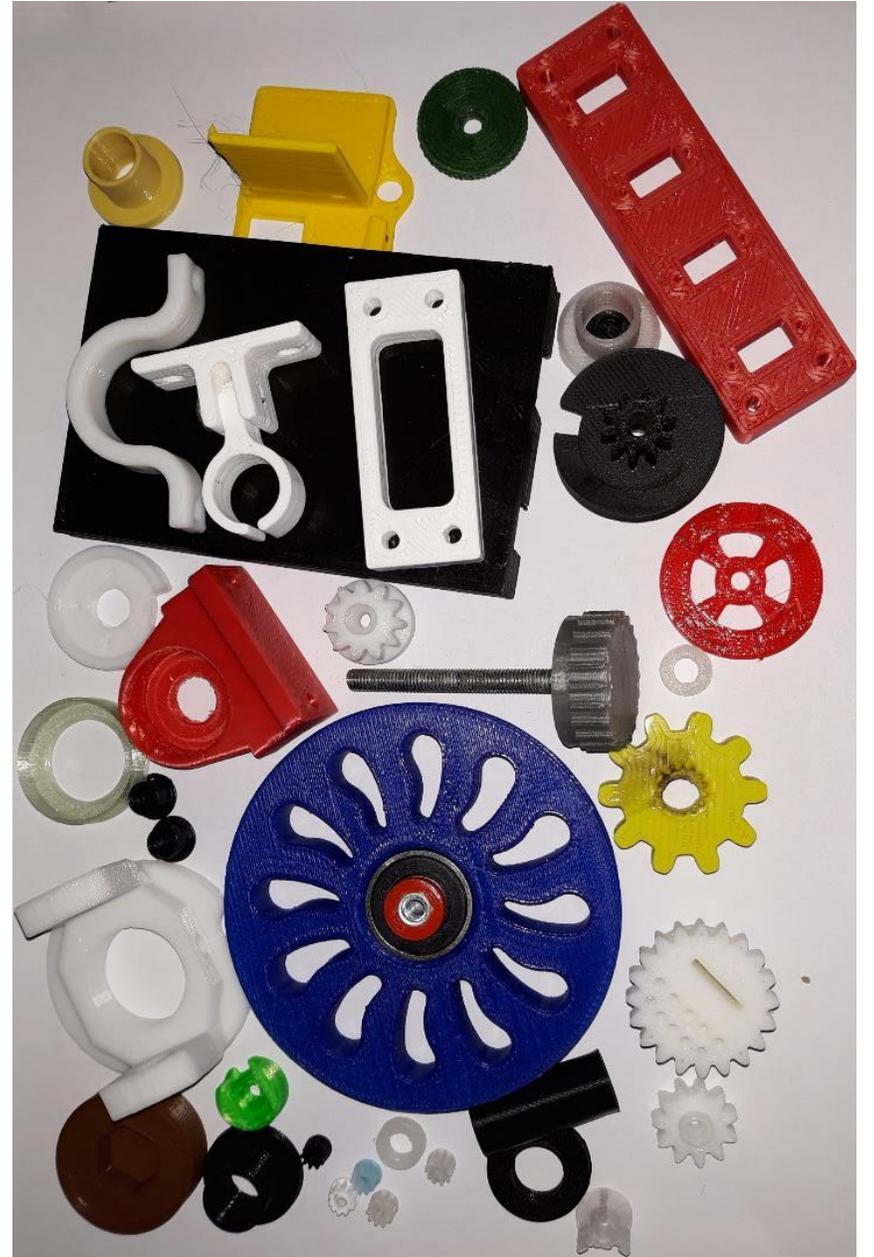
—

# Introduction

- Countless mechanical parts and systems are available as OSHW.

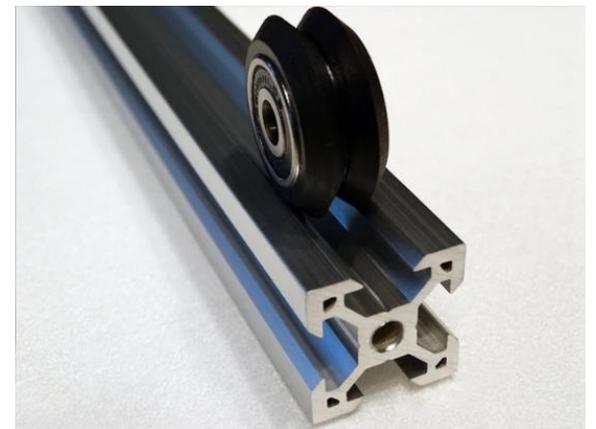
Among these, the most relevant for machine revamping are the following:

- Linear motion systems and components
- 3D printed parts
- Mounting hubs, couplings, knobs
- Brackets, connectors
- Wheels, plates, pulleys, gears
- Nuts, screws, spacers, washers, shims
- Transmission components
- Actuators
- Tools



# OSHW Linear motion systems

- Linear motion systems are used for all types of linear movements of a machinery.
- They include different components such as:
  - aluminum extrusions
  - slide rails
  - bearings
  - various accessories
- **OpenBuilds V-Slot modular building system** – it is based on a high quality extruded aluminum profile building block that has an extremely smooth linear V groove rail on all 4 sides.  
<https://openbuildspartstore.com/>
- **OpenRail** is an Universal Linear Rail System designed to be used on any V-Slot Linear Rail
- **MakerSlide** is an Aluminum Extrusion with V-rail Linear Bearing System Built in. The CAD data is available on  
<https://www.inventables.com/technologies/makerslide>



V-Slot. Source:  
<https://openbuildspartstore.com/>

# OSHW 3D printed parts

- 3D printing allows the fabrication of various parts based on a digital file. Such digital files are made available by people and companies all over the world, mainly through online repositories.

Some of these files can be useful when revamping machineries, for example:

- Arduino cases
- Brackets
- Bearing blocks
- Linear motion components
- Pulley, wheels, gears
- Spare parts
- Components of various machine tools
- 3D printed parts of the open source machineries
- Tools, fixtures, accessories useful in the revamping process

## 3D printing files repositories

Name	Link
<b>Thingiverse</b>	<a href="http://www.thingiverse.com">www.thingiverse.com</a>
<b>MyMiniFactory</b>	<a href="http://www.myminifactory.com">www.myminifactory.com</a>
<b>Cults</b>	<a href="https://cults3d.com">https://cults3d.com</a>
<b>Pinshape</b>	<a href="https://pinshape.com/">https://pinshape.com/</a>
<b>YouMagine</b>	<a href="http://www.youmagine.com">www.youmagine.com</a>
<b>SetkchFab</b>	<a href="https://sketchfab.com/">https://sketchfab.com/</a>
<b>Yeggi</b>	<a href="http://www.yeggi.com">www.yeggi.com</a>
<b>CGTrader</b>	<a href="http://www.cgtrader.com">hwww.cgtrader.com</a>
<b>STL Finder</b>	<a href="http://www.stlfinder.com">www.stlfinder.com</a>

# Open Source Machinery

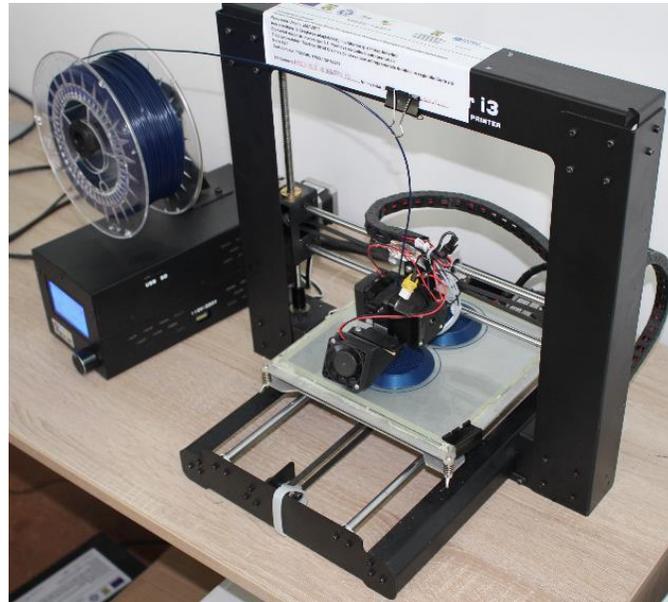
—

# Introduction

- There are several open-source machineries that can be useful for producing the parts needed for revamping machines.

Among these, the most popular are the following types:

- 3D printers
- CNC machines
- Laser cutters



# Open Source 3D Printers

- The open source 3D printers greatly contributed to the growth of 3D printing industry and there is a large number of available models.

Some the most important companies that create open source printers are the following:

- **Prusa Research** currently produces the 3D printers ORIGINAL PRUSA (I3, SL1, Mini and I3 Multi Materials) [www.prusa3d.com/](http://www.prusa3d.com/)
- **BCN3D Technologies** produces, among other things, the 3D printers BCN3D Epsilon, Sigmax and Sigma [www.bcn3d.com/](http://www.bcn3d.com/)
- **Aleph Objects Inc.** produces LulzBot 3D Printers [www.lulzbot.com/](http://www.lulzbot.com/)
- **Ultimaker BV** produces several 3D printers <https://ultimaker.com/>
- **FlashForge Corporation** produces several open source 3D printers [www.flashforge.com/](http://www.flashforge.com/)
- **Creativity 3D** produces several open source 3D printers [www.creativity.com/](http://www.creativity.com/)



Source:  
[www.prusa3d.com/](http://www.prusa3d.com/)

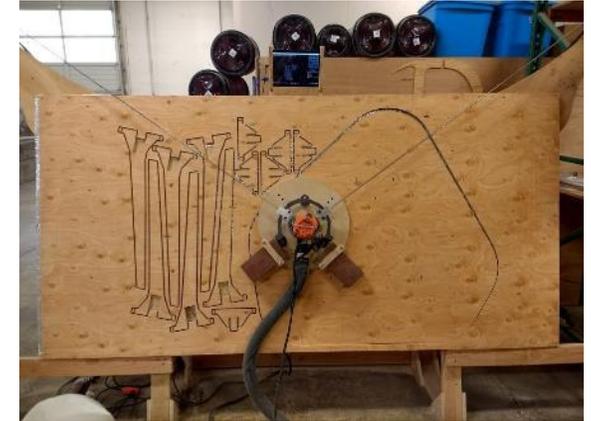
# Open source CNC machines

- Currently, around 600 projects of open source CNC routers and lathes, in various stages of completion, are available on <https://openbuilds.com/>. The builds include instructions, parts lists, video and images, discussions, etc.
- **Shapeoko** is a desktop 3-axis CNC machine. It works with wood, plastic, and aluminum but, also, with a little extra preparation and precaution, with carbon fiber, PCB's, and steel.
- **Maslow CNC** is a large (2438 x 1219 mm) CNC machine designed to cut wood and other flat materials [www.maslowcnc.com/](http://www.maslowcnc.com/)
- **LongMill Benchtop CNC** is a hobby CNC router developed by Sienci Labs (<https://sienci.com/>) that comes in 3 versions:
  - 305x305 mm work area
  - 305x760 mm work area
  - 760x760 mm work area

The Z axis travel is approximately 114 mm for each version.



LongMill Benchtop CNC. Source: <https://sienci.com/>



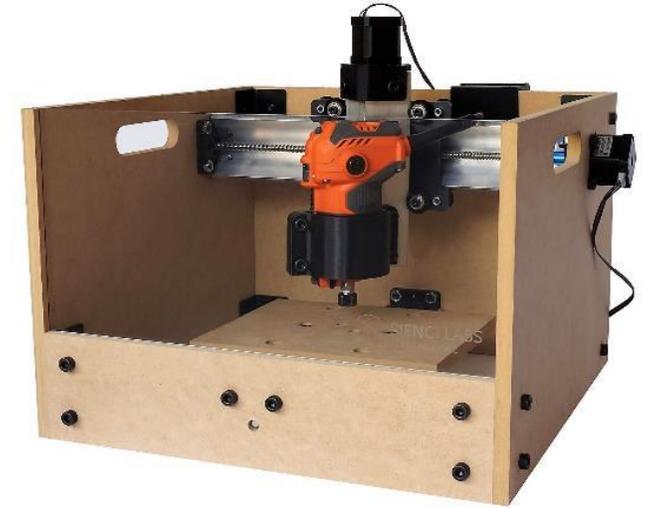
Maslow CNC. Source: [www.maslowcnc.com/](http://www.maslowcnc.com/)



Shapeoko CNC machine. Source: <https://carbide3d.com/shapeoko/>

# Open source CNC machines

- **Sienci Mill One Kit V3** is a CNC router developed by Sienci Labs (<https://sienci.com/>) with a cutting volume of 258mm x 185mm x 76mm suitable for wood, plastic, circuit boards, foam, and soft metals.
- **Ooznest Workbee** is CNC router capable of cutting foams, woods, plastics or aluminum at depths greater than 25 mm and to a 0.2 mm accuracy or greater. <https://ooznest.co.uk/>



Sienci Mill One Kit V3. Source: <https://sienci.com/>



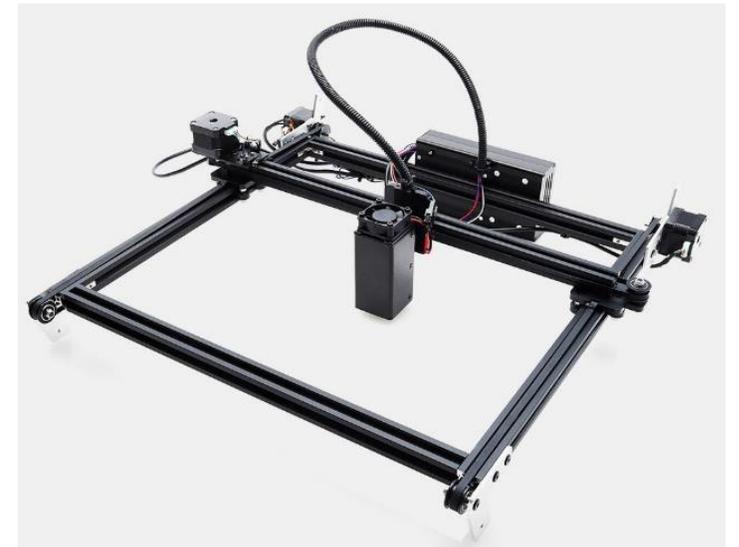
WorkBee CNC Machine. Source: <https://ooznest.co.uk/>

# Open source Laser cutters

- Currently, tens of projects of open source Laser cutters and engravers, in various stages of completion, are available on <https://openbuilds.com/>. The builds include instructions, parts lists, video and images, discussions, etc.
- Some 3D-Printable Laser Cutters have the documentation and the files needed for their fabrication available on <https://www.thingiverse.com/>
- **LaserDuo** integrates two different laser sources (130W CO2 and 75W YAG) and is able to laser cut and engrave a wide range of materials, including steel, aluminum, wood, leather, marble, etc. It has a 1500x1000x500mm working area. <http://laserduo.com/>
- **FABOOL Laser Mini** is a desktop laser cutter with work area of 300x230mm that comes in 2 versions, 1.6W Laser Diode 445nm and 3.5W. [www.smartdiys.cc/](http://www.smartdiys.cc/)
- **Lasersaur** has a 1220x610mm work area equipped with a 120W laser. The documentation required for building it is available on <https://www.lasersaur.com/>
- **FabKit** is a laser cutter with a cutting area of 680mm x 460mm equipped with a Fab40W CO2 laser. [www.fabcreator.com/fabkit](http://www.fabcreator.com/fabkit)



LaserDuo. Source:  
<http://laserduo.com/>



FABOOL Laser Mini. Source:  
[www.smartdiys.cc/](http://www.smartdiys.cc/)

# Conclusions

—

# CONCLUSIONS

- OSHW offers great opportunities for those wanting to revamp old machineries, in terms of both parts, components, tools and production equipment.
- Open Source electronics allows for simple and cheap machinery modernisation that can be done by not very experimented makers
- Free 3D printing files and other fabrication documentation useful in machinery revamping are available thanks to OSHW
- Open Source mechanical hardware allows sourcing cheaper flexible linear motion systems for machinery revamping
- Open Source machineries allows makers to build their own machine tools in order to make the parts needed for revamping

# Source/References



List of open-source hardware projects

[https://en.wikipedia.org/wiki/List\\_of\\_open-source\\_hardware\\_projects](https://en.wikipedia.org/wiki/List_of_open-source_hardware_projects)

Open Hardware Directory

[https://wiki.p2pfoundation.net/Product\\_Hacking](https://wiki.p2pfoundation.net/Product_Hacking)

The Worldwide List of Open Source Hardware Online Stores

<http://makingsociety.com/2013/03/the-worldwide-list-of-open-source-hardware-online-stores/>

Arduino website

<https://www.arduino.cc/>

Contraptor - a DIY open source construction set for personal fabrication

<http://www.contraptor.org/make>

Co-funded by the  
Erasmus+ Programme  
of the European Union



The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



REFITTING

MACHINE



OPEN SOURCE SOFTWARE RELEVANT  
FOR MACHINERY REVAMPING



Co-funded by the  
Erasmus+ Programme  
of the European Union

## Aims and objectives

CHAPTER AIM:	To present and discuss open source software applications used in upgrading equipment
COMPETENCES:	<ul style="list-style-type: none"><li>• Select an appropriate open source software</li><li>• Distinguish between open source software and software that requires a license</li><li>• Find the information needed to write / update/improve a software application using only open source applications</li><li>• Use IDE platforms for software development</li><li>• Create / update software using open source applications for upgrading</li></ul>
LEARNING OUTCOMES:	<ul style="list-style-type: none"><li>• Understanding open source software (OSS)</li><li>• Knowledge of specific / relevant open source software for machine refurbishment</li><li>• Knowledge of programming in various programming languages and development platforms</li></ul>
NUMBER OF HOURS:	4

# Lecture Outline

1. Introduction to "Open source software"
2. Open source operating systems
3. Programming languages and development platforms
4. Licenses for open source applications
5. Open source applications used in 3D modeling
6. Conclusions



# Introduction to "Open Source Software"

—

# Introduction

The notion of open-source has appeared in one form or another since the 1950s and 1960s, when code was written by universities in collaboration with corporations. At start, the emphasis was on collaboration, new information was shared with everyone, and most of those who worked in the field were open to collaboration and to share what they discovered. The main reason why information was shared was the multitude of hardware and software systems that needed to be modified to make them functional or to improve performance. We can modify the software for: computers, mobile phones, electronic equipment.



# Introduction

- Over the years this has changed and standardized and the open-source community has expanded tremendously. The applications have become more and more complex and because some of the corporations were investing large sums on the research and development side, after a while the notion of licensing, trademark and copyrights appeared.

## Advantages of open source software:

- they can be studied by anyone and adapted to certain needs
- can be improved by anyone
- can accelerate the development of new devices
- offers users several free and open forums to share ideas, experiences and
- to support each other

# Why modernization/refurbishment?

- The modernization of an outdated equipment implies the preservation of the functional parts, making it possible to reuse them. For example, upgrade to an old computer (we only change the motherboard and the processor, keeping all the other electronic parts such as the case, memory, HDD, etc.).
- Improving functionality and performance leads to lower costs than purchasing new equipment
- In most cases, old equipment cannot be completely recycled
- Upgrading software on a car can involve improving safety, performance and pollution characteristics by making it comparable to those currently on the market. For example, the creation of software to control the amount of gas emitted from the combustion process of an internal combustion engine, the creation of software for automatic braking in an emergency (obstacle at a certain distance).



# Open source software

- An "open source" software offers free access to the source code and anyone can study, modify or improve it.
- A software that can be read, modified or improved only by a person, a team, or organization that created it and maintains the exclusive control over it is called "proprietary" or "closed source" software. In this case only the authors can copy, view or alter this software. Someone else may use this software only on the basis of a license from the owner/author.
- Open source software is different. Its authors make the source code available to anyone who wants to see, copy, learn, modify or distribute it to someone else. For example, LibreOffice and GIMP are examples of open source software.



# Open source operating systems

—

# Introduction

- The operating system is a collection of programs used to manage computer resources and control its entire activity.
- There are currently many operating systems that fall into the category of "alternatives to Windows". It dominated the PC market, even though this alternative has taken a big lead nowadays.
- The operating system provides the connection between the user and the computer, copies the programs from the executable files on the disk to the internal memory, executes in order the instructions in these programs and communicates the results obtained.



# Linux

- Linux is the kernel that underlies an extremely large family of operating systems globally. Linux is the kernel that "powers" today's operating systems such as:
- Ubuntu (for desktop systems),
- Android (for smartphones, smartwatches, car software, etc.),
- Kali Linux (Hacking and Penetration Testing),
- CentOS (for the server side), etc.
- Linux was inspired by another operating system, Unix, which was extremely popular in the 1980s.
- What makes it special is the freeness and the fact that anyone can change it. Users with the necessary programming knowledge can add elements and even change the graphical interface, making it a customized operating system.
- It can be downloaded here: <https://www.linux.org/pages/download/>



**Linux**

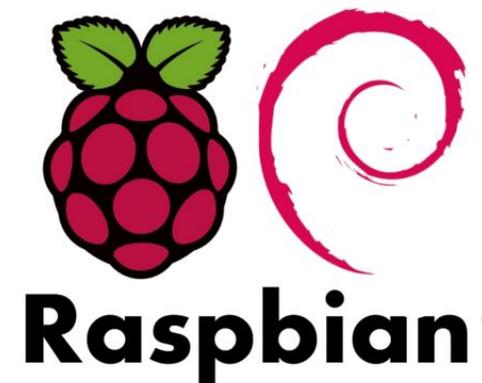
# Advantages of using Linux

The main reasons why Linux is so frequent (over 90 million devices) are:

- It's free - anyone can download, install and use it.
- It's customizable - you can do anything by entering the source code, even changing elements in the kernel.
- Is open source - its source is on a storage server, anyone can work on the source code and make additions. It has hundreds of thousands of contributors, including Microsoft, who are helping to improve it.
- There is a very large community of users who can help you, or more provide you with answers to almost any question.
- It's perfect for programmers. It supports the most popular programming languages: Python, C / C ++, Java, Perl, Ruby.
- It is safe - because it is used by many users, especially experienced and programming oriented.

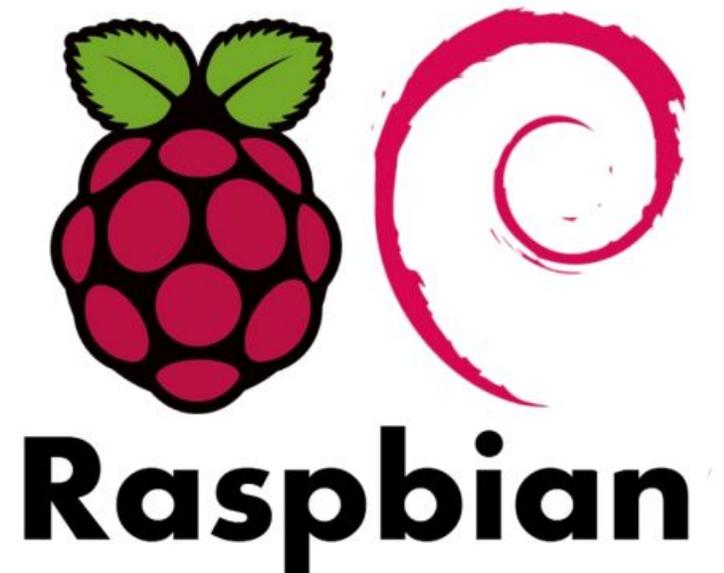
# Raspbian

- Raspbian is an operating system oriented towards the educational environment. Comes pre-installed with several suite of applications such as Python, Scratch, Sonic Pi, Java, Mathematica and others.
- Raspbian is the operating system specially optimized for Raspberry Pi (RPI) boards with most recommendations and support from the community, offering both rich functionality and robustness in conditions of limited resources. Derived from Debian, it offers in addition to the basic functions of the kernel, over 30,000 applications, packages, precompiled software, all arranged in a way that is easy to install and use on Rpi
- You can access the installation guide here <https://freeelectron.ro/card-raspbian/>



# Advantages for using Raspbian

- It's free - anyone can download, install and use it;
- It is optimized for the instruction set of the ARMv6 architecture, on which the Raspberry Pi microcomputer is based.
- It derives from the Debian operating system very well known for the simplicity and the multitude of functionalities offered.
- Runs on the ARM11 hardware of the Raspberry Pi.
- Contains many development tools such as IDLE, Scratch.
- It is open source - its source is on a storage server, anyone can work on the source code and make additions. It has hundreds of thousands of contributors, including Microsoft, who contribute to its improvement.



# Programming languages and development platforms

—

# Programming languages

- A programming language is a formal language of valid expressions and rules (or techniques) for formulating instructions for a computer. A programming language has a defined set of syntactic and semantic rules. It allows the programmer to specify exactly and in detail the actions that the computer must perform, in what order and with what data.
- Open source software is software developed by a community, a company or an individual and offered for use under a free license, which guarantees access to all users to source code.
- Among the most popular programming languages are Python, Java, C ++, PHP.



# Python

- Python language - was developed mainly for UNIX family operating systems (eg Linux). Unlike the standard C ++ or C language, Python is based on specific rules for formatting program code.

Some examples of functional code formatting rules can be considered "basic":

- specifying the path to the compiler;
  - lack of delimiting characters of the end of the line;
  - delimitation of code sections by left alignment;
  - entering comments with the "#" character;
- 
- Python can be installed according to the guide here: <https://wiki.python.org/moin/BeginnersGuide/Download>

C++ code sequences equivalent in Python:

C++ (Arduino IDE)	Python
<code>#include &lt;&gt;</code>	<code>import &lt;&gt;</code>
<code>pinMode ()</code>	<code>mraa.DIR_&lt;IN / OUT&gt;</code>
<code>loop ()</code>	<code>while True write()</code>
<code>digitalWrite()</code>	<code>read()</code>
<code>digitalRead()</code>	<code>print("""</code>
<code>Serial.print("""</code>	

# Advantages for using Python

- The field of use of the Python language is that of applications with real-time execution, especially in areas where physical resources are relatively low (eg embedded work platforms, Automotive).
- Another major advantage over other languages is that, through HTML interoperability modules (eg Flask, NodeJS, MQTT, etc.), the Python language allows the application to run in real time, remotely and its control via a browser.
- Python is a dynamic, high-level programming language that emphasizes expressiveness and easy-to-understand code. Its syntax allows for implementations equivalent to other languages in fewer lines of code. Due to this, Python is very common in both application programming and scripting.
- Python is interpreted, not compiled. This means that Python programs are transformed into an intermediate language. This allows the code to be easily ported to various operating systems and hardware architectures.



# Licenses for open source applications

—

# Introduction

- A software license gives you the legal right to install, use, access, display, execute or interact with a particular software program. Sometimes you may need a license for each computer or device on which the software is installed. A license covers things like downgrade rights and specifies whether it is perpetual (no expiration date) or temporary (with a specific end date).
- Each type of license is suitable for different users. For example, OEM and Retail licenses are intended for regular users, while volume licenses are best for companies and organizations.

## Fast view of license types

License Type	Transfer	Management	Activating the licenses
<u>OEM</u>	Yes	Suitable for end users or small businesses. It can be difficult to track and manage in large companies.	If another device type is used after the license has been removed from the old device, telephone activation is required.
<u>Retail/</u> <u>FPP</u>	Yes	Suitable for large companies and institutions RDS compatible Easy management via VAMT Quick activation of software products on a large number of devices.	Activation online via MAK / KMS

# Licenses for open source applications

- Open Source License (LOS) is a generic name for a variety of software application licensing types (more details on [OpenSource.org](https://opensource.org)). In essence, these are free licenses, with access to the source code, developed by communities of users / programmers. The implementation budget is oriented towards implementation and personalization services, which implies an obvious increase in the value brought to the user compared to the LCS case. The key to the efficiency of this type of applications consists in contracting support services from a professional provider, with experience in the user's activity segment. However, the possibilities for change are limited and associated with high costs. Many Open Source projects are losing momentum and platforms are no longer up to date, which can pose security and adaptation issues to the evolution of IT technologies.

The following types of open source licenses have been approved by OSI :

- Apache License 2.0
- BSD 3-Clause "New" or "Revised" license
- BSD 2-Clause "Simplified" or "FreeBSD" license
- GNU General Public License (GPL)
- GNU Library or "Lesser" General Public License (LGPL)
- MIT license
- Mozilla Public License 2.0
- Common Development and Distribution License
- Eclipse Public License version 2.0



# Open source applications used in 3D modeling

—

# Introduction

- There are several types of "open source" equipment that can be used to produce parts, assemblies and subassemblies needed in the revamping process. The most popular are of the following types:
  - 3D printers
  - CNC machines
  - Laser cutters
- These equipment need 3D models to be able to produce parts or assemblies. In other words, the 3D modeling of the part in the shape required at the entrance by these equipment is provided by software applications.

Among the most used open source 3D modeling applications are:

- Blender
- Sculpttris
- Google Sketchup
- Seamless 3D
- Dust3D
- Mandelbulb 3D

## The Best 8 Free and Open Source 3D Modeling Software

3D Modeling Software	License	Initial Release	3D Rendering Support	User Level	Platform	File Formats
<b>Blender</b>	GPLv2+	1998	Yes	Professional	Windows, Mac, Linux	3ds, dae, fbx, dxf, obj, x, lwo, svg, ply, STL, vrml97, x3d
<b>Sculptris</b>	Freeware	2009	No	Intermediate	Windows, Mac	obj, goz
<b>Wings 3D</b>	BSD	2018	Yes	Beginner	Windows, Mac, Linux	3ds, fbx, obj, dae, lwo, wrl, rwx, STL, x, xml
<b>Seamless 3D</b>	MIT	2001	No	Beginner	Windows	Import/Export files like VRML, X3D Obj
<b>Dust3D</b>	MIT		Yes	Game developers	Cross platform- Windows, Linux, MacOS	FBX, glTF
<b>Mandelbulb 3D</b>	Freeware	2009	Yes	Beginner	Cross-Platform	M3I image + Parameter, .M3P Parameter
<b>SketchUp</b>	Freemium	2000	Yes	Advanced	Windows, Mac	skp, stl, png
<b>Onshape</b>	Commercial Software	2015	Yes	Professional	Windows, Mac, Linux, Chromebook, iOS & Android	Parasolid, ACIS, STEP, IGES, SolidWorks, Inventor, Rhino, OBJ, NX, DXF, DWG, PDF, STL

# Blender 3D

- Blender 3D is an open source 3D graphics software program.
- It may be used for:
  - creating 3D models,
  - UV mapping,
  - texturing,
  - rigging (animation by using "bones"),
  - water simulation,
  - animation,
  - rendering,
  - particles and other computer simulations,
  - non-linear editing,
  - compositing and creating 3D interactive applications.
- Blender is available for several operating systems, including FreeBSD, IRIX, GNU / Linux, Microsoft Windows, Mac OS X, Solaris, SkyOS, and MorphOS.
- Blender has a variety of similar functions in purpose and complexity as other 3D programs such as Softimage | XSI, Cinema 4D, 3ds Max, Lightwave and Maya. These features include advanced simulation tools such as rigid body, fluid, cloth and softbody dynamics, powerful character animation tools, node-based materials and Python scripts.



# Blender 3D

- Blender has a relatively small size when installed and runs on several popular platforms.
- Although it is often distributed without documentation or without complicated exemplary scenes, the program abounds in functionalities characteristic of top modeling software.
- It supports a variety of primitive geometric shapes, including polygonal structures, rapid surface subdivision modeling, Bezier curves and NURBS surfaces, metaballs, polygon carving, and vector typeface fonts.
- It has versatile internal rendering and integration capabilities with the YafRay open source raytracer.
- Provides animation tools, including reverse kinematics, reinforcement (skeletal) and lattice deformations, shape keys, keyframes, timeline, nonlinear animation, constraints, vertex weighting, softbody dynamics, including collision detection between object structures, fluid dynamics, hard body dynamics, hair based on the particle system, and a particle system with collision detection function.
- It is a Python scripting tool for creating new tools or tool prototypes, logical game scripting, or automating certain tasks.
- Allows basic non-linear video editing and compositing capabilities.
- Allows the creation of standalone applications that can run in real time, from architectural visualization to video game programming.

# Blender 3D

- The Blender installation kit is only 9 MB and requires only 30 MB of disk space, and a "minimal" installation requires only 2.2 MB, while other programs, such as AutoCAD, require approximately 2 GB. Thus, Blender can be easily downloaded (although some books include a CD with Blender).

Source: <https://www.blender.org/download/>



# Sculptris

- Sculptris is a program of the Freeware software category, which you can download for free and which allows users to model in 3D.
- Using Sculptris you can model and sculpt bodies, objects, buildings and figures in three dimensions.
- Sculptris has various 3D drawing and sculpture tools, allows the export and import of objects and allows the coloring or application of different textures.
- Sculptris has a simple and intuitive interface from which anyone can use the program without any problem.
- Sculptris is an easy to use and install program, the Sculptris program does not consume many system resources and does not take up much space on the hard disk.
- For more information about using the program Sculptris, use the Help function, which is on the toolbar.
- The installation of Sculptris is easy to do, if the program comes compressed into one of the known formats (usually .rar or .zip), it will first unzip the file, after which you will need to look for the installer, something like "install. exe "or at least with the extension" .exe "(usually there is only one icon, the installer on which you have to double click).
- From here nothing is simpler, just follow the instructions in the installer and accept the terms and conditions of use of the program.

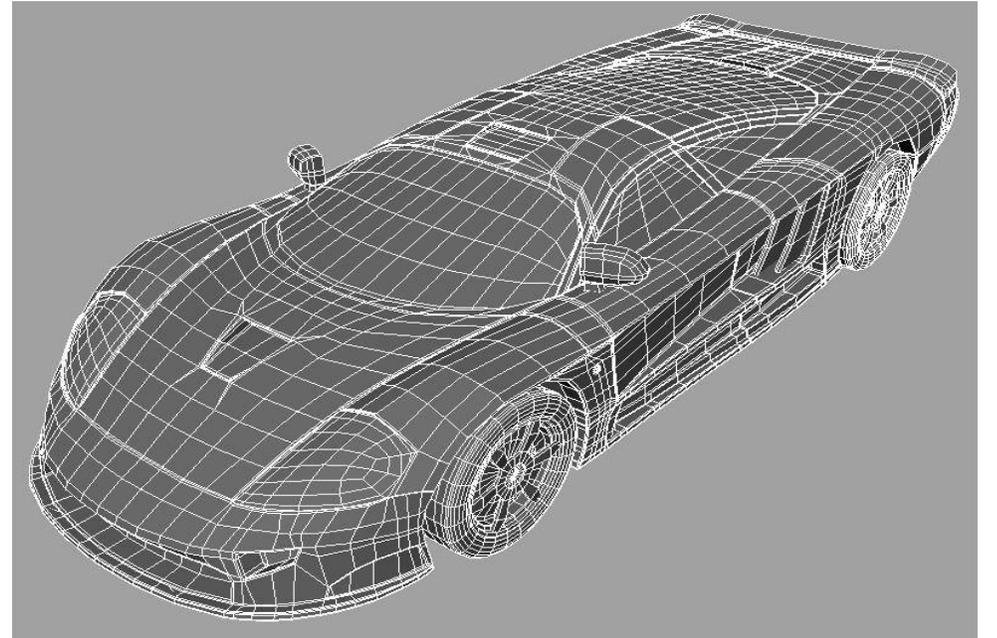
# Sculptris

- Sculptris works with Windows operating systems - Windows XP/Windows Vista/Windows 7/Windows 8/Windows 8.1 / Windows 10 - and Mac, works very well with Windows 10 and Windows 8.1.
- In order to use Sculptris you need at least: processor: 1 GHz Pentium || Memory: 2 Gb RAM || Free disk space: 1 GB ||
- Recommended: processor: 2.4 GHz Pentium || Memory: 8 Gb RAM || Free disk space: 4 GB ||
- The most important features of Sculptris:
  - Manual update;
  - Sculptris is an application easy to use;
  - Simple and intuitive interface;
  - Different 3D carving tools;
  - Various 3D modeling tools;
  - Different 3D drawing tools;
  - Sculpture of creatures, bodies, objects, beings in 3D;
  - Installation / uninstallation support, etc.
- For free download Sculptris you can use the following link:  
<https://sculptris.en.softonic.com/>



# Dust3D

- Dust3D is an open-source cross-source modeling software. It helps you create a watertight 3D model in seconds. Use it to speed up character modeling in making games, 3D printing and so on.
- The Dust 3D application is free and belongs to the category of open-source programs. Moreover it is cross-Platform, whether you are on Windows, Linux or MacOS, you will get the same extraordinary experience.



# Conclusions

—

# CONCLUSIONS

- Open source software offers excellent opportunities for those who want to modernize machines, especially old machines with outdated technology.
- Using open source software equipment can be updated at little cost. This is an opportunity for people who want to study and develop professionally to learn how to use OSS and replan their careers.
- Outdated machines are often polluting and have safety considerations for both users and the environment. Through the use of open source software one can obtain safer equipment and an environmentally better suited equipment.
- OSS is a high-quality software which provides simple license management and integrated management. It benefits of abundant support and entails lesser software and hardware costs in building the equipment.

# Source/References



List of open-source software

[https://en.wikipedia.org/wiki/Open-source\\_software](https://en.wikipedia.org/wiki/Open-source_software)

Open Source Initiative

<https://opensource.org/licenses>

Blender website

<https://www.blender.org/>

Raspberian website

<https://www.raspberrypi.org/downloads/>

Sculptris website

<http://pixologic.com/sculptris/>

Dust3D website

<https://dust3d.org/>

Co-funded by the  
Erasmus+ Programme  
of the European Union



The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



REFITTING

MACHINE



DESIGN OF SOFTWARE INTERFACES



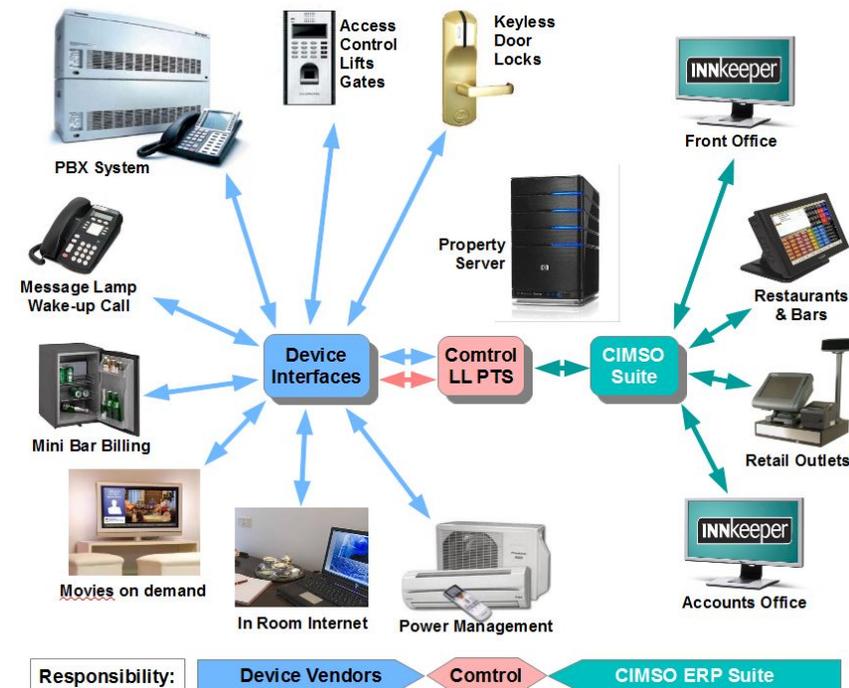
Co-funded by the  
Erasmus+ Programme  
of the European Union

## Aims and objectives

CHAPTER AIM:	To equip learners with the basic principles in designing user interfaces
COMPETENCES:	<ul style="list-style-type: none"><li>• Ability to design software interfaces</li></ul>
LEARNING OUTCOMES:	<ul style="list-style-type: none"><li>• Knowledge on existing types of user interfaces and the requirements for user interfaces</li><li>• Knowledge about graphic user interfaces</li><li>• Awareness of graphic user interface elements and useful information related to software interfaces</li><li>• Knowledge on existing languages and codes used for software interfaces</li><li>• Knowledge on software interfaces</li><li>• Knowledge on user interfaces</li></ul>
NUMBER OF HOURS:	3

# Lecture Outline

1. Introduction to "Software Interfaces"
2. Software Interfaces
3. Language Codes Used
4. Interface Types
5. Conclusions



# Introduction to "Software Interfaces"

—

# Introduction to "Software Interfaces"

- An interface is any tool that allows communication between an operating system and an operator, whether that tool is hardware or software.
- Software interfaces are software systems that initiate and maintain a dialogue with the computer user in order to use and / or configure it.
- The software interfaces can be:
  - Monitors.
  - Command line interfaces (or text interfaces).
  - Graphical interfaces.
- In the industrial design of human-computer interaction, the user interface (UI) is the space where interactions between humans and machines take place.
- The purpose of this interaction is to allow the operation and effective control of the machine and the machine simultaneously provides information that helps the decision-making process of the operators.



# Software Interfaces

—

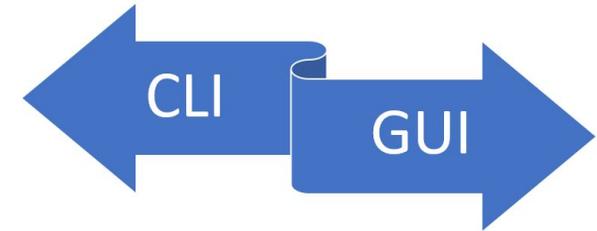
# Software Interfaces

Interface is any tool that allows communication between a software operating system and the user.

Software interfaces are software systems that maintain a dialogue with the computer user in order to use and configure it.

Requirements :

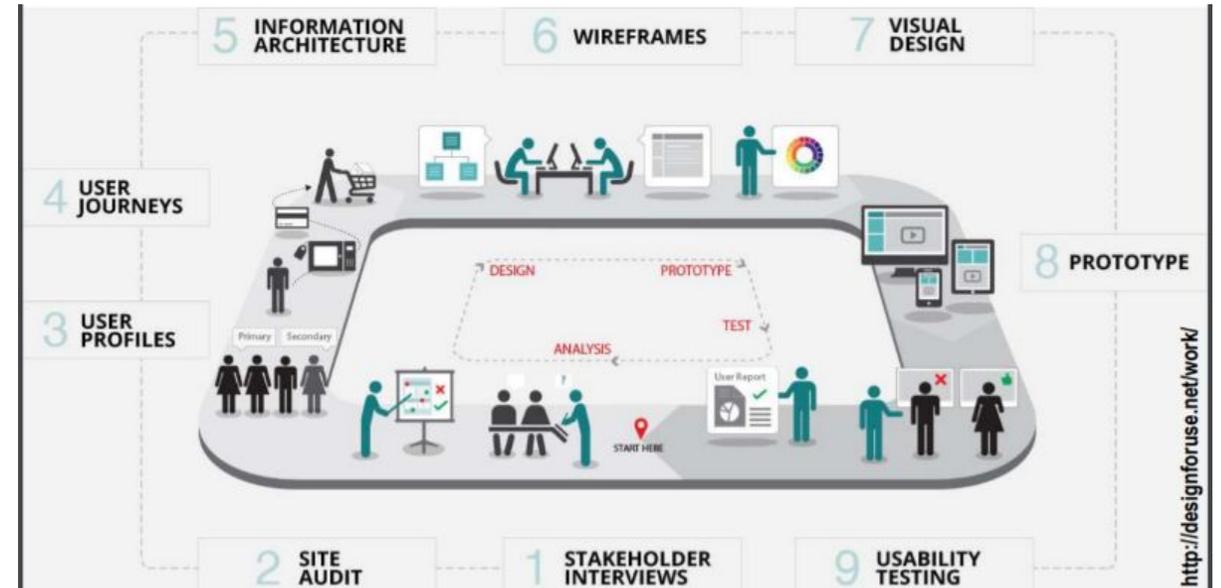
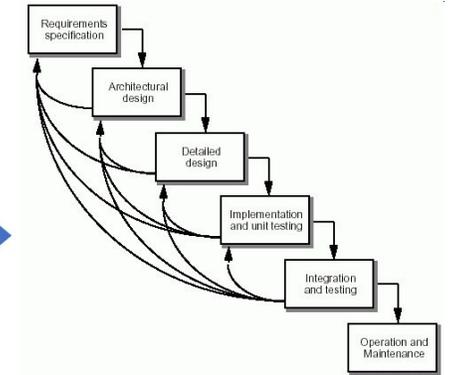
- useful
- usable
- valuable
- desirable
- findable
- accessible
- credible



# Software Interfaces

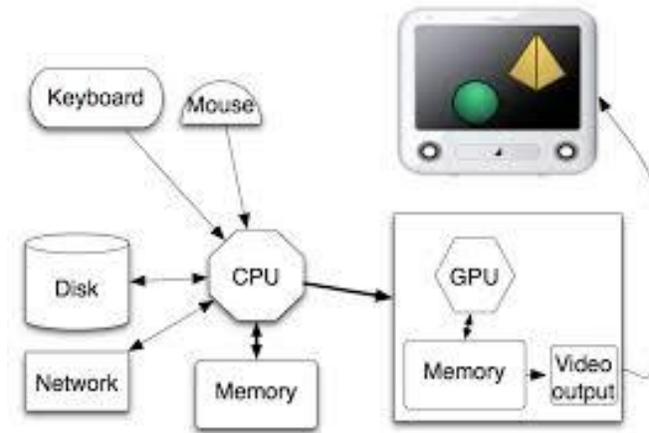
The design of user interfaces, made by graphic designers, programmers, testers, is the sum of the following activities:

- understanding the needs of users
- design
- prototyping
- evaluation / testing
- final implementation
- maintenance



# User Interaction with Software

- Command line (program: shell)
- Graphical User Interface (GUI)
- Touch (User User Interface - TUI)
- Multimedia (voice, animation, etc.)
- Smart (gesture recognition, conversational, etc.)



# User Direct Manipulation

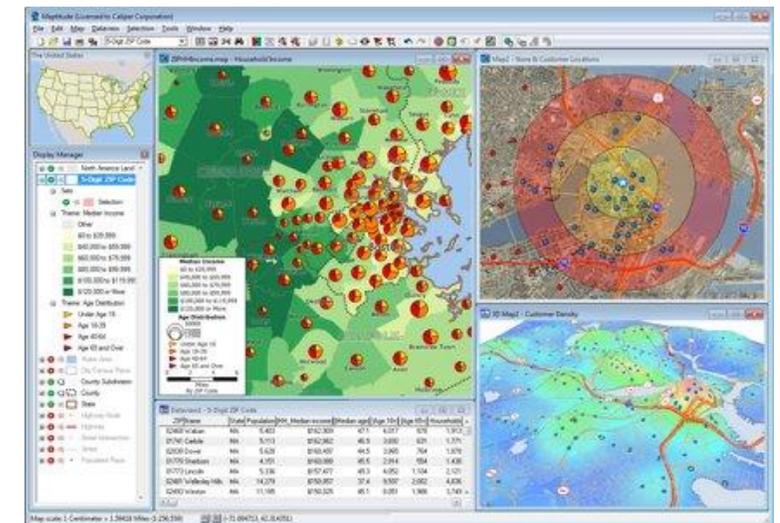
Users interact with the interface through direct actions such as:

- moving information, replacing information, etc.
- text editors, spreadsheets
- geographic computer systems and video games have such interfaces.

The advantages of these interfaces are:

- users feel they control the system;
- short learning time;
- mistakes can be detected and corrected immediately.

These interfaces are difficult to implement and require a lot of computing resources (memory, processor).



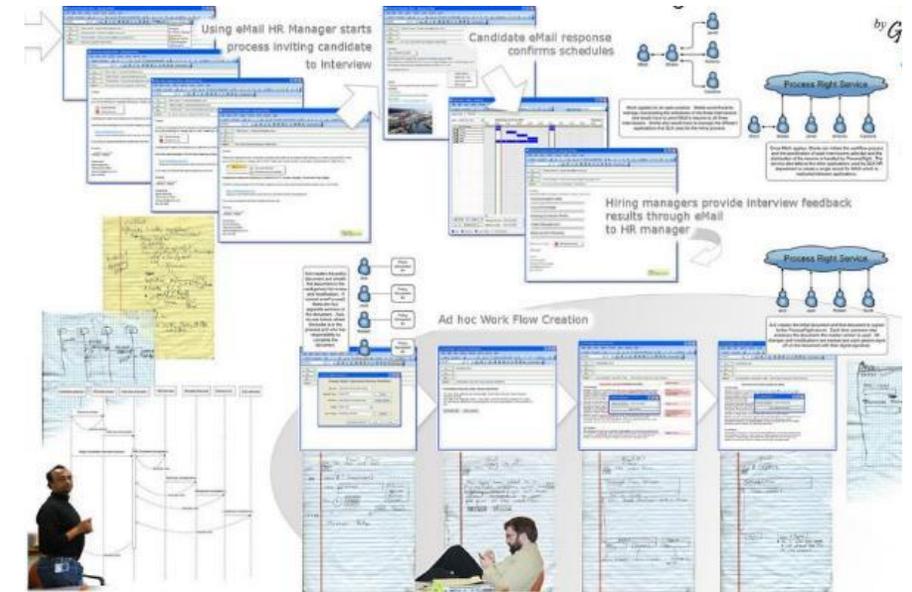
Source: <https://I3software.com>

# Designing the Interface

Steps in designing and creating an interface:

- identifying and understanding the needs of end users
- involving users as evaluators, consultants, designers
- analysis of tasks and the context of human-machine interactions
- interface prototyping
- interface evaluation
- interface programming

Interface design requires a very large software development effort



Source: <https://www.diagrameditor.com/>

# Language Codes Used

—

# Languages for Software Interfaces

An interface description language or interface definition language (IDL), is a specification language used to describe a software component's application programming interface (API).

IDLs describe an interface in a language-independent way, enabling communication between software components that do not share one language.

IDLs are commonly used in remote procedure call software. In these cases the machines at either end of the link may be using different operating systems and computer languages. IDLs offer a bridge between the two different systems.

Filter by language	
✓ All	15,491
C++	8,447
C	960
Python	813
JavaScript	567
Java	537
HTML	270
C#	250
Processing	154
PHP	82



# C / C++

- C / C ++: general programming language
- The C programming language was standardized in 1998
- C ++ was designed with a bias toward system programming and embedded, resource-constrained software and large systems, with performance, efficiency, and flexibility of use as its design highlights.
- C ++ has also been found useful in many other contexts, with key strengths being software infrastructure and resource-constrained applications, including desktop applications, video games, servers

- C Syntax
- C Variables/C Identifiers
- C Data Types
  - Numeric Data Types
  - Boolean Data Types
  - Character Data Types
  - String Types
- C While Loop/For Loop/Do-While Loop
- C Functions
- C Classes
- OOP
  - Classes and Objects
  - Class Methods
  - Constructors
  - Encapsulation
  - Inheritance
  - Polymorphism



# Python

- Python is a dynamic programming language, created in 1989 by Dutch programmer Guido van Rossum.
- Python is a multifunctional language used for example by companies like Google or Yahoo! for programming web applications.
- Python is the main development language used by specialized programmers.
- Python can serve as a language for object-oriented software, but also allows imperative, functional or procedural programming.
- The typing system is dynamic, it has ample libraries of standard methods.

- Python Functions
- Python Classes and Objects
- OOP
  - Pythonclasses and ObjePythonts
  - Pythonclass Methods
  - PythononstruPythontors
- EnPythonapsulation/Tuples
- InheritanPythone/Polymorphism
- Python Modules
- Python JSON
- Python Try ExPythonept
- File Handling
- MaPythonhine Learning
- Python MySQL
- Python MongoDB



# Java / JavaScript

- Java is a heavily typed object-oriented programming language, designed by James Gosling in the early 1990s, and released in 1995.
- The new technological evolutions allow its use also on mobile devices: telephone, electronic diary. A unique platform is created, at the level of the programmer, above an extremely diversified heterogeneous environment.
- The language borrows much of the syntax from C and C ++, but has a simpler object model, a compiled, correctly written Java program can be run on any platform that has a Java virtual machine installed

- JavaScript Data Types
  - Numbers/Booleans/Operators
  - Variables/Functions/Strings
- JavaScript Objects
- Java Arrays
- Java Methods
- JavaScript Number Methods
- JavaScript Array Methods
- JavaScript Get Date Methods
- Java Classes and Objects JS Forms
- JS Objects
- JS HTML DOM
- JS Browser
  - BOMJ/ S AJAX
  - JS JSON/ JS vs jQuery
  - JS References



# HTML

- HTML is a form of bookmarking aimed at presenting text documents on a single page, using specialized rendering software called an HTML user agent, the best example of such software being the web browser.
- HTML provides the means by which the content of a document can be annotated with various types of metadata and playback instructions, can include information that allows the document to be linked to other documents to form hyperlinks (or the web).
- HTML is a text format designed to be read and edited by people using a simple text editor.
- Graphic editors: Macromedia Dreamweaver, Adobe GoLive or Microsoft FrontPage allow web pages to be treated similarly to Word documents,
- HTML can be generated directly using server-side encoding technologies such as PHP, JSP or ASP.
- HTML is also used in email.

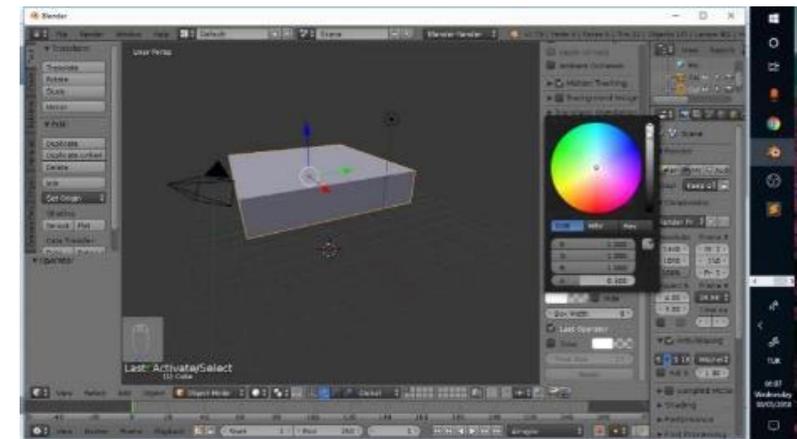
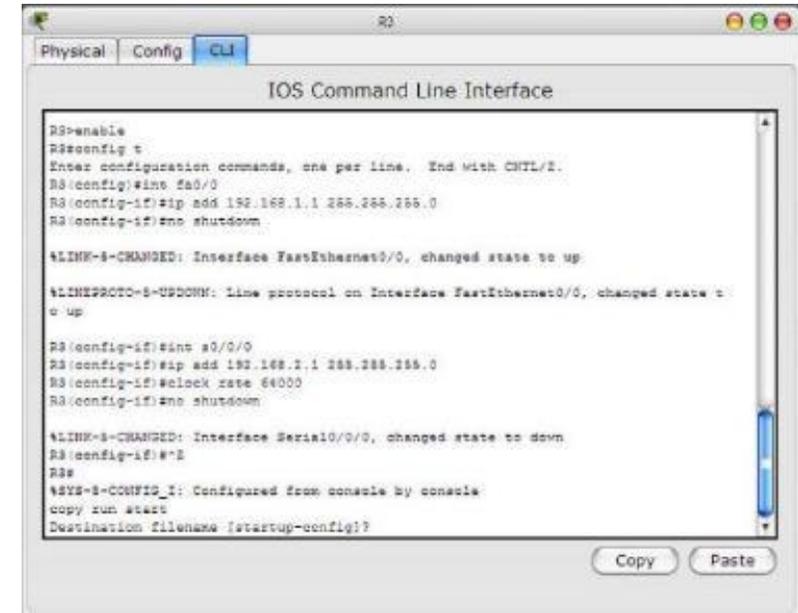
- HTML Codes
  - Text Code/Table Code
  - Link Code/Image Code
  - Color Code/Form Code
  - Textbox Code/Scrollbox Code
- Character Codes
- HTML Editors
- HTML Generators
- HTML Reference
- HTML Tags
- HTML Graphics
- HTML Media
- HTML APIs/HTML References

# Interface Types

—

# Interface Types

- interfaces that use natural language;
- question and answer interfaces (dialog box)
- interfaces based on input / output video formats;  
Display fields that contain data items or parameters that must be communicated to the user. The user can select the desired video format and complete it.
- command line type interfaces;  
Dedicated to programmers, allow the user to control the dialog, the user types a command, it is executed immediately by the system.
- interfaces that allow direct manipulation;  
It is necessary to have facilities for generating error messages and handling errors.
- menus  
Consist of a list of options, which ensures a quick and easy communication with the user. Selecting an option can be done by: typing a letter/selecting a key combination associated with that option/positioning the mouse on the option and pressing the right button or using the directional keys



# Graphic Interfaces

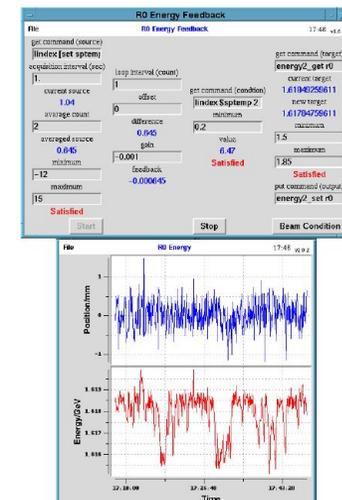
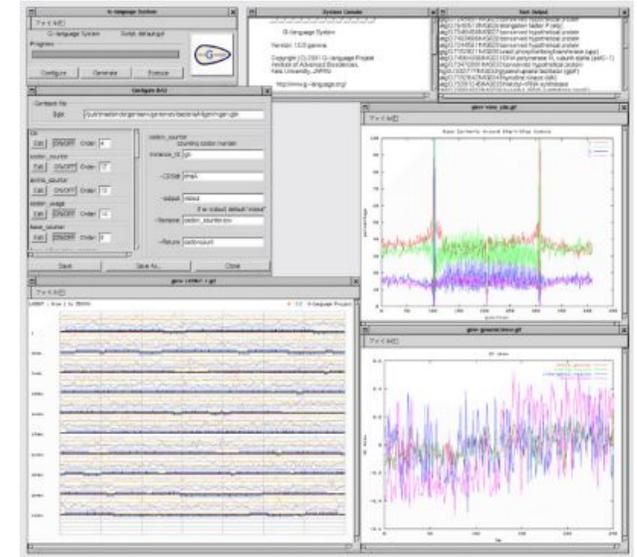
A GUI (Graphic User Interface) is a graphical user interface and represents a model for that part of a program that interacts with the user and uses icons and visual indicators to represent the characteristics of the program.

The graphical interface is called the graphical-visual display system on a screen, functionally located between the user and electronic devices such as computers, hand-held personal devices (MP3 players, portable media players, play devices), home appliances and some office equipment.

## The advantages of using GUI are:

- easier and more efficient computer interaction for the user;
- simplification of complex instructions, made with the help of icons and menus
- intuitive initiation of commands to the computer;

Programs and files are easier to handle and organize.



# Advantages and Disadvantages



Command line interface	Graphic Interface
<p><b>Benefits:</b></p> <ul style="list-style-type: none"><li>• Allows clear and explicit writing of commands, with all parameters well defined</li><li>• Provides flexibility in use</li><li>• Communication with the operating system is fast and efficient</li></ul>	<p><b>Benefits:</b></p> <ul style="list-style-type: none"><li>• It is intuitive and easy to use</li><li>• It can also be used by non-professionals</li><li>• Creates an orderly work environment</li><li>• It allows the creation and use of complex applications, as well as their integration in unitary work environments</li></ul>
<p><b>Disadvantages:</b></p> <ul style="list-style-type: none"><li>• The operator must be well aware of the commands and their effects</li><li>• It is more difficult to use by non-professionals</li></ul>	<p><b>Disadvantages:</b></p> <ul style="list-style-type: none"><li>• Some operations, such as system setup, may not be accessible from menus and graphical interface windows.</li><li>• The interface hides certain details related to taking and executing commands</li><li>• It uses more resources and is less flexible than the command line interface</li></ul>

# Stages in creating an application with graphic interface

## Design

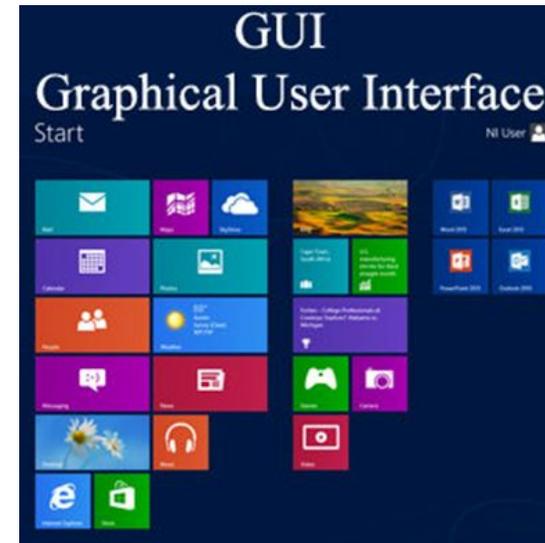
- Creating display surfaces (containers)
- Creation and placement of components

## Functionality

- Defining actions
- "Linking" the components of actions
- "Listening" and dealing with events

## Considerations

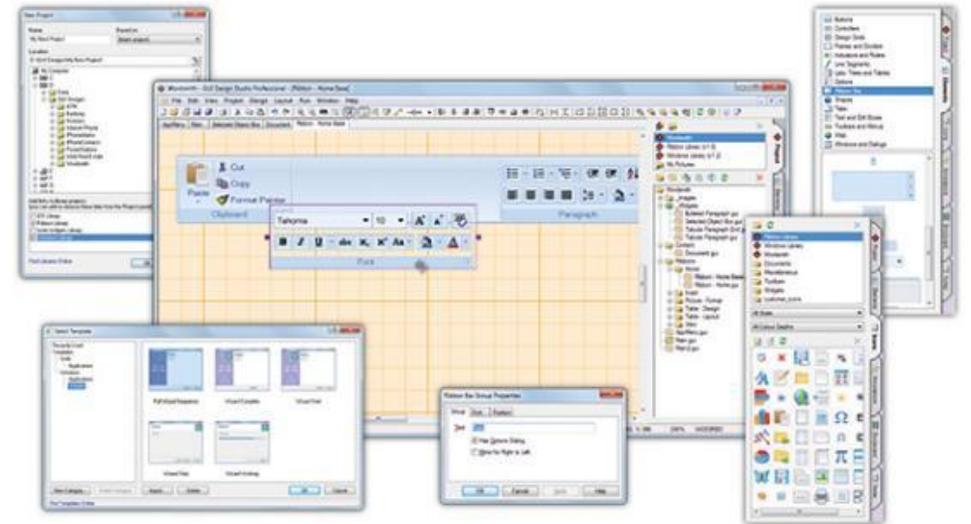
- Programmatic
- Declarative
- Visual
- Separation between GUI level and application logic



# GUI dialogue

A software support provides the programmer with the following elements:

- a library of control elements (scroll bars, borders, buttons, etc.).
- a window manager dictates how a window is assembled and equipped, as well as how it will be manipulated.
- a library of predefined functions or classes that allows the construction of the graphical interface, starting from the application window, according to the standard imposed by the window manager installed on the machine running the application.



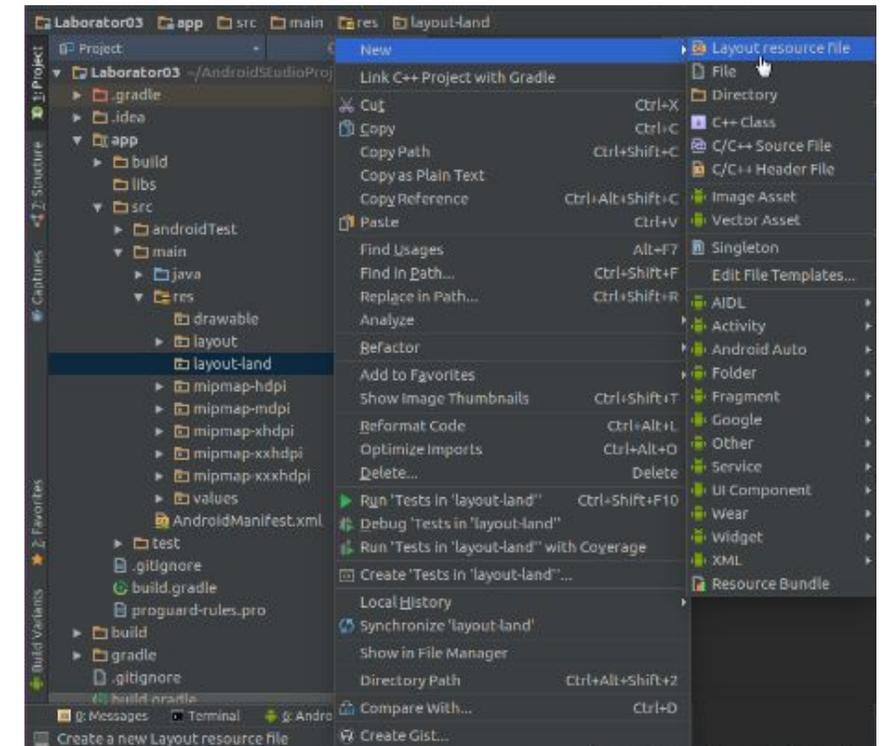
# Software analysis for the access/functioning of GUI

Usability is a quality feature of software systems and refers to the extent to which specified users meet specified purposes effectively, efficiently and satisfactorily in a specified context of use.

A graphical interface contains elements that have the ability to display information to the user, to interact with him, taking over the data necessary to achieve the various operational flows within the application.

There are graphic controls, responsible only for the management of the arrangement mechanism of the other components, determining how they will be placed in the window as well as the coordinates at which they will be positioned.

The structure of a graphical interface is tree-like. The root element will be a control that manages the way its components are arranged, while the leaf elements are actual graphic controls, visible on the screen, on intermediate levels in this hierarchy you can find elements of both types (both graphics and content delivery mechanisms - which thus control a section of the user interface)



# Usage principles

- **Perceptibility:** the information and components of the user interface must be presented to users in a form that is as easy to perceive as possible (with at least one of the senses).
- **Operability:** user interface and navigation components must be operable and as easy to operate as possible.
- **Comprehensibility:** the information and the operation of the user interface can be understood by the user.
- **Robustness:** the content must be robust enough to be interpreted with a degree of confidence acceptable to a variety of user agents, including assistive technologies.



# UX -User Experience, Project Checklist

UX is about projecting something easy to use

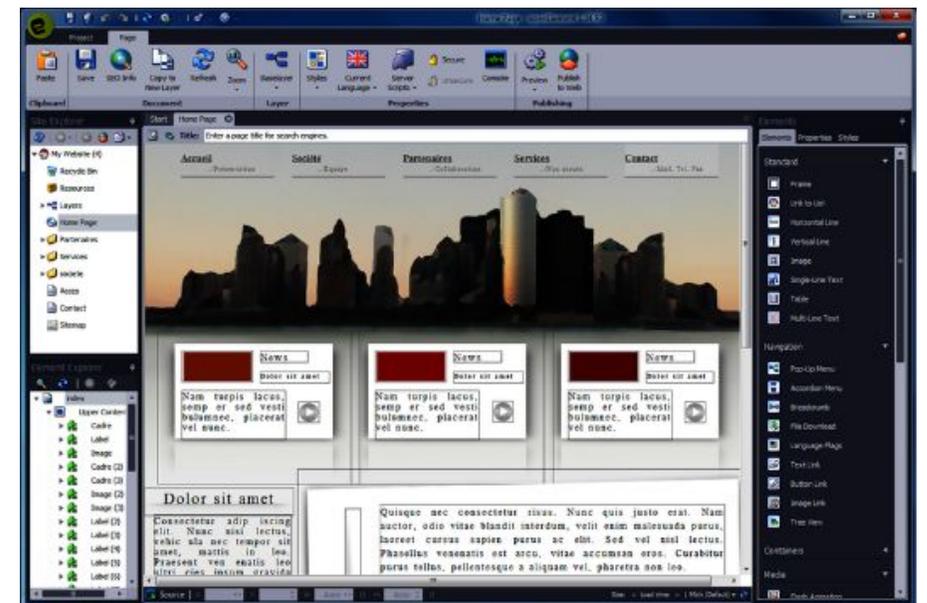
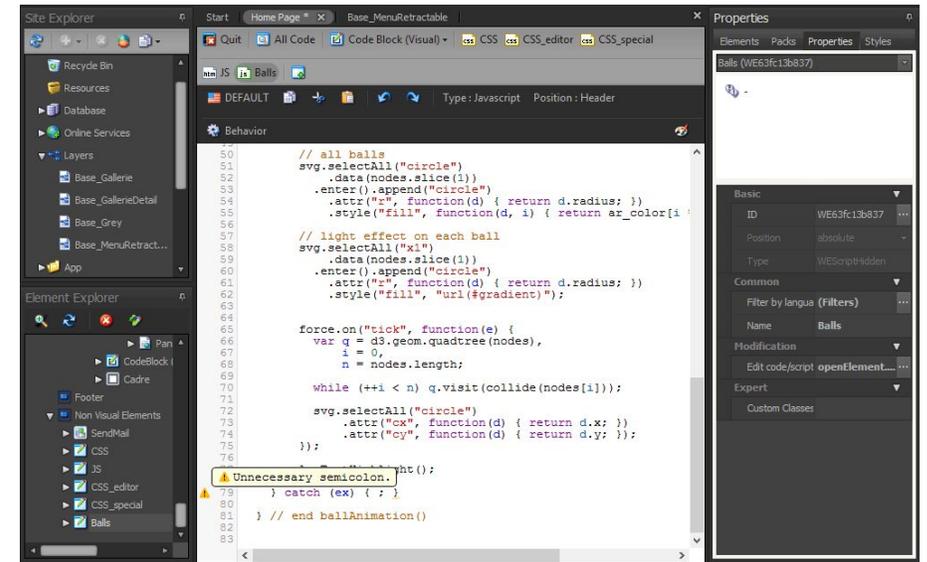
- Research
- Plan
- Explore
- Communicate
- Create
- Give feedback
- Finalise
- Delight
- Analyse

<b>Research</b>	<b>Competitive Analysis</b> See how others solve similar problems and try to not reinvent the wheel. <a href="#">Read more</a>	<b>Data analysis</b> Do you have all the user data you need to make data-driven code page-level improvements? <a href="#">Read more</a>	<b>User feedback</b> How do you get customer feedback? Do you have a plan for how you'll do it? What are your customer experience goals? <a href="#">Read more</a>
<b>Plan</b>	<b>User stories</b> How do you write user stories? What do they look like? How do you use them to create user stories and scenarios? <a href="#">Read more</a>	<b>User flows</b> Create your user flow based on the scenarios you created. You can use it to define the journey and create wireframes on top of each step. <a href="#">Read more</a>	<b>Red routes</b> Define red routes for your product and you'll be able to identify, prioritize and ultimately identify obstacles on the user journey. <a href="#">Read more</a>
<b>Explore</b>	<b>Brainstorm &amp; sketch</b> Find a way to brainstorm and create ideas together and sketch ideas. Use sketchbook for <a href="#">Read more</a>	<b>Wireframe</b> Add some details and structure to your ideas. Make content and create page structure of your user flows. You'll not see anything same. <a href="#">Read more</a>	<b>Prototype</b> You can start creating paper prototypes and continuously iterate how functional ones. Use sketches, HTML, paper or digital pages that you get some ideas and test. <a href="#">Read more</a>
<b>Communicate</b>	<b>IA</b> Understand your users, your data structure and your content. How can you organize your navigation and content in a clear and consistent way? <a href="#">Read more</a>	<b>Language</b> How do you write copywriting? How do you include culture and language in the context of your products and how is it being implemented? <a href="#">Read more</a>	<b>Accessibility</b> You don't need to add extra functionality or to exclude any content. The way to simply to assess the requirements of those with different skills and assist devices. <a href="#">Read more</a>
<b>Create</b>	<b>Sustainable</b> Help the users to reduce the resources you use. Think about better behaviors and create a path to help them. Test your product on a small scale. <a href="#">Read more</a>	<b>Ethical</b> How do you create a code of ethics? How do you ensure your product is ethical? How do you ensure your product is ethical? <a href="#">Read more</a>	<b>Inclusive</b> Remember that everything you design is viewed by someone and background. Be sure to consider their process to remove your bias and design for everyone. <a href="#">Read more</a>
<b>Give feedback</b>	<b>UI elements</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>Buttons</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>Responsiveness</b> Can you use a mobile app? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>
<b>Finalise</b>	<b>Waiting times</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>Errors</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>Completed actions</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>
<b>Delight</b>	<b>Finalise layout</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>Use of images and icons</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>Font &amp; colour hierarchy</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>
<b>Analyse</b>	<b>Micro copy</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>Micro interactions</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>Transitions</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>
	<b>KPI Setup</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>AB Test plan</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>	<b>Test</b> Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? Do you have a consistent UI? <a href="#">Read more</a>

User Experience means analytical thinking, attention to detail, empathy and simplification of the processes that your customers have to go through

# Web Applications

- A web application is a computer software program that runs on a web server, as opposed to computer-based software programs that are stored locally on a device's operating system (OS).
- Web applications are accessed by the user through a web browser with an active internet connection.
- These applications are programmed using a client-server-shaped structure - the user ("client") is provided through a server outside the third-party hosted site.
- Examples of commonly used web applications include: email, online retail, online banking, and online auctions.



# Interface Design for Web Applications

- Collections of interconnected web pages, with dynamic content, offering a specific functionality
- Web applications need to provide simple, intuitive, and responsive user interfaces that allow users to do things with less effort and time.

## Application design steps:

- Model - the data to be processed are included
- View - contains all specialized classes for storing / modifying data
- Controller - it is the part of the program that is familiar to the user, as he only works with the front-end part of the project.



# Artificial Intelligence

“Machine Learning” (ML), i.e. artificial intelligence, will allow computers to learn from their own experiences and evolve just like us humans.

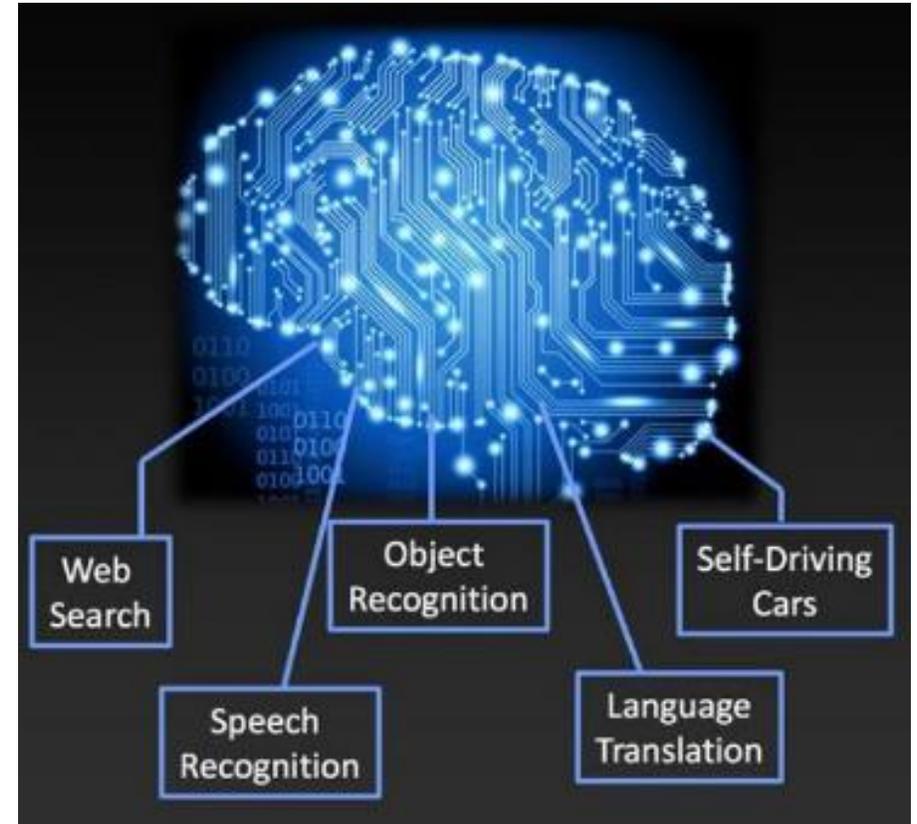
The three areas of research here are:

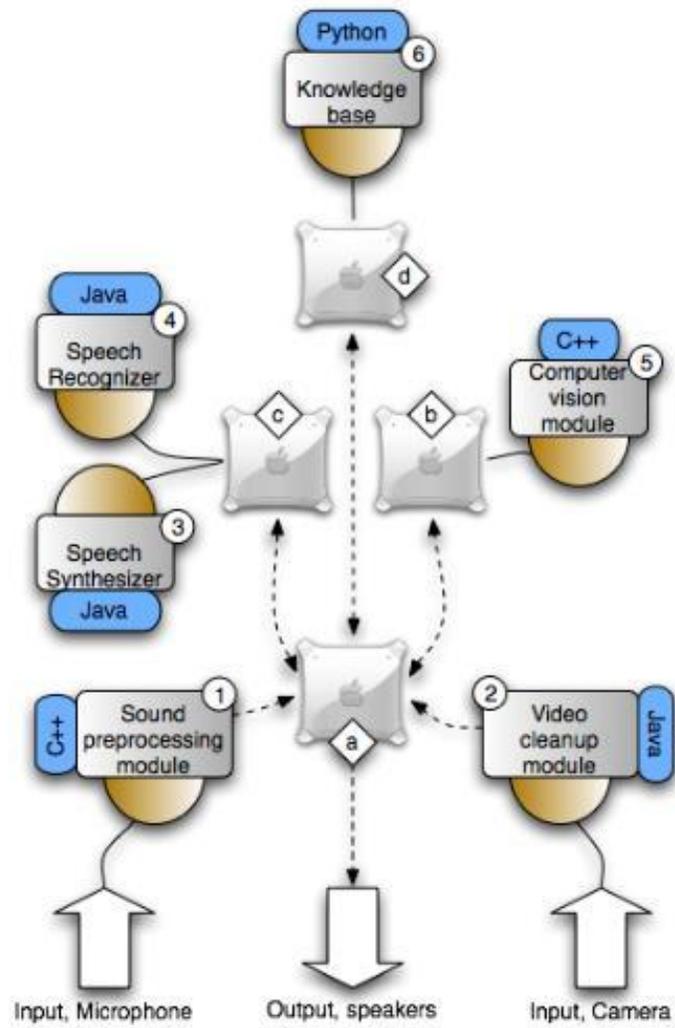
- computer intelligence,
- natural language processing,
- the perception of cars,
- creating systems that can think, listen and see.



# Artificial Intelligence

- The software that learns is called neural network and mimics the functioning of the human brain.
- It is made up of millions or even billions of "neurons", which are small computational units that each make a simple computation and then transmit the information to the neurons to which they are connected.
- The neural network can learn to recognize quite complex patterns, learn to perform tasks.





**An example of A.I. systems integration using message protocols and blackboard systems such as OpenAIR and Psyclone**

-  Communication protocol for modules
-  Programming language
-  Message routes

# Conclusions

—

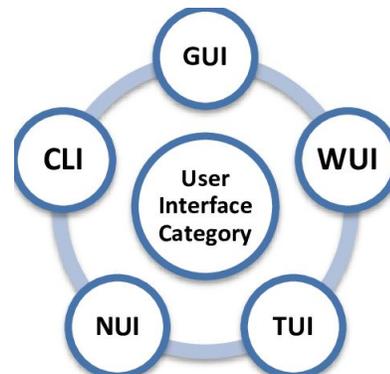
# CONCLUSIONS

## Future user interfaces

- A natural user interface, NUI, is a user interface that is effectively invisible, and remains invisible as the user continuously learns increasingly complex interactions.
- The word natural is used because most computer interfaces use artificial control devices whose operation has to be learned.
- While the interface requires learning, that learning is eased through design which gives the user the feeling that they are instantly and continuously successful.

### Where we're at...

<b>The past</b>	CLI : Command Line Interface
<b>Now</b>	GUI : Graphical User Interface
<b>Near future</b>	NUI : Natural User Interface
<b>Future</b>	OUI : Organic User Interface



# Source/References



Interface and interaction design

<https://www.oreilly.com/content/interface-and-interaction-design/>

<https://l3software.com>

Software Application Architecture

<https://www.sciencedirect.com/topics/computer-science/software-interface>

JAVA Graphic User Interface (GUI)

<http://docs.oracle.com/javase/tutorial/ui/index.html>

Artificial intelligence systems integration

[https://en.wikipedia.org/wiki/Artificial\\_intelligence\\_systems\\_integration](https://en.wikipedia.org/wiki/Artificial_intelligence_systems_integration)

<https://www.udemy.com/course/machinelearning/>

Natural user interface

[https://en.wikipedia.org/wiki/Artificial\\_intelligence\\_systems\\_integration](https://en.wikipedia.org/wiki/Artificial_intelligence_systems_integration)

# Source/References



Natural user interface

<https://www.youtube.com/watch?v=WtoK7BzalsA>

<https://www.youtube.com/watch?v=RtPnVtXw6HU>

<https://www.youtube.com/watch?v=I0-vBdh4sZ8>

Co-funded by the  
Erasmus+ Programme  
of the European Union



The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



REFITTING

MACHINE



REFITTING  
MACHINE

ECONOMIC BENEFITS OF  
MACHINERY REVAMPING



Co-funded by the  
Erasmus+ Programme  
of the European Union

## Aims and objectives

CHAPTER AIM:	Present and discuss the economic benefits that result from machinery revamping
COMPETENCES:	<ul style="list-style-type: none"><li>• Recognize the economic effects of machinery revamping</li><li>• Recognize the methods that are used during the machinery revamping and how enterprises could save money</li><li>• Ability to select the best method for the machinery revamping</li><li>• Develop critical thinking as to the various economic benefits of machinery revamping.</li></ul>
LEARNING OUTCOMES:	<ul style="list-style-type: none"><li>• Understanding how users can benefit in terms of economy during the machinery revamping</li></ul>
NUMBER OF HOURS:	4

# Lecture Outline

1. Introduction
2. Machinery revamping
3. Economic benefits of machinery revamping
4. Circular economy and machinery revamping
5. Conclusions



# Introduction

—

# Introduction

- This chapter will focus on machinery revamping and the various benefits that derive from this method. Under the present economic situation, companies, users and, generally, economy can use the modernization of machines with the aim to grow and create machines with more possibilities.
- This chapter includes useful information, videos and numerous sources on the impact that machinery revamping brings to economy.



# Machinery revamping

—

# Machinery Revamping

- During this period, the process of machinery revamping is very important for the users in order to update machines through new technologies.
- The workers, the producers and the economy could benefit from machinery revamping, as it provides a variety of economic goods. The productivity could be improved, and the efficiency increased for the companies.



Watch the following video  
about the modernization of a  
sewing machine:



Source: <https://www.youtube.com/watch?v=T5H2l6TRnA8>

# Economic benefits of machinery revamping

—

# Economic benefits of machinery revamping

To name but a few, the economic benefits of machinery revamping include the following:

1. Update of the software and/or hardware
2. Increase in productivity
3. Variety of goods
4. Increased efficiency of the worker
5. Create employment opportunities

In the next slides, we are going to study them one by one. Naturally, this list is not exhaustive and as machinery revamping is gaining ground more and more advantages are going to surface.



# 1. Update the software and/or hardware

In some cases, equipment and machines suffer failures which may be due to the most different occurrences or they need to follow the market demand by organizing the production time. The installation of a new software or hardware could be very expensive for the companies. For this reason there is a possibility to update the current software/hardware and it's not important to buy the new version. With this way, the companies will reduce the installation costs.



# Update the software and/or hardware

- The update of a software's machine is an innovative way to reborn and upgraded the technology of it. Machines are the leaders of the development in the industrial agricultural, tertiary and export sectors of the economy. The goal is to increasing the availability of the machines in order to offer bigger number of products/services.
- Through the update, users will have the opportunity to modify their machines according to their needs. With this action the cost will minimized in case that company decide to buy a new software/hardware. So, is an option to reduce the cost and modify the machine in such a way to respond to the needs that they have identified.



# Update the software and/or hardware

Watch the following video that presents a case of a firmware update:



Source: [https://www.youtube.com/watch?v=17BmvUSKntE&feature=emb\\_title](https://www.youtube.com/watch?v=17BmvUSKntE&feature=emb_title)

## 2. Increase in productivity

- The answer to the customers' demand is the provision of innovative products/services that meet their needs. Digitalisation of the industrial sector and the technology that has developed during the last decade, helps to increase productivity and contributes to the efficiency. The method of machinery revamping is a way to save the quality of the equipment and maintaining or improving the process of production.
- The replacement of outdated machines sometimes is quite expensive. For companies, revamping is the best solution in order to update their machines and systems according to their needs at the lowest cost. This way, users are enabled to increase production, minimize both time and effort of human resources and produce a greater number of deliverables.



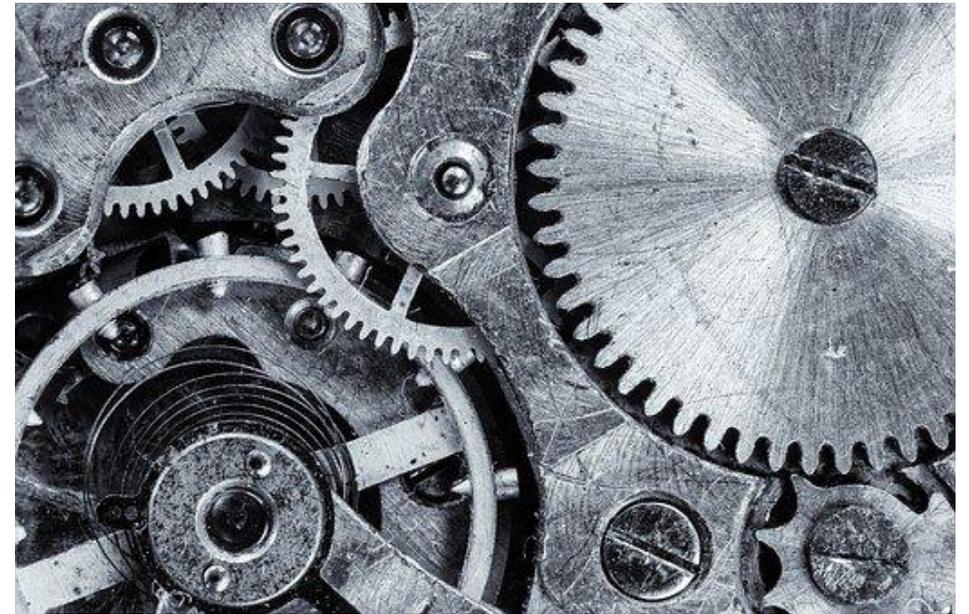
# Increase in productivity

The use of machines after revamping helps producers to increase their income. An updated machine will be able to work faster than people. Users, operating a computer or one part of the new machine, complete the work faster than many persons engaged in doing the same work by hand. Thus, through machinery revamping, the industry increases labour productivity, maximizes production and saves financial resources.



# 3. Variety of goods

- Machines provide a variety of goods to the consumers with the aim of covering their needs. The manufacture, or the modernization, of innumerable consumer goods from the smallest part (engineering components, revamping of small parts, etc.) to the largest (machinery revamping and update all the machine and the equipment) has been made possible by machines.
- Nowadays, consumers are creating new needs. If the industry is able to follow the technology and provide new products, then it will give way to the world's biggest economy. New jobs and more employment opportunities will be the results of the usability of machines.



# 4. Increased efficiency of the worker

Through machinery revamping and the use of a new updated machine workers can perform their duties in a better way than they would do manually. The aim is to increase the efficiency of the worker in order to produce more accurately and faster qualitative products in larger quantities. New technologies and the result of machinery revamping stimulate the interest of the worker and the efficiency increases. As a result, workers with more skills and competences will be able to also increase their income.



# 5. Create Employment opportunities

In the latest years, machinery creates employment and increases productivity, reducing costs for the industry and making goods and products cheaper; this leads to demand increase. The industry needs more workers in order to face the demand.

Some of the categories that continue growing are the following:

- Mechanical Engineers
- Aerospace Engineering and Operations Technicians
- Electro-mechanical Technicians
- Sales Engineers
- Computer and Information Research Scientists
- Computer Programmers.



# Circular economy and machinery revamping

—

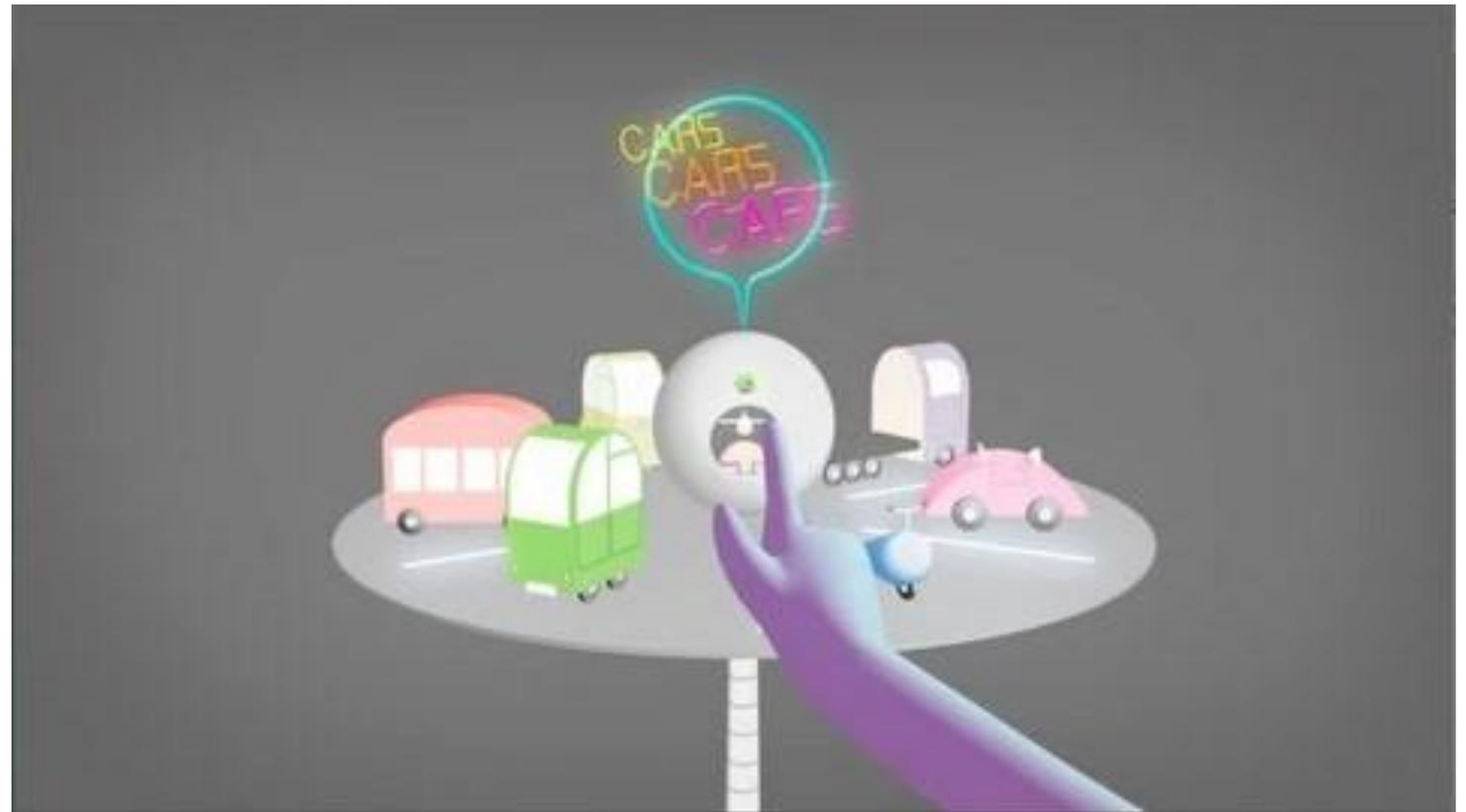
# Circular economy and machinery revamping

Circular economy is the system that aims to eliminate waste as well as exhaustion and depletion of resources. The goal of circular economy is to retain as much value as possible for as long as possible in the economy. Reutilization and modernization of the machines are its key elements. The adoption of the circular systems in the industry consists of reuse, sharing, repair, revamp, refurbishment, remanufacturing and recycling to create a close-loop system, minimizing the use of resource inputs and the creation of waste, pollution and carbon emissions. Many of these aspects are included in the machinery revamping.



# Circular economy and machinery revamping

Please, watch the following video in order to understand better about the circular economy:



Source: [https://www.youtube.com/watch?v=Cd\\_isKtGaf8&feature=emb\\_title](https://www.youtube.com/watch?v=Cd_isKtGaf8&feature=emb_title)

# Circular economy and machinery revamping

Machines are products with long life which are used for more than 20 years. Their durability can be extended through machinery revamping.

Machinery revamping is one of the key elements of circular economy. The companies that are using this system are able to repair and recycle the machines or their parts and modernize their equipment. In this way, companies will reduce the costs, update the machines according to their needs and follow the method of the digital circular manufacturing and modernizing of machines.



**NOTE:** Chapter 7 (social benefits of machinery revamping) also contains information about the social impact and benefits of the Circular Economy, while Chapter 8 (environmental benefits of machinery revamping) explains the environmental benefits, including the circular economy approach.

# Conclusion

—

# Conclusions

- Nowadays, machinery revamping is required for the industry in order to follow the technology and meet the consumers' needs better with more quality.
- Economy can grow through the machines: increase the production, create employment opportunities, increase the income of the workers.



# Sources/References



Economic Effects of Machinery

<https://www.economicdiscussion.net/articles/economic-effects-of-machinery-advantages-and-disadvantages/18463>

'Revamping', the technique that breathes new life into industrial machines

<https://blog.ferrovial.com/en/2018/09/revamping-industrial-machines/>

Machinery Revamping, Rehabilitation and Modernization

<http://www.cstfirenze.com/en/service-diagnostics/machinery-revamping-rehabilitation-and-modernization.html>

Hardware installation of the implemented applications

<https://www.automazioneindustrialeferrazza.it/machine-side-boards/?lang=en>

All images and pictures were downloaded from pixabay.com

<https://pixabay.com/>

Co-funded by the  
Erasmus+ Programme  
of the European Union



The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



REFITTING

MACHINE



SOCIAL BENEFITS OF MACHINERY  
REVAMPING



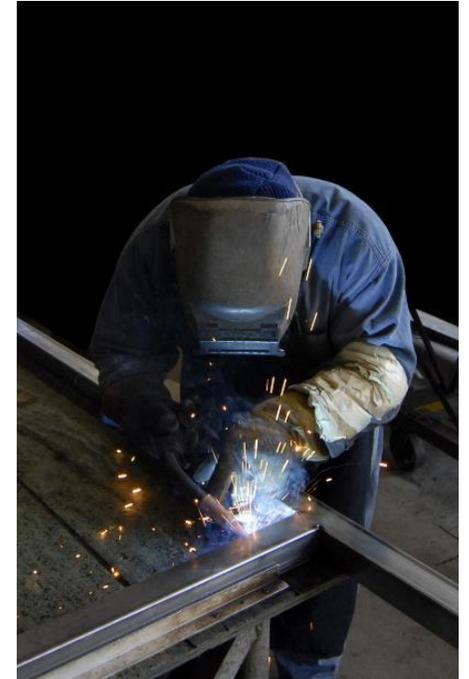
Co-funded by the  
Erasmus+ Programme  
of the European Union

## Aims and objectives

CHAPTER AIM:	Examine the social benefits of machinery revamping
COMPETENCES:	<ul style="list-style-type: none"><li>• Develop critical thinking as to the various social benefits of machinery revamping.</li><li>• Evaluate current studies, testimonials, and examples of successful machine revamps and their positive impact to the society, the economy, and the environment.</li></ul>
LEARNING OUTCOMES:	<ul style="list-style-type: none"><li>• Understand of the social benefits of revamping.</li><li>• Distinguish the benefits of revamping machines compared to buying new ones.</li></ul>
NUMBER OF HOURS:	2

# Lecture Outline

1. Introduction
2. Machine revamping in the wake of societal change
3. The social benefits of machinery revamping
4. Conclusions



# Introduction

—

# Introduction

- This chapter will focus on the various social benefits of applying revamping or retrofitting techniques to modernize old or obsolete machineries.
- The chapter includes various sources, videos, interviews, and research studies, all indicating the beneficial impact that modernizing machines brings to society, including the economy and the environment.
- *Please note that, since the social dimension of machinery revamping incorporates both economical, social, and environmental matters, various issues discussed in this chapter are also mentioned in chapters 6 and 8.*



Image by PxHere.  
Source: [www.pxhere.com](http://www.pxhere.com)

# Machine revamping in the wake of societal change

—

# Machine revamping in the wake of societal change

- Without doubt, revamping practices breathes new and improved life into industrial machinery. The rapid digitalization and technology advances in industrial processes results is mass innovations that often render older machines obsolete.
- As research ([Sakao et al 2019](#)) shows, products or machines designed without the capability to reuse their components and materials in mind, will have a more limited lifetime, thus causing a number of important social implications.
- A need to update or “revamp” such machines, without wasting resources for buying new equipment, results in a variety of benefits for businesses and the society itself.
- In fact, revamping or “retrofitting” has become a highly significant approach in achieving sustainability at all social, economic, and environmental levels, and improve people’s standard of living.



Image by PxHere.  
Source: [www.pxhere.com](http://www.pxhere.com)

# The social benefits of machinery revamping

- 1. Automation of Production Processes
  2. Better Performance
  3. Employment Opportunities
  4. Better Workplace Environments
  5. Educational Opportunities
  6. Economic Benefits
  7. Environmental Benefits

# Automation of Production Processes

- Modernized machines help to increase the production and durability of goods and products. By incorporating state-of-art technologies to existing machinery, old machines become more productive and last longer, allowing mass and automate production of the products, and thus leading to large-scale production, reducing of costs, and raising of profits.
- When modernizing an equipment, production should increase at faster-operating speeds with better controls. As a result, and as production increases, the incomes of the workforce and the industry increases as well.
- Put simply, machines work faster than humans by replacing manual work with automatic performances, thus saving time and labour. Modernized machines can help workers perform their duties in a better way than by hands. Therefore the efficiency of the worker increases, as the worker can perform tasks accurately and faster, and produce high-quality products in large quantities.

Video indicating the refurbishing of a forklift by “Jungheinrich”

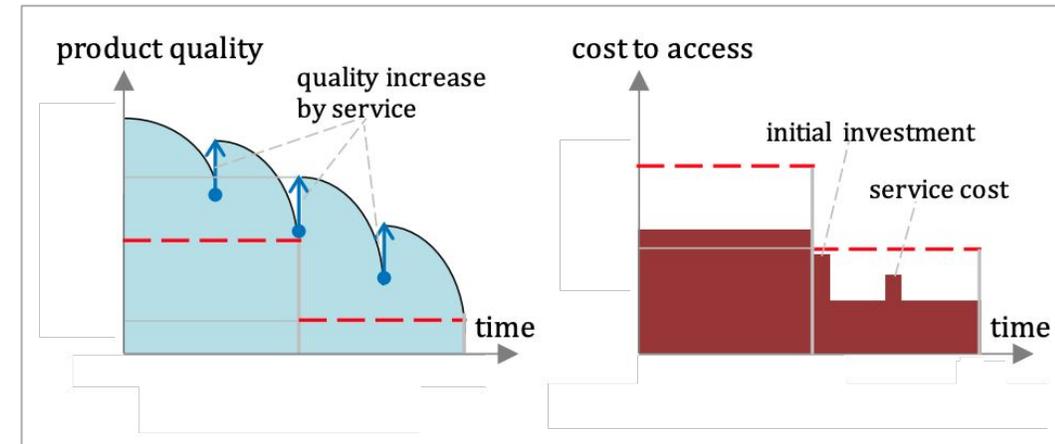


Video Source:

[https://www.youtube.com/watch?time\\_continue=8&v=FLav\\_Q5l-0o&feature=emb\\_title](https://www.youtube.com/watch?time_continue=8&v=FLav_Q5l-0o&feature=emb_title)

# Better Performance

- As explained in the previous slide, revamping ensures that machines function smoothly and according to modern technology demands. Used or obsolete machines may show excessive wear or might not be compliant with current standards and practices of the industries. When modern equipment is up-to-date, through incorporating the latest technologies and features, they work more efficiently and are more probably to eliminate potential faults.
- Revamping may include a replacement of a particular system or of used parts into new ones. Due to this transformation, the productivity of the manufacturing department is improved, as well as the quality of the services provided.
- As a result, state-of-art components used for revamping results in the expand of the performance capacities of machines and leads to an overall more efficient workplace, that is safer and user-friendly for workers and employees, while being profitable for the employers.



*As the figure shows, “Increasing the life of the machine [...] under a system where maintenance and refurbishment of vulnerable parts is included — leads to a better chance of managing the machine into a second life”.*

(Figure and quote source:

<https://www.greenbiz.com/article/circular-economy-product-service-has-social-and-environmental-benefits>)

# Employment Opportunities

- Although a general notion regarding the machine industry tends to hold that machines replace human workforce, a lot of human creativity is still needed when modernizing machines. That is, when updating a machine, there are many levels that must be conserved: structure, dimensions, security systems etc. This turns revamping into an almost manual technique, unique to each brand and context, which needs to be considered by an employer or technician.
- Therefore, while a certain level of machinery work might indeed replace human labour, in the long run, the need to revamp *creates* employment. The increase of productivity also increases the demand of workers employed to increase their production. Workers are always needed to manufacture new machines, or maintain, repair, and modernize older ones. Consequently, production rises, which will further increase the demand for goods, and in turn, necessitating the employment of more workers.



Image by PxHere. Source:  
<https://pxhere.com/en/photo/955665>

# Better Workplace Environments

- Replacing or renewing outdated components of a machine, which results in better effectiveness of the entire machine, also results in a better workplace environment. Revamping, as explained above, ensures that a machine functions according to latest technology demands and current standards of practices. In this way, the possibility that a machine causes unforeseen breakdowns or potential faults is reduced, or even eliminated.
- As a result, the everyday work of employees dealing with machines and construction work is improved, including their working conditions and safety aspects.

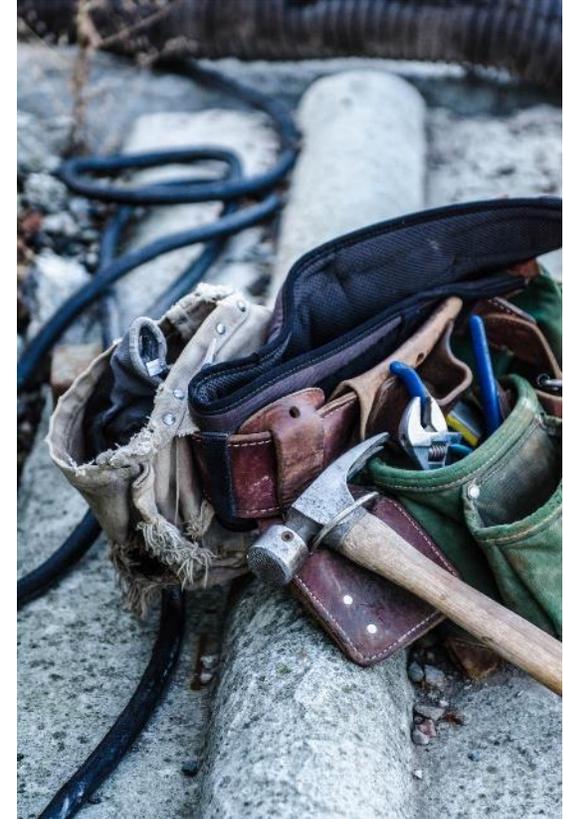


Image by Unsplash Source:  
<https://unsplash.com/>

# Educational Opportunities

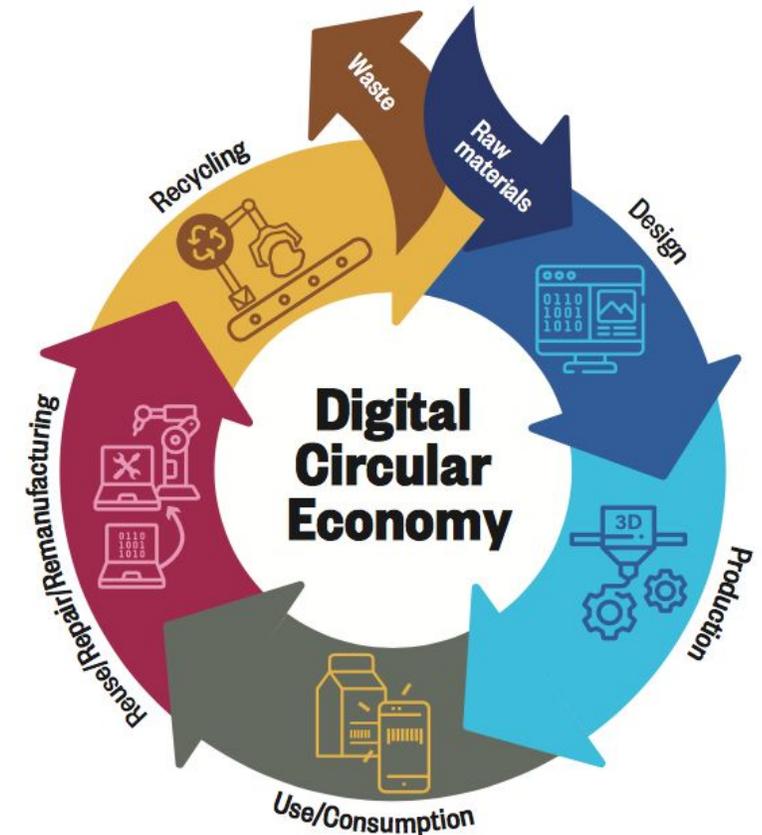
- Another dimension of machinery revamping is the creation of educational opportunities. That is, machines require educated and skilled manpower for their operations, repairs, maintenance, and modernization. This leads to the demand of formal or non-formal technical education, which in turn creates demand for relevant teaching staff.
- Educational opportunities regarding revamping extends to a large amount of education fields, for example engineering, machine learning, 3D design, software development, etc.



Images by Unsplash. Source: <https://unsplash.com/>

# Economic Benefits

- Revamping machines also brings positive financial or economic benefits. By raising the productivity of an industry, modernized machines also raise the overall production of the economy; as a result, employment, national income, and the growth rate of the economy increases.
- *Put simply*, revamping is generally cheaper than buying new products or equipment. For example, when revamping a vehicle, functional parts are reused (like the seats, chassis, gears, windows, etc.). This not only increases safety due to using more advanced tech solutions, but also reduces operating costs.
- Also, revamping or retrofitting are common practices that embrace key principles of the “circular economy”, whereby machines are designed with ease of maintenance in mind and with much of the materials to be recycled at the end of their lifetime. Spare parts of old/obsolete machines are repaired or reproduced for more effective use, thus reducing the amount of waste and expanding the lifetime of the product while using fewer resources. These practices are key aspects in improving the environmental performance of machine tools as well, while not ensuring customer demands for productivity and reliability.
- *More about the Economic Benefits of machinery revamping in Chapter 6.*



Source:  
<https://ecircular.climate-kic.org/news/eit-climate-kic-sup-ports-digital-roadmap-for-a-circular-economy/>

# Environmental Benefits

- While reusing machinery components makes the process of modernization cheaper and more attractive, it also optimizes energy performance and help to prolong the life of machines. This is especially true when applying retrofitting techniques to make buildings more thermal efficient and sustainable. Studies ([Jafari 2017](#); [Khairi et al 2017](#)) conclude that adding new technologies and systems to existing constructions makes it cheaper and easier to run buildings, can help reduce carbon emissions, and contributes to overcoming poor ventilation issues, therefore improving the overall health of occupants. At the same time, it increases building adaptability, resiliency, and durability.
- *More about the Environmental Benefits of machinery revamping in Chapter 8*

**NOTE:** Chapter 6 (Economic benefits of machinery revamping) also contains information about the economic impact and benefits of the Circular Economy, while Chapter 8 (environmental benefits of machinery revamping) explains the environmental benefits, including the circular economy approach.

Video on the benefits problems of energy-efficient retrofits to buildings



Video Source:

<https://www.youtube.com/watch?v=id7MGOF-Zh4&t=23s>

# An example on the benefits of retrofitting

- The video on the right is a short testimonial by an employee of Oklahoma Chiller\*, briefing some of the benefits of retrofitting.

*\* a commercial & industrial air conditioning and refrigeration company based in Tulsa, Oklahoma offering retrofit solutions ([www.okchiller.com](http://www.okchiller.com))*



Video Source:

<https://www.youtube.com/watch?v=sYTBa660bJQ&feature=youtu.be>

# Conclusions

—

# Conclusions

- The rapid technological and digital advances has recently resulted in mass innovations leading to the revamping or refitting of old/obsolete machines.
- The modernization of such machines causes various and important benefits at a the social, economic, and environmental levels, while increasing the standard of living.
- By revamping existing machinery, their lifetime increases, thus increasing the production of goods or services, improving employment conditions, and creating further work opportunities, without neglecting customer demands for productivity and reliability.
- Revamping also causes a reduce in the operating costs compared to purchasing new equipment, and improves the performance level of machines, while meeting the latest technological demands and meeting customers' expectations.
- In terms of the environmental benefits, retrofits or revamps ensures maximum reuse of existing equipment, thus reducing the amount of waste and optimizing energy performance, and therefore, causing maximum sustainability.
- Finally, the demand for skilled and educated employees needed for machine operations, repairs, maintenance, and modernization leads to the need of increasing relevant education programmes and teaching staff.

# Source/References



Economic Effects of Machinery

<https://bit.ly/3dGZ0uQ>

Economical Analysis of Existing Machine Tools through Retrofitting

<https://www.industr.com/en/economical-analysis-of-existing-machine-tools-through-retrofitting-2353580>

General Information on Revamping

<https://blog.ferrovial.com/en/2018/09/revamping-industrial-machines/#>

Report on the Circular Economy

[https://circulareconomy.europa.eu/platform/sites/default/files/circular\\_economy\\_report.pdf](https://circulareconomy.europa.eu/platform/sites/default/files/circular_economy_report.pdf)

Retrofit – Building Designs Wiki

<https://www.designingbuildings.co.uk/wiki/Retrofit>

# Source/References



Sakao, T., Raphael, W. and Fabrice, M., (2019) 'A methodological approach for manufacturers to enhance value-in-use of service-based offerings considering three dimensions of sustainability', *CIRP annals*, 68(1), <https://doi.org/10.1016/j.cirp.2019.04.084>

The Benefits of Machine Modernization

<https://squarespheretechnology.com/en/what-benefits-does-the-modernization-of-the-machines-brings/>

When and Why You Should Modernize

<https://businessingmag.com/6584/equipping/equipment-modernization-when-and-why-you-should-modernize/>

Co-funded by the  
Erasmus+ Programme  
of the European Union



The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



REFITTING

MACHINE



REFITTING  
MACHINE

ENVIRONMENTAL BENEFITS OF  
MACHINERY REVAMPING



Co-funded by the  
Erasmus+ Programme  
of the European Union

## Aims and objectives

CHAPTER AIM:	To equip learners with basic knowledge to identify and assess the environmental benefits of machinery revamping .
COMPETENCES:	<ul style="list-style-type: none"><li>• Identify the environmental issues related to the old machinery revamping;</li><li>• Assess the values that motivated the environmental approach in old machinery revamping;</li><li>• Identify the key environmental issues to support the decision on old machinery revamping in the company.</li></ul>
LEARNING OUTCOMES:	At the end of this module, the learners will be able to identify the environmental values behind the old machinery revamping.
NUMBER OF HOURS:	1.5

# Lecture Outline

1. Introduction
2. Environmental sustainability in the industry
3. Environmental impacts
4. Sustainability and productions tools
5. Environmental benefits of machinery revamping



# Introduction

—

# Introduction

Today environmental sustainability is an important part of any economic activity and particularly in the field of industry.

Environmental impact has become a key instrument in business management, and any decision made always takes these parameters into account. Furthermore, the emergence of new concepts and models (green economy, circular economy) together with the already mature environmental management policies (waste management, energy efficiency, etc.) represent an important part of the process.

The recovery of obsolete machinery will have a strong influence on this whole model as it responds not only to environmental programmes for waste management, energy efficiency and raw material reduction, but will also contribute decisively to the circular economy.

The concept of circular economy is the basis for explaining some of the benefits of refurbishing obsolete machinery. This covers the economic as well as the social and environmental aspects. This is why you can find the content on this topic in modules 6, 7 and 8 of the toolkit, adapted according to its economic, social or environmental impact.

# Environmental sustainability and industry

---

Ideas and concepts

# Industrial challenges

It is expected that by 2050 economic activity will double its numbers and use 50% of the available resources and will be responsible for 20% of CO2 emissions. As the activity is fundamental to the world economy, we need to achieve a resilient economy.

We must think about the need to promote a more sustainable model of economic activity that meets the double challenge of reducing its emissions and using its resources efficiently.

In this way, the model will move from being part of the problem to being part of the solution.

One of the biggest challenges facing industry today is the need to further improve its environmental performance in order truly to become compatible with sustainable development. The industry must be an active actor in the process through responsible entrepreneurship and eco-efficiency. Increased environmental performance will mean reducing the negative environmental impacts that occur at each stage of the product life-cycle, from the extraction of raw materials through the production processes, transport and distribution of products to the use and disposal of products.

# Sustainable development

- The concept of sustainability appears in the late 80's. The report "Our Common Policy" defined **Sustainable development** as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
- When we talk about sustainability, we do not refer exclusively to environmental issues, such as energy efficiency or climate change. The principle of sustainability is based on the connections between the environment, society and the economy.



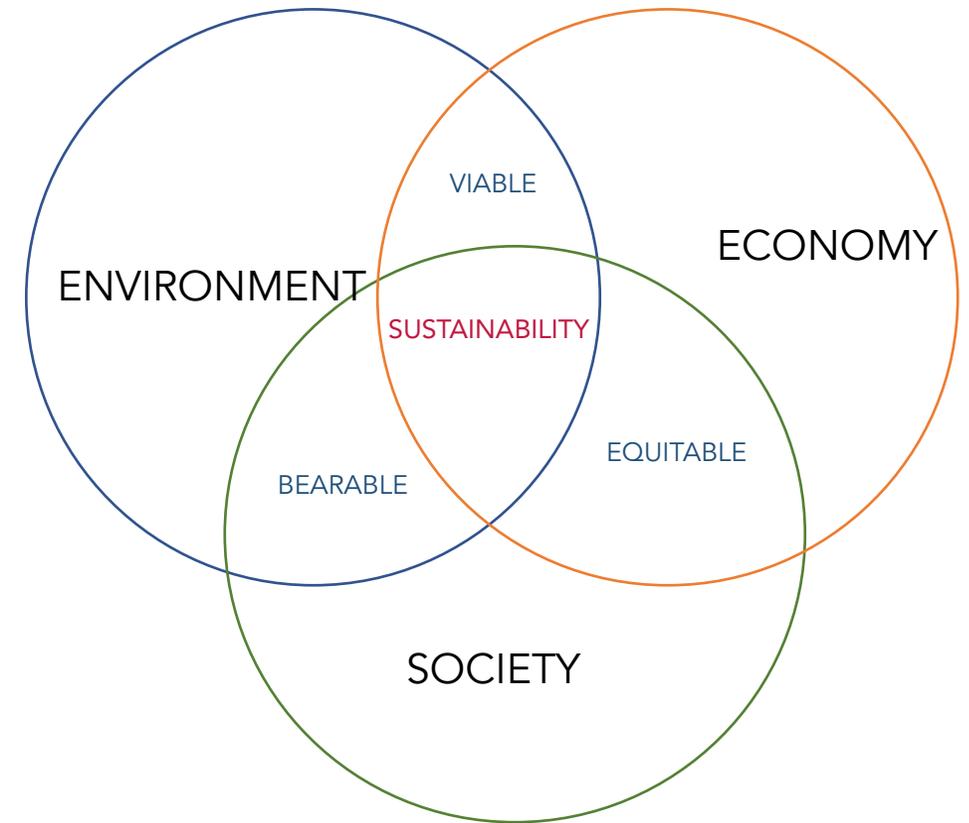
*Check the video above  
to learn more about sustainability*

# Sustainable development principles

These are the principles of the sustainable development:

- Environmental sustainability
- Societal Sustainability
- Economic sustainability

The environment is of primary importance because a healthy ecosystem is required to nourish a robust society. Consequently, Society and Social Responsibility are of secondary importance. Economic Sustainability is third one because a prosperous Economy cannot exist without a healthy and just society.

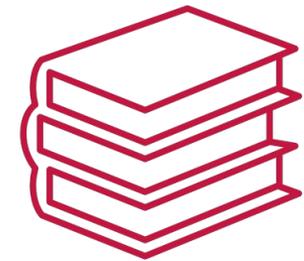


*Three principles of the sustainable development*

# Environmental sustainability

Environmental sustainability refers to ways of structuring human activities that ensure the preservation of the biosphere's resources and their quality over time. In the industrial context, environmental sustainability is linked to local development policies that guarantee equitable access to public services while minimizing the impact on the ecological environment. Thus, companies contribute to environmental sustainability through:

- efficient use of resources;
- proper waste management;
- responsible water management; and
- application of elements of energy efficiency and effectiveness.



## FURTHER READING

Read the following article:  
[\*Environmental sustainability –  
definition and issues\*](#)

# Dimensions of environmental sustainability

There are three important dimensions to understanding the meaning of environmental sustainability. First, environmental sustainability must be thought of globally, beyond local space, since the different planetary ecosystems are interconnected. Secondly, it is a long-term issue, as ecosystems must be managed for future generations. Thirdly, environmental sustainability must be conceived in an integrated manner, harmonizing ecological, economic and social factors in a respectful and effective way.



# Key points



By 2050 the industry will use 50% of the available resources and will be responsible for 20% of CO2 emissions.



Industry has to improve its environmental performance in order truly to become compatible with sustainable development.



Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs.



Environmental sustainability refers to ways of structuring human activities that ensure the preservation of the biosphere's resources and their quality over time.



Industries contribute to environmental sustainability through the efficient use and management of resources.

# Environmental impact

—  
Bridging the environmental gap

# Environmental impact

All human activity always influenced the environment. The pollution of the seas, the emission of hazardous gases into the atmosphere, noise pollution or the loss of natural habitats are part of the effects that our activity generates on the environment.

We can define **environmental impact** as the effect (positive or negative) that human activity produces on the environment.



*Open the video above  
to learn more about environmental  
impact of the industry*

# Environmental impact of industrial activities

There are different industrial activities and processes, but every one of them have one element in common: their environmental impact.

The processes developed by industry have a **strong environmental impact on air, water and soil**. A majority of companies emit **polluting gases into the atmosphere** (which contribute to global warming), pollute water through **uncontrolled discharges into terrestrial aquifers** (rivers, lakes, etc.) and the oceans and through leaks into underground aquifers; and pollute soils through uncontrolled process leaks or **poor management of their resources and materials**.

To this must be added the impact of the poor management of natural resources: water, energy and raw materials.

Indirectly, they also affect the habitat of the territory in which they are located.

# Environmental impact of industry

The industrial processes that cause most common environmental impacts (click on the concept for more information about it):

-  [Depletion of biotic resources](#)
-  [Climate change](#)
-  [Ozone depletion](#)
-  [Photochemical smog](#)
-  [Acidification](#)
-  [Eutrophication](#)
-  [Toxicity – Environmental hazards](#)



# Environmental impact systems

Companies can apply different methods to reduce their environmental impact. And here we come to environmental management systems.

**Environmental management systems** can be defined as a set of structured processes and activities that allow companies to **reduce their environmental impact** and **increase their efficiency** by making **economic, environmental and operational improvements**. These activities include training for the company's staff, definition of an environmental policy and objectives, risk management, inspections, etc.

Most of these systems are internationally standardized models and are audited by national or international organizations. In the environmental field, the most widely known and used are [ISO14001](#) and [EMAS](#).

The [following video](#) explains how environmental management systems work .

# Key points



Environmental impact is the effect (positive or negative) that human activity produces on the environment.



The processes developed by industry have a strong environmental impact on air, water and soil.



We must add the impact caused by poor management of natural resources: water, energy and raw materials.



Industries can apply different methods to reduce their environmental impact.



Environmental management systems can be defined as a set of structured processes and activities that allow companies to reduce their environmental impact and increase their efficiency.

# Sustainability and production

—  
Towards green economy

# Towards a sustainable industry

The environmental challenges of the industry in the coming years are critical. Together with environmental management systems, companies must implement different strategies that lead us towards a green economy. More sustainable models of production and management together with the application of new methods, will help the industry to be more sustainable and reinforce the concept of green economy.

The application of circular economy models, as well as the principles of waste management, together with more rational models of water and energy management will be key to sustainability.



*Open the video above to learn more about why to move for a sustainable industry*

# Green economy

In the past, economic growth relied on a model of natural resource utilization as if the resources were unlimited. However, this model has led to a resource crisis that threatens the disappearance of many resources.

Consequently, an increasing number of economic, social and environmental agents are working on different development models that favour growth without damaging the environment.

These models fall within the idea of the Green Economy. There is currently no single definition for this new concept. UNEP has defined the **green economy** as “one that results in **improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low carbon, resource efficient, and socially inclusive**” (UNEP, 2011)

For more information on Green Economy, visit the UN site [GREEN ECONOMY.](#)



# Supporting the transition to green economy

There are some measures to boost sustainable growth and help Europe make the transition towards a more Green and circular economy.

**Resource efficiency:** Using resources more efficiently for a greener, more competitive economy.

**Eco-innovation:** Enabling green growth and the transition towards a more circular economy.

**Raw Materials:** Ensuring our use of raw materials does not deplete the planet's resources.

**Production:** Promoting greener products and supporting greener companies and organisations.

**Consumption:** Providing transparent information to consumers enabling them to make greener choices.

**Waste prevention and management:** Reducing waste and improving waste management.

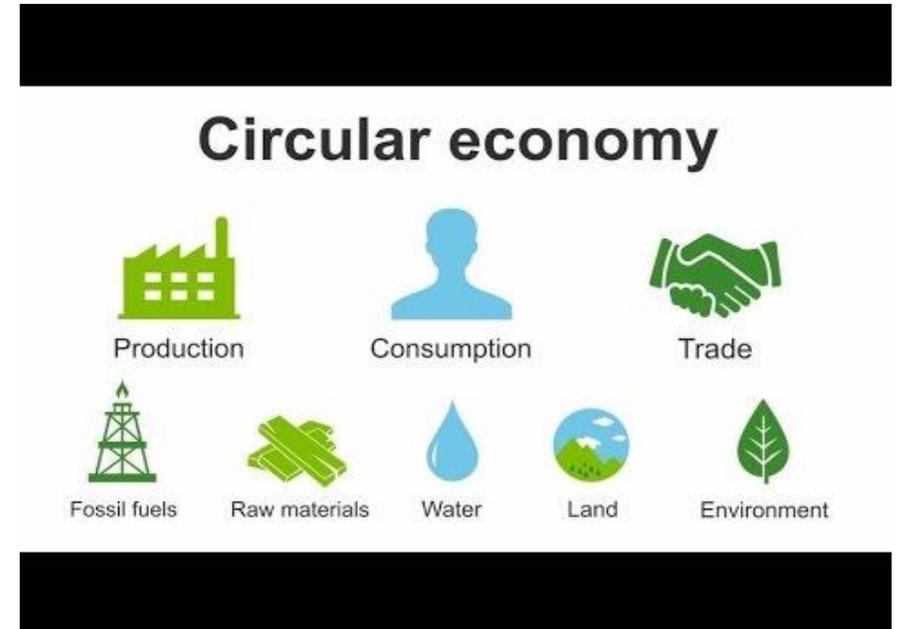


# Circular economy

One of the economic models supporting the transition to the green economy is the circular economy. As opposed to an extractive industrial model that does not take into account the exhaustibility of resources and the impact of their extensive use, the circular economy seeks to redefine growth. According to Ellen MacArthur foundation:

*In a circular economy, economic activity builds and rebuilds overall system health. The concept recognises the importance of the economy needing to work effectively at all scales – for large and small businesses, for organisations and individuals, globally and locally.*

**NOTE:** Chapter 6 (Economic benefits of machinery revamping) also contains information about the economic impact and benefits of the Circular Economy, while Chapter 7 (social benefits of machinery revamping) explains the social impact of economic and environment benefits of revamping machines.



*Open the video above to learn more about circular economy and industry*

# Circular economy principles

The circular economy seeks to gradually dissociate economic activity from the consumption of finite resources and to redesign the waste management model. The circular model is based on three principles.

## 1. Preserve and enhance natural capital:

Seek to use natural and renewable resource flows more efficiently.

Where natural resources are needed, select those that use renewable resources or use smaller quantities of natural products.

## 2. Optimize the use of resources:

Seek a greater rotation of products and their components, achieving a longer cycle of use, and therefore, a longer life cycle. For this purpose, eco-design is fundamental, so that the product can be created, repaired and/or recycled in an efficient manner.

## 3. To promote the effectiveness of the system:

Its objective is to reduce the externalities of the processes of use of natural resources (for example, using food remains, using less or better the territory...), and looking for synergies between the different agents that intervene in this process.

# Ideas for a circular economy

**Reuse to reintroduce** into the economic circuit those products that no longer correspond to the needs of consumers, but that can still be useful. Also to reuse certain parts of the products that can still work for the elaboration of new ones.

**Recycle** to take advantage of the materials found in the waste and give them a new life, making new products with them.

**Valorization** to take advantage energetically of the residues that cannot be recycled.

**Using less energy for each unit produced.** It is not enough to manufacture with fewer resources, less waste and then recycle.



# Some measures to move towards sustainability

Here is a set of measures that will help companies to contribute to environmental sustainability.

- Reduce (rapidly) the resource and energy intensity in the production of existing goods;
- Rethink business models;
- Reduce material and energy consumption by 25%;
- Use 90% of the materials (which are currently discarded);
- Apply the "cradle to cradle" concept to your materials;
- Renew and reuse sophisticated and durable components; and
- Nurturing environmental niches.

# Key points



The environmental challenges of the industry in the coming years are critical. Reducing the impact on the environment is one of their strategic objectives.



Green economy is “one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low carbon, resource efficient, and socially inclusive.



One of the economic models supporting the transition to the green economy is the circular economy.



*In a circular economy, economic activity builds and rebuilds overall system health.*



The circular economy seeks to gradually dissociate economic activity from the consumption of finite resources and to redesign the waste management model

# Environmental benefits of machinery revamping

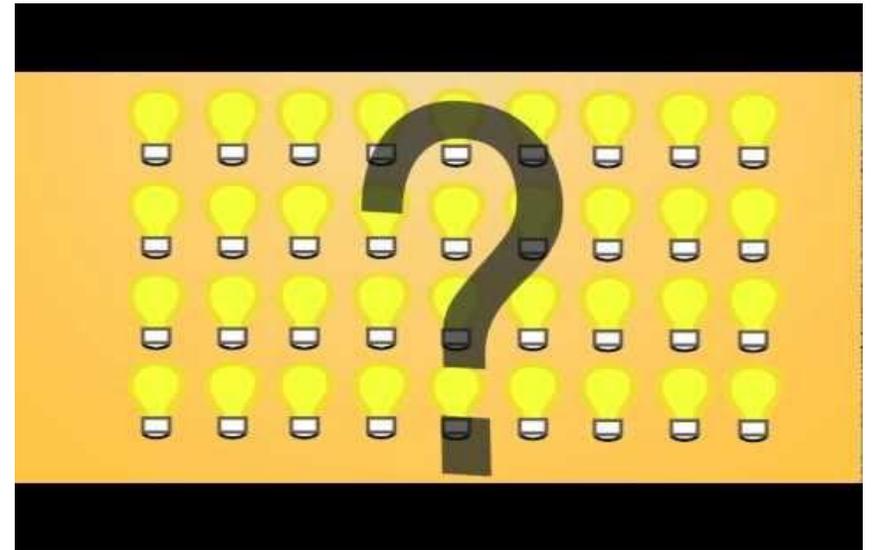
---

Reusing and renewing for more sustainable companies

# Planned obsolescence

Economic models preceding the concept of sustainability were based on the use of resources as if they were unlimited. Programmed obsolescence perfectly defines these productive models.

The products were made to last for a limited time, after which their reuse was almost impossible, so they were removed and replaced by newer products. This concept supported a business model based on selling more and more products, regardless of the resources (raw materials, energy, etc.) used for their production. This was an unsustainable model of both production and consumption.



*Open the video above  
to learn more about planned  
obsolescence*

# Resources management in industry

Resource management is one of the fundamental axes on which plans to reduce the environmental impact of companies are based. Reduce, reuse (by recovering waste) and recycle are three fundamental principles that define the company's environmental management. The three concepts form the principle of the three Rs:

**Reduce:** The first step is to reduce resources. Resources are needed to manufacture, transport and dispose of products, so reduction minimizes the use of new resources.

**Reuse:** Use the materials more than once in their original form instead of throwing them away after each use. Reuse prevents new resources from being systematically incorporated and old ones from entering the waste stream.

**Recycle:** Convert waste materials into new products by changing them from their original form through physical and chemical processes. Although recycling uses energy, it prevents old materials from going to landfills without valorizing and recycling their components generating a strong environmental impact.

# Revamping machinery

When we talk about recycling or reusing, we always think of a glass bottle or an old newspaper or using a television for a longer period. These two ideas can be combined in the form of revamping, i.e. the technique that gives industrial machinery a life by improving it. The degree of digitalisation and technification of organisations, industrial processes and related activities means that new machines are emerging every year. The previous machines become obsolete, and at some point they are removed and replaced by newer ones. The technique of revamping consists of renewing them, adapting them to new requirements and putting them to work again. We have to understand that it is not a question of repairing them, but of changing part of their components (even design) so that they go from being obsolete machines to being working again.



# Environmental benefits of machinery revamping



Develop more resource-efficient machinery that generates less effluent, waste and pollutants.

Apply a circular economy mindset when designing products to improve reuse and recycling at the end of the product's life cycle.



Incorporate innovative technologies, such as 3D printing, into manufacturing processes to reduce long-term production waste and prototyping.



Develop and implement improved processes (e.g. closed-loop manufacturing) to reduce, reuse and recycle water, raw materials, non-renewable minerals, other inputs, by-products and waste.



Increase energy efficiency in industrial manufacturing plants introducing new components or adapting the obsolete ones by others more energetical efficient.



# Key points



Economic models preceding the concept of sustainability were based on the use of resources as if they were unlimited. Programmed obsolescence perfectly defines these productive models.

This was an unsustainable model of both production and consumption.



Reduce, reuse (by recovering waste) and recycle are three fundamental principles that define the company's environmental management.



The technique of revamping consists of renewing them, adapting them to new requirements and putting them to work again



Revamping machinery is a sustainable practice for companies that help reduce their impact in the environment providing several environmental benefits



# Conclusions

—

# CONCLUSIONS

Today we are moving towards more **sustainable economic models**, ensuring the resources of the present and the future. Industry is an economic activity with a great environmental impact. It is a model that has traditionally been based on considering resources as unlimited. This paradigm is changing and companies are **moving towards more sustainable models of production** (resulting in more sustainable models of consumption).

**Environmental management systems**, as well as new economic models for the **green economy**, change this scenario. The concept of the **circular economy** encourages the companies to review their production models and introduce more sustainable processes by reducing the use of resources, increasing their efficiency and lengthening their life cycles.

**Revamping obsolete machinery** reinforces this idea of sustainable management, **recovering** these machines by adapting them to current models. We are not only talking about fixing machinery, but also about adapting it to current requirements and making it contribute (among other things) to **reducing the company's environmental impact**.

**Revamping** contributes to **environmental sustainability** by:

1. Contributing to the 3R principle - **reduce, reuse and recycle machinery**;
2. Generating more **effective models of water and energy management** (by adapting certain parts of the machinery to more sustainable models);
3. Developing more efficient schemes for the transformation of raw materials, generating **less waste and pollution**.

# Source/References



Our common future – UN = 1987

<https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf>

Why industry is going green on the quiet? - The Guardian

<https://www.theguardian.com/science/2019/sep/08/producers-keep-sustainable-practices-secret>

Sustainability = Wikipedia

<https://en.wikipedia.org/wiki/Sustainability>

Environmental sustainability definition – The Economist

<https://www.economicshelp.org/blog/143879/economics/environmental-sustainability-definition-and-issues/>

Circular Economy – Ellen MacArthur Foundation

<https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy>

Environmental impact of business (in Spanish)

<http://blogseguridadindustrial.com/el-impacto-ambiental-de-las-empresas/>

Environmental monitoring systems – Wikipedia

[https://en.wikipedia.org/wiki/Environmental\\_monitoring](https://en.wikipedia.org/wiki/Environmental_monitoring)

# Source/References



Industrial process sustainability (in Spanish)

<https://www.eadic.com/sostenibilidad-de-proceso-industrial/>

Green Economy – European Commission

[https://ec.europa.eu/environment/basics/green-economy/index\\_en.htm](https://ec.europa.eu/environment/basics/green-economy/index_en.htm)

Sustainable Development Goals – United Nations

[https://ec.europa.eu/environment/basics/green-economy/index\\_en.htm](https://ec.europa.eu/environment/basics/green-economy/index_en.htm)

Green Growth and sustainable development – OECD

<https://www.oecd.org/greengrowth/>

Sustainable development – European Union

[https://ec.europa.eu/environment/sustainable-development/index\\_en.htm](https://ec.europa.eu/environment/sustainable-development/index_en.htm)

Sustainability transition – European Environment Agency

<https://www.eea.europa.eu/themes/sustainability-transitions>

Resources efficiency and waste – European Environment Agency

<https://www.eea.europa.eu/themes/waste>

# Source/References



What is sustainability?

<https://www.youtube.com/watch?v=FbAjxkGvDNs&feature=youtu.be>

Urban impacts on environment

[https://www.youtube.com/watch?v=IKZMGBA\\_0lk&feature=youtu.be](https://www.youtube.com/watch?v=IKZMGBA_0lk&feature=youtu.be)

Environmental impact of textil industry

<https://www.youtube.com/watch?v=NXTIfczSnE&feature=youtu.be>

Environmental Management in the UN - Greening the Blue

<https://www.youtube.com/watch?v=3wT-V8aPSNg&feature=youtu.be>

How to became a green SME in a Circular Economy

<https://www.youtube.com/watch?v=V1Tszs48xCI&feature=youtu.be>

# Source/References



Green economy in Europe

<https://www.youtube.com/watch?v=tlgMRYJuKnY&feature=youtu.be>

What is planned obsolescence?

<https://www.youtube.com/watch?v=69YgDoJocZk&feature=youtu.be>

Understanding the dimensions of sustainable development

<https://www.youtube.com/watch?v=pgNLonYOc9s&feature=youtu.be>

Bridge business opportunities and environmental performance

<https://www.youtube.com/watch?v=8r2BziT435A&feature=youtu.be>

European Environmental Regulation for SMEs

<https://www.youtube.com/watch?v=4-vAXbWtDgg&feature=youtu.be>

Co-funded by the  
Erasmus+ Programme  
of the European Union



The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



REFITTING

MACHINE



# REFITTING MACHINE

CASE-STUDIES RELATED TO  
SUCCESSFUL OLD MACHINERY  
MODERNIZATION



Co-funded by the  
Erasmus+ Programme  
of the European Union

## Aims and objectives

CHAPTER AIM:	<ul style="list-style-type: none"><li>• Present and analyse case-studies of successful modernisation of old machinery.</li><li>• Examine success project stories of machinery revamping</li><li>• Illustrate case studies that indicate the potential of old machinery in the view of Industry 4.0.</li></ul>
COMPETENCES:	<ul style="list-style-type: none"><li>• Critical thinking</li><li>• Technical competencies</li><li>• Logical reasoning</li><li>• Selection of the right approaches for old machinery revamping</li><li>• Identification of the potential benefits of old machinery revamping</li></ul>
LEARNING OUTCOMES:	<ul style="list-style-type: none"><li>• Expand learners' knowledge about machinery revamping</li><li>• Understanding the potential of Arduino, Raspberry Pi and other products and technologies at different scales of intervention</li><li>• Knowledge about products and technologies that can create new opportunities in retrofitting operations of production lines with old machinery</li><li>• Developing critical thinking towards the possibility of giving "new" life to various types of equipment</li></ul>
NUMBER OF HOURS:	5

# Lecture Outline



Case study 1: Mill modernization using Arduino and Raspberry Pi

Case study 2: Universal grinder retrofit

Case study 3: Burckhardt Compression – Compression Revamps

Case study 4: AiC: Rolling Mill revamping

Case study 5: Retrofitting of an old FM Radio

Case study 6: RetroFab

Case study 7: SIEMENS Gateway IoT SIMATIC IOT 2020

Case study 8: B&R - Orange Box

Case study 9: Smart anti theft car security system based on GSM

Case study 10: Revamping of a grinding machine

Case study 11: Revamping of refrigeration system

Case study 12: Revamping of a three-staged synthesis gas radial turbo compressor

Case study 13: Revamping a cooling tower

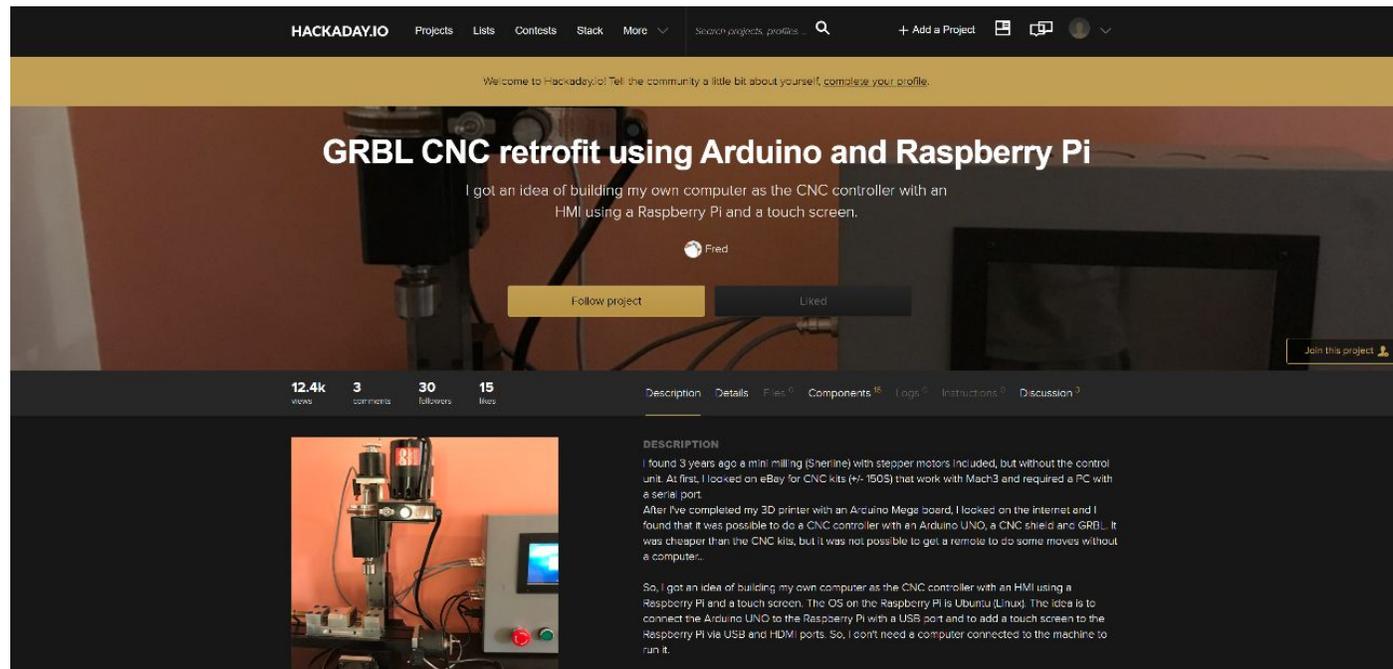
Case study 14: Revamping MIR HMG 380

# CS1 – Mill modernization using Arduino and Raspberry Pi

—

# Introduction

This case-study showcases the modernisation of an old milling machine made by the maker IndyFred and presented on HACKADAY.IO (<https://hackaday.io/project/27740-grbl-cnc-retrofit-using-arduino-and-raspberry-pi>). It illustrates how a manual machine tool can be transformed in a Computer Numerical Control (CNC) machine using open-source hardware and software.



The screenshot shows the Hackaday.io project page for "GRBL CNC retrofit using Arduino and Raspberry Pi". The page features a dark theme with a yellow header. The main content area displays the project title, a brief description, and a "Follow project" button. Below the main content, there are statistics for views, comments, followers, and likes, along with navigation tabs for Description, Details, Files, Components, Logs, Instructions, and Discussion. A small image of the CNC machine is visible in the bottom left corner.

HACKADAY.IO Projects Lists Contests Stack More Search projects, profiles... + Add a Project

Welcome to Hackaday.io! Tell the community a little bit about yourself, complete your profile.

## GRBL CNC retrofit using Arduino and Raspberry Pi

I got an idea of building my own computer as the CNC controller with an HMI using a Raspberry Pi and a touch screen.

Fred

Follow project Liked

Join this project

12.4k views 3 comments 30 followers 15 likes

Description Details Files Components Logs Instructions Discussion

**DESCRIPTION**

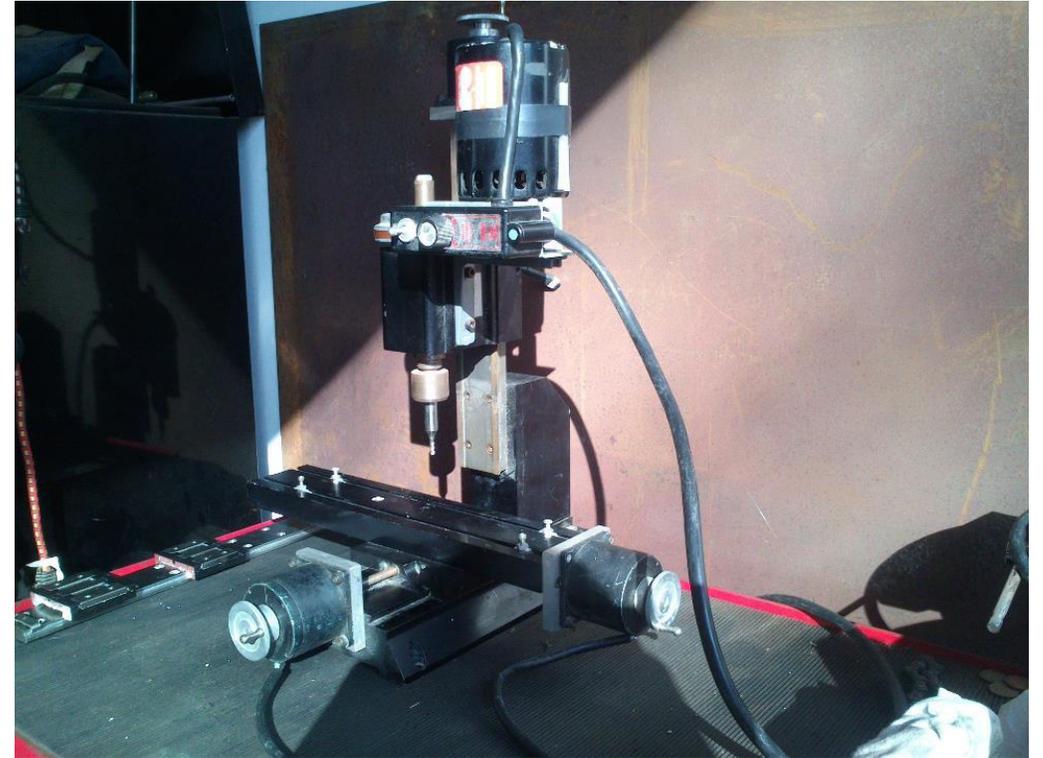
I found 3 years ago a mini milling (Sherline) with stepper motors included, but without the control unit. At first, I looked on eBay for CNC kits (~150\$) that work with Mach3 and required a PC with a serial port.

After I've completed my 3D printer with an Arduino Mega board, I looked on the internet and I found that it was possible to do a CNC controller with an Arduino UNO, a CNC shield and GRBL. It was cheaper than the CNC kits, but it was not possible to get a remote to do some moves without a computer...

So, I got an idea of building my own computer as the CNC controller with an HMI using a Raspberry Pi and a touch screen. The OS on the Raspberry Pi is Ubuntu (Linux). The idea is to connect the Arduino UNO to the Raspberry Pi with a USB port and to add a touch screen to the Raspberry Pi via USB and HDMI ports. So, I don't need a computer connected to the machine to run it.

# The old machinery

The machinery to be modernised is an old manually controlled vertical milling machine produced by Sherline Products Inc. ([www.sherline.com](http://www.sherline.com))



Mill to be modernized. Source:  
<https://hackaday.io/project/27740-grbl-cnc-retrofit-using-arduino-and-raspberry-pi#menu-description>

# The modernisation idea

By equipping the manually controlled milling machine with a CNC controller this is transformed in a modern machine able to convert a digital design into an object.

The CNC controller can be built using open-source hardware (Arduino, Raspberry Pi, CNC Shield) and open-source software, this way greatly reducing the costs.



# The components and software used

- Open-source software:

- Arduino IDE <https://www.arduino.cc/en/main/software>
- Ubuntu MATE (OS of Raspberry Pi) <https://ubuntu-mate.org/>
- GRBL <https://github.com/gnea/grbl/wiki>
- Universal G-Code Sender <https://github.com/winder/Universal-G-Code-Sender>

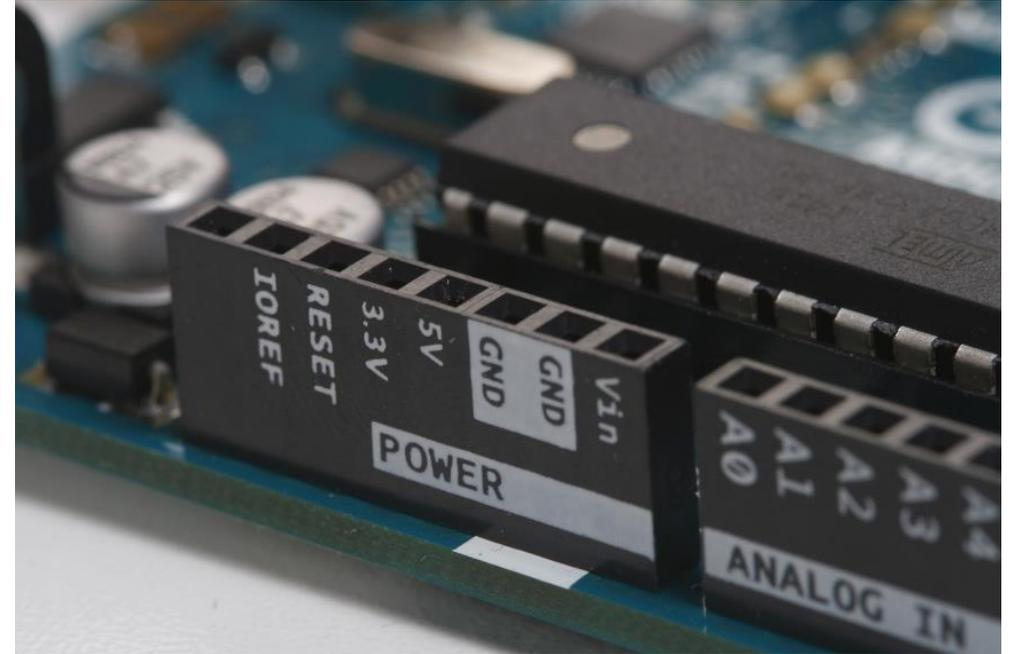
- Open-source hardware:

- Arduino UNO board
- CNC Shield V3.0
- Raspberry Pi computer
- CNC shield

- Other hardware

- Touch screen
- 3D printed parts specially designed
- Stepper motor drivers
- Junction box, buttons, connectors, cables, power supply, USB and Ethernet panel mount adaptors

Sender



# CS2 – Universal grinder retrofit

—

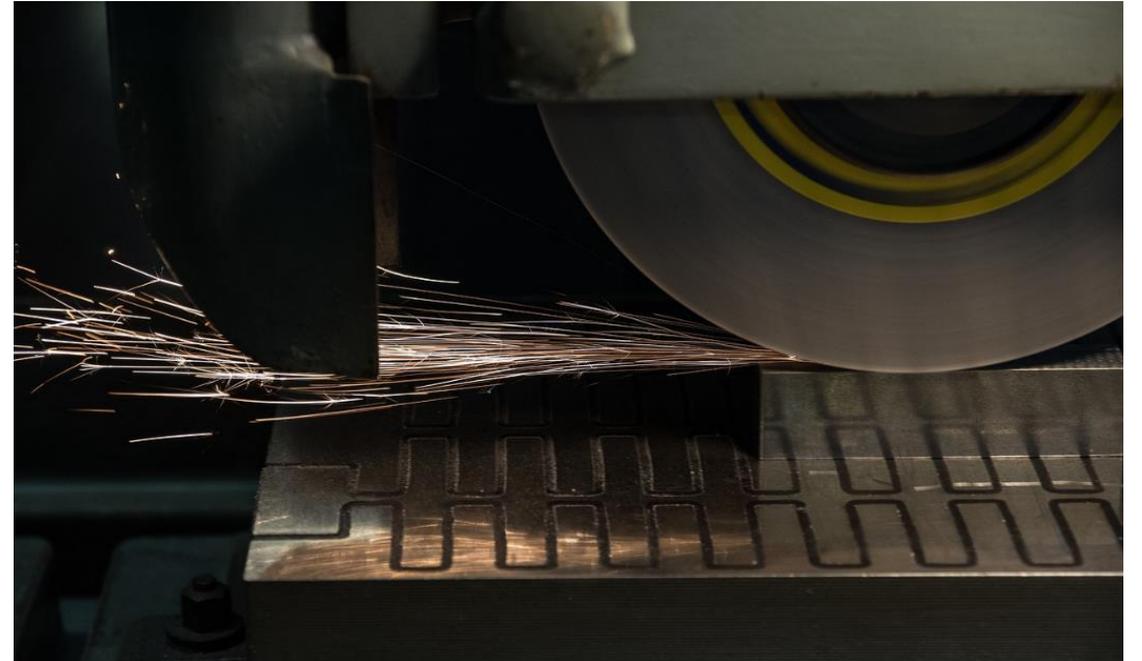
# Introduction

This case-study showcases the modernisation of a very old manual grinder.

It illustrates how a manual machine tool can be upgraded to a CNC to increase its accuracy and reliability while keeping low the investment cost.

The information is available on:

<https://machmotion.com/blog/brown-sharpe-grinder-retrofit>



# The modernisation idea

By transforming the manually controlled grinder in a CNC machine, it can be controlled by a computer, without the need of a human to be present in order to operate or supervise it

CNC grinders are doing forms and angles much easier than manual ones, are more accurate and time saving.

Servo motors and a MachMotion CNC grinder control (<https://machmotion.com/>) have been used.

The upgrade cost of the old machinery is a tenth the price of a new CNC grinder.

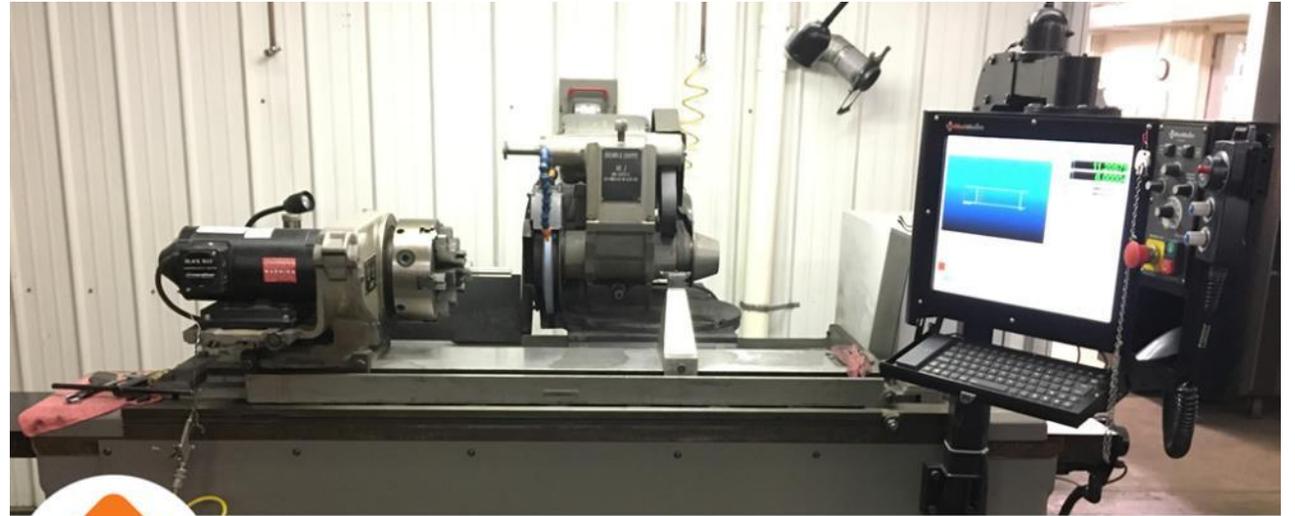


# Old vs Modernized machinery

The machinery to be modernised is a Brown & Sharpe No. 2 grinder produced in the 1950's.



Source: **Brown & Sharpe No. 2 grinder.**  
<https://www.machinio.com/>



**MachMotion**  
**Brown & Sharpe** Grinder Retrofit

# CS3 - Burckhardt Compression – Compression Revamps

—

# About the company

Burckhardt Compression specializes in customized compressor systems for different segments in the oil and gas industry.

They use up-to-date technologies for the design and manufacture of new compressors, as well as revamping and modernizing existing machinery.

The following case indicates a modernization of an existing compressor to stop leaking issues.

More information about the company is available here:

<https://www.burckhardtcompression.com/about-us/>



## Burckhardt Compression



Images by Burckhardt Compression. Source:  
<https://bit.ly/3ciBa8u>

# The old machinery

Because of tightened Health, Safety, and Environment (HSE) regulations by the Israel government, PAZ Ashdod Refinery had to revamp their existing gas compressors to be compliant with the new standards.

The compressors faced high leakage and energy loss issues due to low motor efficiency.

The capacity control system could only be activated manually due to its old design.

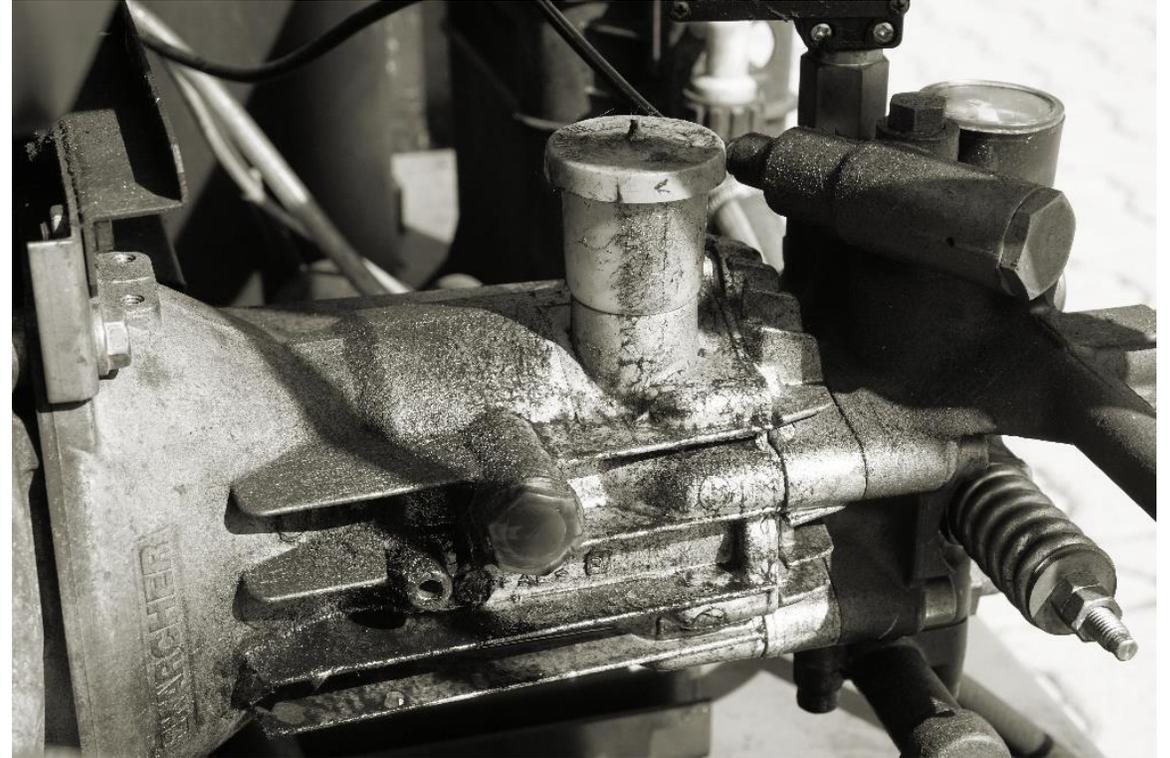


Image by PxHere. Link: <https://pxhere.com/en/photo/1218269>

# The modernisation idea

Burckhardt Compression performed a complete revamp using the latest technology:

- Advanced design for the 1st and 2nd stage cylinders with improved cooling effect
- Applied sealing systems, packing, rings, and valves
- Applied new motor and flexible coupling for reduced maintenance and higher reliability
- Installed state-of-the-art bugger/purge system of the distance piece and packing
- Replaced the old capacity control system with a modern one which included saver activation through the control panel.



Image by Burckhardt Compression. Source:  
<https://www.burckhardtcompression.com/service/services/revampsupgrades/>

# Old vs Modernized machinery

Compressor before revamp (left) and new cylinder designed during the revamp service installation (right)

The revamped compressor is now compliant with the latest Health, Safety, and Environment Regulations, shows no signs of leakage, its maintainability and operation is improved, and the investment costs are lower.



Images Source:

[https://www.burckhardtcompression.com/wp-content/uploads/2018/03/145\\_e\\_Success\\_Story\\_Revamp.pdf](https://www.burckhardtcompression.com/wp-content/uploads/2018/03/145_e_Success_Story_Revamp.pdf)

# Source/Reference



Case Study Reference

[https://www.burckhardtcompression.com/wp-content/uploads/2018/03/145\\_e\\_Success\\_Story\\_Revamp.pdf](https://www.burckhardtcompression.com/wp-content/uploads/2018/03/145_e_Success_Story_Revamp.pdf)

More revamping cases by Burckhardt Compression

[https://www.burckhardtcompression.com/wp-content/uploads/2015/11/BC\\_Brochure\\_Revamp\\_WEB.pdf](https://www.burckhardtcompression.com/wp-content/uploads/2015/11/BC_Brochure_Revamp_WEB.pdf)



Webinar about the case study by Burckhardt Compression

<https://youtu.be/Ugy2v6jNv10>

# CS4 - AiC: Rolling Mill revamping

—

# About the Company

Automazioni Industriali Capitanio (AiC) designs, manufactures, and commissions tailored state-of-the-art industrial automation systems, specializing in the whole metals industry.

AiC focuses both on new installations and revamping of existing mills.

This case study indicates how a state-of-the-art automation system can modernize an existing rolling mill plant to ensure reduction of costs and increase of efficiency, safety, and reliability.

More information about the company is available here: <http://www.aicnet.it/>



Image by Automazioni Industriali Capitanio. Source: <http://www.aicnet.it/>

# The old machinery

The old machinery is a rolling mill owned by ORI Martin – a primary group specializing in product steel production. The revamped plan specializes in the hot rolling of billets for the production of straight bars, wire rods, and coiler bars.



Collecting of technical data of the plant (Image by AiC). Source:  
<http://www.aicnet.it/media-download/case-history/best-practices-to-implement-complete-revamping-of-obsolete-plants-idc8.html>

# The modernisation idea

The revamping project included a complete on-site upgrade of the stand drives through new drive control cards, an the provision of new electrical equipment for auxiliary services, main and local desks, and new PLC platform that allows complete process automation and optimization of the steel plant.

## The aims of the production performance:

- Increase of packing performance through automatic cycles.
- Increase of quality and uniformity of bundles
- New control for binding cycles.
- Complete automation and securing of delivery area(safety operating activities).
- Data and alarms interchange with rolling mill and cut lines software.



Sample of DC drives before and after revamping (Image by AiC). Source: <http://www.aicnet.it/media-download/case-history/best-practices-to-implementation-complete-revamping-of-obsolete-plants-idc8.html>

# Supply Services

- Electrical engineering services
- Upgrade of all drivers
- 12 automation PLCs (with more than 7,000 I/O)
- Safety system based on safety PLCs, integrated in the main automation architecture
- SCADA control system in client-server configuration
- Main desks
- Local desks and control stations.
- Hydraulic control.
- Closed-circuit video equipment (CCVE) system.
- Spare part management.



Sample of DC drives before and after revamping (Image by AiC). Source: <http://www.aicnet.it/media-download/case-history/best-practices-to-implementation-complete-revamping-of-obsolete-plants-idc8.html>

# Old vs Modernized machinery

The use of the modernized machinery increases productivity, reduces direct costs, and allows to optimize productivity with a great improvement of efficacy, efficiency and rolling performances — without investing in new mechanical equipment.



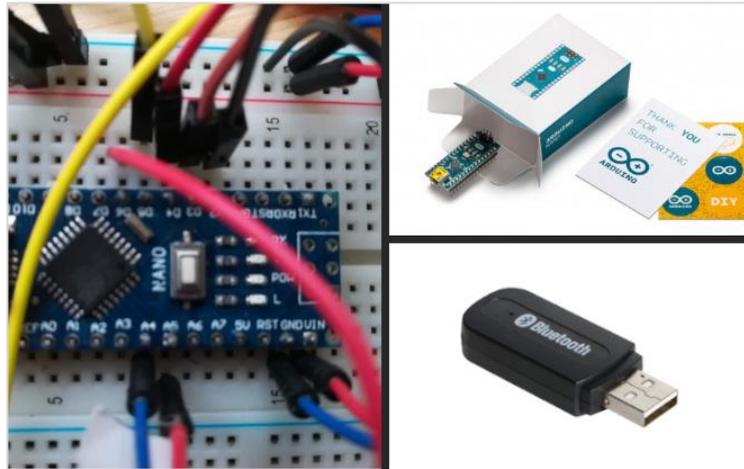
Main control room (rolling mill area) before and after revamping (**Image** by AiC). Source: <http://www.aicnet.it/media-download/case-history/best-practices-to-implement-complete-revamping-of-obsolete-plants-idc8.html>

# CS5 – Retrofitting of an old FM Radio

—

# Retrofitting of an old FM Radio

The project consists in the Retrofitting of an old FM radio providing Bluetooth connectivity through an ARDUINO microcontroller. The model used is the Arduino Nano which controls the turning on of the Bluetooth stick and the operation of the FM radio module. Through Arduino you can then select whether to operate the radio or Bluetooth through a button for the switch. In this way our radio can be used both to listen to the FM radio and to listen to music from our smartphone.



Author:  
Giulio Pons

Source:  
<https://hackaday.io/project/162367-retrofitting-of-an-old-fm-philips-radio>

<https://www.youtube.com/watch?v=MuxsjAEGdNI>

# Quote by the Author

*“A fun and somewhat spoiled aspect of retrofitting consists in trying to reuse pieces, for this reason, I find it nice that the 3W speakers that I used come from a radio, not very old but broken and destined for the landfill. This is the radio and unfortunately, it is too complex and integrated to be able to repair and operate it, but the speakers have been recovered. The same goes for the Bluetooth receiver, I have not looked for a new module for Arduino, but I have inserted a Bluetooth stick that I already had at home and I was not using. Recycling and reuse are terms that in retrofitting must find space.”*



Author:  
Giulio Pons

Source:  
<https://hackaday.io/project/162367-retrofitting-of-an-old-fm-philips-radio> and  
<https://www.youtube.com/watch?v=MuxsjAEGdNI>

# CS6 – RetroFab

—

# RETROFAB

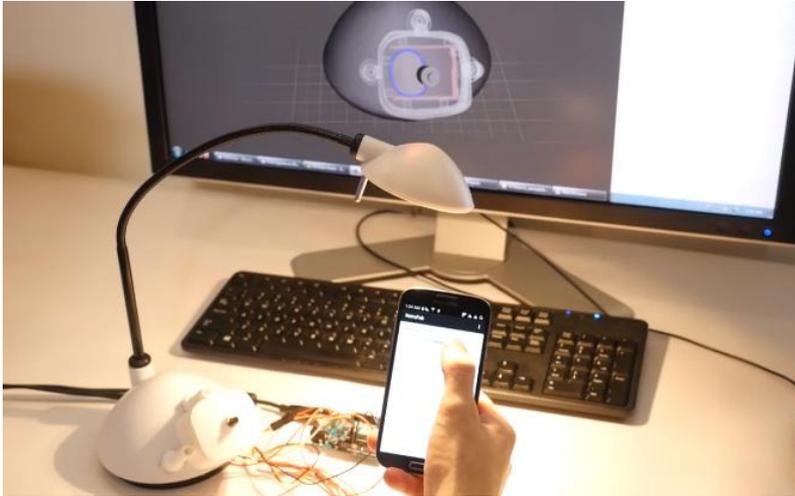
RetroFab: A Design Tool for Retrofitting Physical Interfaces using Actuators, Sensors and 3D Printing.

The RetroFab project consists in retrofitting the user interface of domestic appliances, using Arduino microcontrollers and a 3D printer. A project designed for non-experts with an end-to-end process.

The project starts from the observation that all domestic appliances (electrical appliances; lamps; etc.) have a rigid physical interface with few customization possibilities. With RetroFab is designed a new physical interface that manages smart interactions and customizations. The RetroFab kit is supplied with 12 additional components to make it usable with a wide range of electronic devices and equipment.



# RETROFAB



Author:  
Raf Ramakers  
Fraser Anderson  
Tovi Grossman  
George Fitzmaurice

Sources:  
<https://dl.acm.org/doi/pdf/10.1145/2858036.2858485>  
<https://blog.arduino.cc/2016/05/05/retrofit-your-old-appliances-with-new-controls/>  
<https://www.youtube.com/watch?v=Se7RwAtH0vg>

# CS7 – SIEMENS Gateway IoT SIMATIC IOT 2020

—

# SIEMENS Gateway IoT. SIMATIC IOT 2020

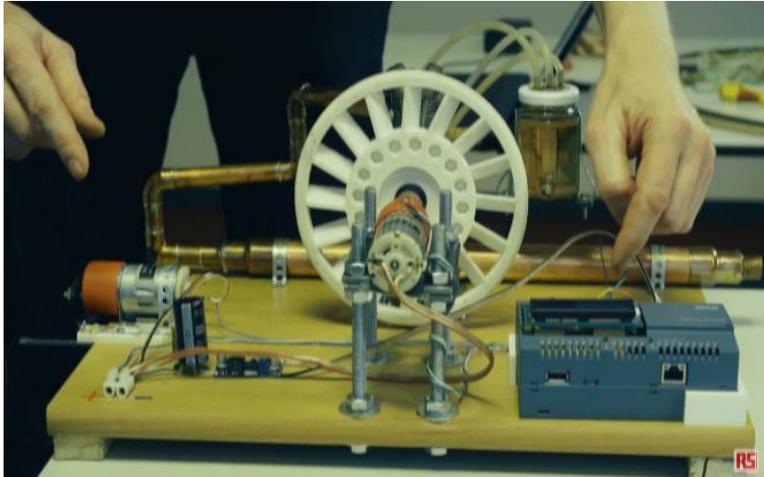
The SIMATIC IOT2020 from SIEMENS is an open gateway designed for the industrial IoT.

This device aims to provide technicians, makers, students and novice developers with a low-cost tool capable of interfacing with open source hardware and software such as Arduino, Intel Galileo or Raspberry Pi (a huge ecosystem of open source programs and libraries) but also with industrial equipment and applications because it has all the necessary certifications.

SIMATIC IOT2020 is not a logical microcontroller but rather has been developed to be the brain of an IoT network, capable of acquiring and managing data from different types of peripherals (machinery; PLC; drive; sensors; etc.). Furthermore, if I / O ports need to be set up, it is possible to connect Arduino connectors or shields on the market to the IOT2020.



# SIEMENS Gateway IoT. SIMATIC IOT 2020



Product:  
Gateway IoT SIMATIC IOT2020

Brand:  
SIEMENS

Sources:

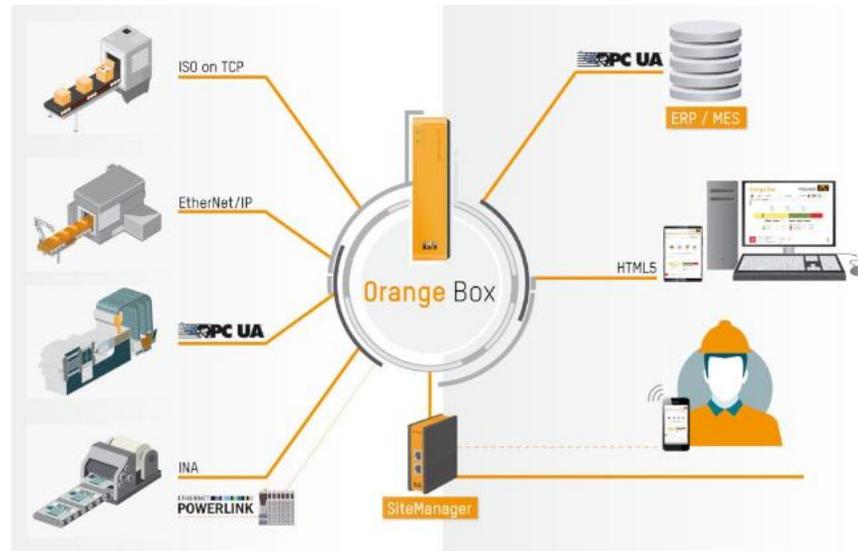
<https://it.rs-online.com/web/generalDisplay.html?id=siemens-simatic-iot2020>  
[https://www.youtube.com/watch?v=Rq7hkGPzPPU&feature=emb\\_title](https://www.youtube.com/watch?v=Rq7hkGPzPPU&feature=emb_title)  
[https://www.youtube.com/watch?v=0hJSrAgzqFw&feature=emb\\_logo](https://www.youtube.com/watch?v=0hJSrAgzqFw&feature=emb_logo)

# CS8 – B&R - Orange Box

—

# B&R - Orange Box

Orange Box is a product that allows operators, with minimal effort, to collect and analyze data from "traditional" machines and production lines by creating a smart factory. This device consists of a controller with ready-to-use pre-configured modules and interfaces. The controller collects the data of any machine through its I/O channels and then analyzes them generating performance indices and many other data useful for the management and optimization of the production line. In addition, the Orange Box is simple to use as a smartphone, in fact it connects without requiring any modification to the hardware or software of the machine, becoming a fundamental element in order to obtain from the production lines an increase in productivity or a reduction in processing times.



Source:  
<https://www.br-automation.com/it-it/chisiamo/press-room/technology-highlights/from-your-brownfield-to-the-cloud/>

# CS9 – Smart anti theft car security system based on GSM

—

# Introduction

Old cars are more likely to be stolen than modern cars. That's because, old cars don't have the same kind of security innovations as newer cars. This is what we are trying to ensure, a more secure car, but not at the price of a modern car.



# The old car

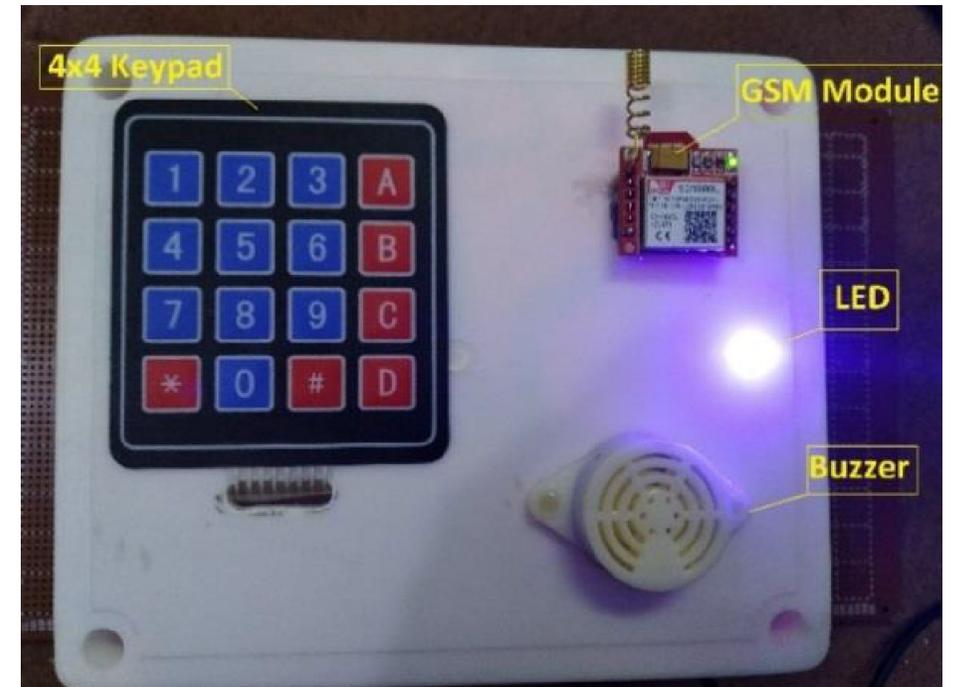
Any kind of automobile older than 10 years could be revamped with this new security system alarm.



# The modernisation idea

This case-study showcases the modernisation of an old car alarm. The new system alarm will be activated based on the inputs coming from the vibration sensor. In this system the Arduino microcontroller, vibration sensor, GSM SIM 800L module and Bluetooth HC-05 are used to implement the system, the vibration sensor is used for the purpose of detecting the vibration resulting from the operation of the engine of the car when the sensor detects something, a message is sent through the GSM to the owner. The alarm whistle can be turned to alert the owner of the car.

When the owner of the automobile wants to open his car he will be entering the password on the keypad to run the engine. It can also be operated via Bluetooth command from the smartphone. When someone enters the wrong password more than twice, the alarm turns on and the attempt appears on the interface of the mobile phone app. The purpose is to make the system more genuine and secure.



Source:

[https://www.researchgate.net/publication/331966489\\_Implementation\\_of\\_smart\\_anti-theft\\_car\\_security\\_system\\_based\\_on\\_GSM](https://www.researchgate.net/publication/331966489_Implementation_of_smart_anti-theft_car_security_system_based_on_GSM)

# The components and software used

## Open-source software:

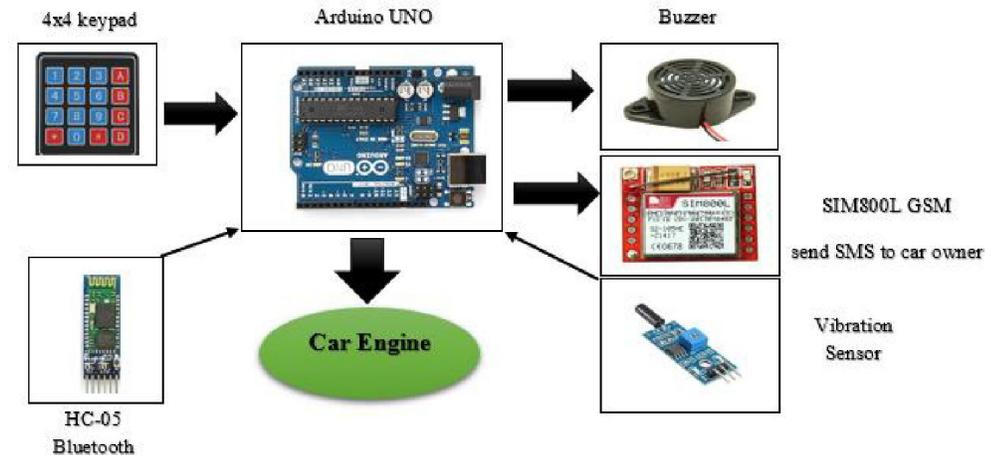
- Arduino IDE <https://www.arduino.cc/en/main/software>
- Universal G-Code Sender <https://github.com/winder/Universal-G-Code-Sender>
- Operating system (e.g. Linux)
- BlueTerm – free terminal emulator to communicate with any serial device with Bluetooth device
- BlueTooth terminal – free application under IOS like BlueTerm

## Open-source hardware:

- Arduino UNO board
- GSM SIM800L
- SW-18015P vibration sensor
- HC-05 Bluetooth module
- 4x4 keypad Arduino
- Buzzer ( could be used the old existing one in the car)

## Other hardware

- Phone with Android /IOS operating system



Case Study Reference:

<http://www.aicnet.it/media-download/case-history/best-practices-to-implement-complete-revamping-of-obsolete-plants-idx8.html>

YouTube Channel:

<https://www.youtube.com/channel/UCuHt-UjXoKVAXImXlJ3q8Q>

# CS10 – Revamping of grinding machines

—

# Introduction

Coordinate grinding machines with a precision of the order of microns are available either as new machines or by upgrading an old machine that still works with mechanical precision. In 2016, the company, IHR Elektronik AG / SA from Swiss Lajoux (Switzerland) offers these upgrades - with components FANUC upgraded two Hauser machines to two companies in Switzerland, Pomtava S.A. and Diametal AG.



# The old machinery

250 x 600 flat grinding machine

These planar grinding machines are intended for grinding flat surfaces. In rare cases, using the rotating table, folding, on these machines are rectified external or internal conical surfaces with a very high top angle to large parts.

The processing can be finishing, being preceded by other cutting operations by milling, planing or it can be used both for roughing and for finishing.



# The modernisation idea

The mechanical components of these coordinate grinding machines are very well executed and keep their precision high for a long time, but they are also very complicated.

These Z and U axis grinding machines are also suitable for making conical holes and modeling. Understanding how they work in detail is important. To make holes with a tolerance of  $5\ \mu\text{m}$ , precision mechanical systems use coordinate grinding machines manufactured by Hauser that Roland Haslebacher has modernized.

The mechanisms of the cars about 20 years old were in perfect condition, which means that only the electrical components had to be adjusted. The previous FANUC type 0 control system had to be replaced by the latest Oi F model in the CNC series offered by FANUC. With up to eleven axles, four shafts with shafts and two rails, it fully meets the requirements of this application.



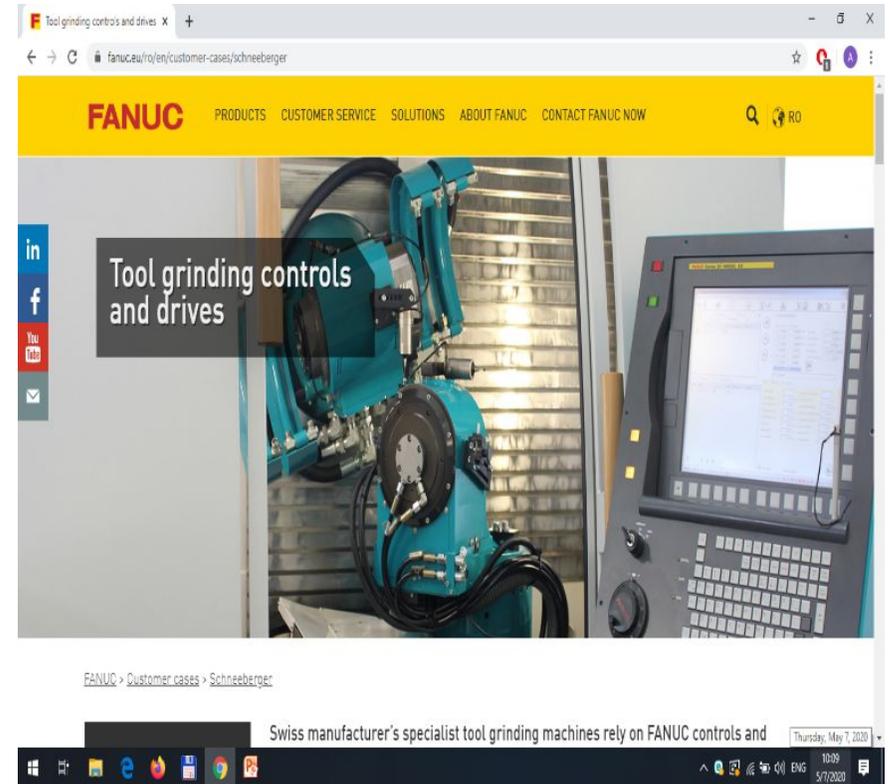
# Pioneer in the field of tool grinding

As early as 1923, Walter Schneeberger founded the company with his name. Two years later, he launched the R1 model on the market, a tool grinding machine with universal applications.

The company designed and built the first CNC-controlled grinding machines in 1985 - a new era in tool quality.

Schneeberger launched the concept of 5-axis grinding (1990), the first machine with linear drive systems, Sirius HPM (2003).

The current product range of this company: CNC grinding machines Corvus, Gemini and Norma, with output powers of up to 40 kW, and with the Aries series, Schneeberger offers an economical alternative to 5-axis technology in the field of resharpening. The specialized tool grinding machines of the Swiss manufacturer are based on FANUC control and drive systems



Source:

<https://www.fanuc.eu/ro/en/customer-cases/schneeberger>

# The components and software used

The HCC (High-speed Cycle Cutting) software, which FANUC provides in the ultra-performing CNC systems of the 30i and 31i series, can achieve homogeneous and precise processing routines, which cannot be obtained in any other process. The basic structure is simple: For each axis to be moved, a table is created in which the movements related to that axis are programmed for a defined time interval (eg 1 millisecond).



# CS11 – Revamping of refrigeration system

—

# Introduction

This case-study showcases the revamping of a refrigeration system.

Sometimes, factories have different production processes. The modernization of the system that aims to dissipate the heat is necessary. The constant growth of the factory Hero and its production lines made it necessary from 1974 to apply a new system to dissipate the heat that replaced the old refrigeration systems, which, in addition, had low energy efficiency, high consumption of water and high maintenance costs.

The logo for Hero, featuring the word "Hero" in a white, bold, sans-serif font, centered within a dark blue oval shape.

Source: **TORRAVAL cooling**

<https://www.torraval.com/en/revamping-of-refrigeration-system-of-production-processes-at-the-hero-spain-plant/>

# Aim of the revamping

The new system has to meet the needs of the production line, the safety of workers and environmental sustainability and energy efficiency. The problem that mechanics had also to faced was the lack of water in the area, the high temperature and the factory's growth forecast.



TORRAVAL cooling. Source:

<https://www.torraval.com/en/revamping-of-refrigeration-system-of-production-processes-at-the-hero-spain-plant/>

# The solution

Engineers and technicians decided to install system of evaporative cooling towers.

The characteristics are the following:

- Material of the towers: GRP (polyester reinforced with fiberglass).
- Type of tower: forced draft.
- Filling: laminar-drip.



TORRAVAL cooling. Source:  
<https://www.torraval.com/en/revamping-of-refrigeration-system-of-production-processes-at-the-hero-spain-plant/>

# Results and benefits of the process

- High versatility
- Savings of up to 50% of electricity consumption
- Maximum security
- Lower acquisition and maintenance costs
- Environmental benefits
- No incident related to biological problems in in 40 years
- Perfect operation for 50 years
- Minimum and versatile maintenance



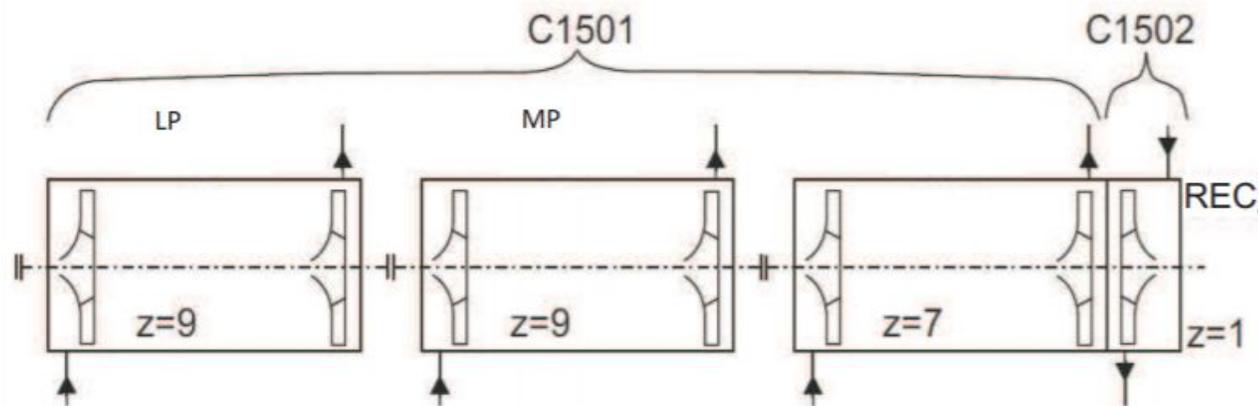
TORRAVAL cooling. Source:  
<https://www.torraval.com/en/revamping-of-refrigeration-system-of-production-processes-at-the-hero-spain-plant/>

# CS12 – Revamping of a three-staged synthesis gas radial turbo compressor

—

# Introduction

This case-study showcases the revamping of a compressor. The old machine was a compressor that has established from middle sixties of previous century. Due the changes on the technology and the production life, industry needs new and updated machines or equipment. The modernization was a joint venture of Neo-Tec and Institute of Turbomachinery, Lodz University of Technology.



INSTYTUT MASZYN PRZEPLYWOWYCH. Source:  
[https://www.imp.gda.pl/files/transactions/131/131\\_10\\_.pdf](https://www.imp.gda.pl/files/transactions/131/131_10_.pdf)

# Aim of the revamping

The aim of the revamping was to adapt the compressor to the new working conditions. Through the modernization the aim was a modernised machine that driven by a steam turbine.

Engineers and technicians agreed the following scope:

- complete new flow channel (gas path) design,
- new diaphragms design and manufacturing,
- new bearings, seals and couplings,
- new vaneless diffusers manufacturing



INSTYTUT MASZYN PRZEPŁYWOWYCH. Source:  
[https://www.imp.gda.pl/files/transactions/131/131\\_10\\_.pdf](https://www.imp.gda.pl/files/transactions/131/131_10_.pdf)

# Results and benefits of the process

- New working parameters
- Original piping and cooling system can be preserved (reducing the cost)
- Energy efficient
- Preserving the original balancing system of HP section and updating



INSTYTUT MASZYN PRZEPIYWOWYCH. Source:  
[https://www.imp.gda.pl/files/transactions/131/131\\_10\\_.pdf](https://www.imp.gda.pl/files/transactions/131/131_10_.pdf)

Case Study Sources:

<https://www.torraval.com/en/revamping-of-refrigeration-system-of-production-processes-at-the-hero-spain-plant/>

[https://www.imp.gda.pl/files/transactions/131/131\\_10\\_.pdf](https://www.imp.gda.pl/files/transactions/131/131_10_.pdf)

# Source/References



Case Study Reference

<http://www.aicnet.it/media-download/case-history/best-practices-to-implementation-complete-revamping-of-obsolete-plants-idc8.html>



YouTube Channel

<https://www.youtube.com/channel/UCuHt-UjXoKViAXImXJl3q8Q>

# CS13 – Revamping a cooling tower

—

# Introduction

This case-study showcases the rehabilitation of a cooling power in the Arcelor Mittal plant of Sagunto (Valencia – Spain). The objective was to refurbish the old cooling tower to deal with the needs of the productions increasing. Revamping was implemented by Torraval Cooling Company to deal with the challenge to reduce the cooling temperature.



## THE CHALLENGE

Due to an increase in the production of its plant in Sagunto, the iron and steel company, ArcelorMittal decided to refurbish the old cooling tower with a revamping. It

Source:

<https://www.torraval.com/en/revamping-of-arcelormittal-cooling-tower-in-a-record-time/>

# The old cooling tower

The old cooling tower was a tower of a single concrete cell, measuring 15 x 19 meters. The lack of maintenance had deteriorated markedly over the years, so its revamping was considered a quite complex work.

Due to an increase in the production of its plant in Sagunto, the iron and steel company, ArcelorMittal decided to refurbish the old cooling tower with a revamping.



Arcelor Mitral plant in Sagunto (Valecnia – Spain). Source [https://eleconomico.es/media/k2/items/cache/a58762379308f82a900eda6f2d095dd4\\_XL.jpg](https://eleconomico.es/media/k2/items/cache/a58762379308f82a900eda6f2d095dd4_XL.jpg)

# The solution

To comply with the required deadlines and with the technical aspects specified by ArcelorMittal, Torraval takes up the project with great flexibility, taking charge of the design and storage in record time of the material for the rehabilitation of the cooling tower. In addition, a study would also be carried out to guarantee compliance with a thermal program that is more demanding than the previous one, taking advantage of the existing mechanical equipment.



Cooling tower after revamping: Source:  
<https://www.torraval.com/en/revamping-of-arcelormittal-cooling-tower-in-a-record-time/>

# The components used

- The items supplied were the following:
- Complete set of high efficiency PVC drift eliminators.
- Complete set of PVC laminar filling.
- Galvanized steel purling for the correct support of the filling.
- Complete set of water distribution system.
- Cladding of FRP plates.
- Complete perimeter handrail of FRP.
- Galvanized steel metal benches for mechanical equipment.
- Galvanized steel interior platforms for access to mechanical equipment.
- FRP deflectors for side air intakes.



Source:  
<https://www.torraval.com/en/revamping-of-arcelormittal-cooling-tower-in-a-record-time/>

# Benefits for the customer

- Start-up installation on due date, in a record time.
- Corrosion resistant materials
- Compliance with the new, more demanding thermal program by reusing existing mechanical equipment.
- Appearance of modern and renovated installation.
- Easy and accessible maintenance



Video source:

<https://www.youtube.com/watch?v=Sd-yuKU7lkc>

Source:

<https://www.torraval.com/en/revamping-of-arcelormittal-cooling-tower-in-a-record-time/>

# CS14 – Revamping MIR HMG 380

—

# Introduction

This case-study showcases the revamping of a injection molding machine MIR HGM 380 (year 1992). The process was implemented by BSS Asistencia.

BSS ASISTENCIA Servicios Marcas Trabajos realizados Nosotros Contacto

REVAMPING EN MIR HGM 380

Máquina del año 1991, Modelo: HGM 380

A DESTACAR :



- Instalación de una segunda bomba en la máquina
- Adaptación de 2 servo bombas al circuito hidráulico

Source: <https://www.bssasistencia.com/revamping-en-mir-hmg-380/>

# Revamping process

The entire electrical cabinet was reinstalled on this machine from :

- Control 6 Temperature Zones.
- Frequency inverters for heavy moulds, loading and brushing.
- Safety module for doors and mushrooms.
- Gefran PLC for machine control.
- 2 inverters for the control of the servomotors.



Text and image source:

<https://www.bsasistencia.com/revamping-en-mir-hmg-380/>

# Improvements

- Reduce energy consumption by installing inverters.
- Safety, by installing protective plates and limit switches.
- Improvement of the machine's operational control, by changing the automaton and the display, as well as new software.
- Corrective maintenance, from changing piston and valve seals, replacing obsolete parts and any repairs.
- Renovation, good cleaning and painting.



# Source/References



Case Study Reference

<https://www.torraval.com/en/revamping-of-arcelormittal-cooling-tower-in-a-record-time/>

<https://www.bssasistencia.com/revamping-en-mir-hmg-380/>



YouTube Channel

<https://youtu.be/Sd-yuKU7lkc>

# CONCLUSIONS

—

# Conclusions

- Various types of equipment can be modernized with significant benefits in terms of performances, reliability, costs, efficiency, environment, etc.
- Several open-source and proprietary technologies, hardware and software are available to help in machinery revamping
- Different machine tools can be easily transformed from manually to computer controlled equipment
- Real-life case studies proves that modernizing an old equipment can be save money and ameliorate environmental issues
- Internet of things (IoT) can give new life to machinery and equipment of different nature and size.

# Conclusions

- Connecting machines via IOT means having greater control of production processes and therefore improving and making them efficient. It is possible to have an integrated and smart management of the entire production line by analyzing the data and anticipating possible problems. Consequently, a company could be able to optimize production and become more competitive on the market.
- Making household appliances; lighting; heating; etc. accessible and communicating with each other through a new customized interface allows everyone to obtain a smart home tailor-made for those who will live in it; something that the most popular home automation products on the market does not allow.
- For the purposes of the Erasmus + "Refitting Machine" project, the presented study-cases represent an excellent track on which to build a training path for a new technical figure who specializes in retrofitting operations.

Co-funded by the  
Erasmus+ Programme  
of the European Union



The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



REFITTING

MACHINE