POLITECNICO
MILANO 1863

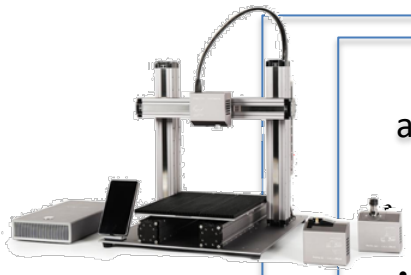
mecc

DIPARTIMENTO DI ECCELLENZA
MIUR 2018-2022

Production 4.0

Teaching Lab at Mechanical Engineering

Production 4.0 stations



Snapmaker 2.0

Hybrid additive/subtractive machine tool

NI bundle

Milling, laser engraving, FDM

- Incorporated sensors
- Ready for augmented reality

CowTech Ciclop

Geometrical verification

- Multiple sensors
- Feed to the nominal model

Control PC

- CAD
- CAM
- Simulation
- Acquisition

LabVIEW, MATLAB, SW, CATIA, esi SYSWELD, INVENTOR, SIEMENS NX, VERICUT, ABAQUS

Preparation

- Material rack
- Tools

MEASUREMENTS

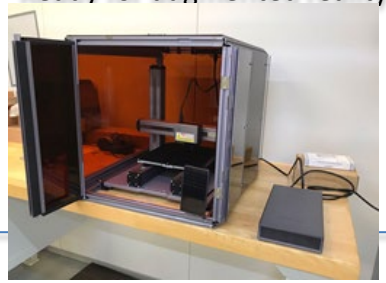
Material analysis and characterization

- Optical microscopy
- Camera for imaging
- Mini universal testing machine
- Serves 8 stations – Low load factor
- Adjustable demonsrators

Station

Hybrid additive/subtractive machine tool

- Incorporated sensors
- Ready for augmented reality



Geometrical verification

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LabVIEW MATLAB SOLIDWORKS CATIA SYSWELD INVENTOR SIEMENS NX VERICUT ABAQUS

Preparation

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Main course features

- Workload: 3 ECTS
- Location: DMEC Bovisa
- The course is organized in project activities
- Activities are developed by teams, each team has a specific objective
- Teams are composed of 4-5 members
- Tutors from different disciplines will supervise teams
- Intermediate resultrs will be supervised every 2 weeks
- The course will close with a final presentation
- Evaluation will be based on attendance and final presentation

Schedule

Meeting	Week	Day (to be defined)	Description	Hours @Polimi	Hours @Home
1	1	19 oct 2021	Lesson 0	1	2
2	3	2 nov 2021	Audit & discussion	4	8
3	5	16 nov 2021	Audit & discussion	4	8
4	7	30 nov 2021	Audit & discussion	4	8
5	9	4 dec 2021	Audit & discussion	4	8
6	11	14 dec 2021	Audit & discussion	4	8
7	13	21 dec 2021	Final presentation	4	8
				25	**50**

Activities

Vertical – Area oriented

1. Manufacturing Case Study
2. Materials Case Study
3. Product Design Case Study
4. Dynamics Case Study

Horizontal – Service oriented

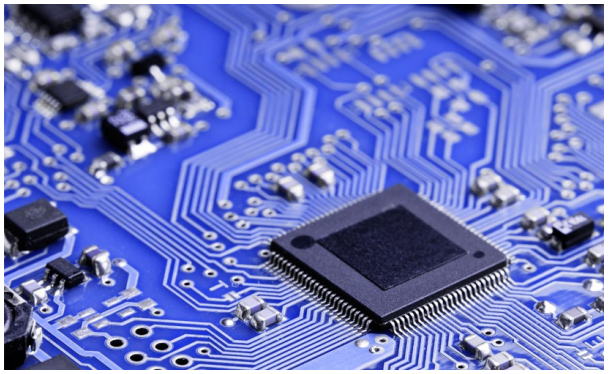
5. Production Cell Digitization Case Study
6. User interfaces & Guidelines
7. Layout Planning, Ergonomy & Safety Issues

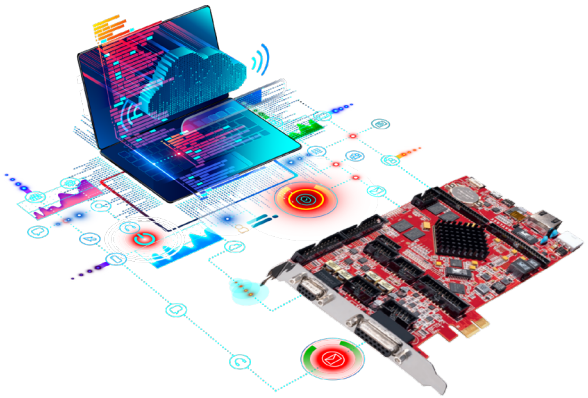
Manufacturing Case Study

On-demand manufacturing of custom PCB boards

Examples of PCB boards

[PCB Marking - Control Micro Systems (cmslaser.com)]





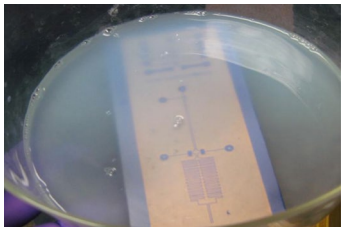
PCB prototyping process

25 µm Cu coating over FR-4 fiber glass

Paint coating over Cu coating

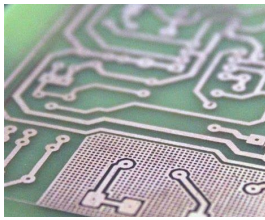
Selective laser stripping

Selective chemical etching



Chemical washing

Final product: PCB card

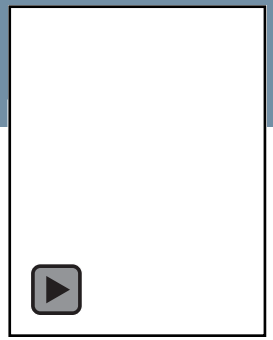


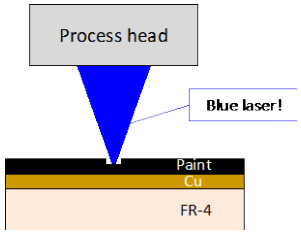
- Hands on lab experience
- Learning by doing
- Theoretical basis
- Technological perspective

Manufacturing Case Study

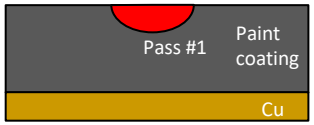
Aim of the project:

- Design the manufacturing process for custom PCB board production
- Calibrate, simulate, CAM, test



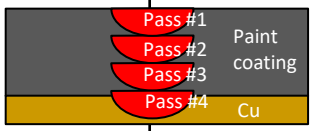


Single scan experiments



Understand the basics of laser material interaction

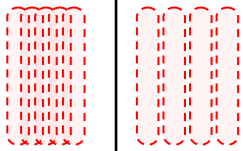
N° of passes?

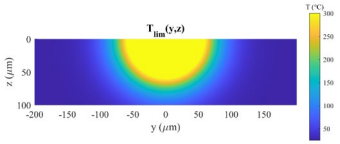


Scan overlap?

Positive overlap

Negative overlap





Definition of technological parameters

Validation run

Proof of concept validation of initial test

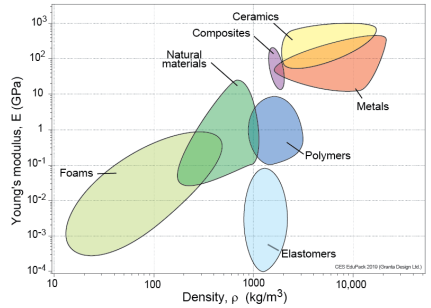
PCB card prototyping

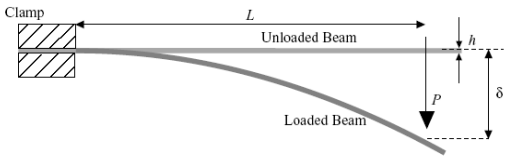
On-demand manufacturing

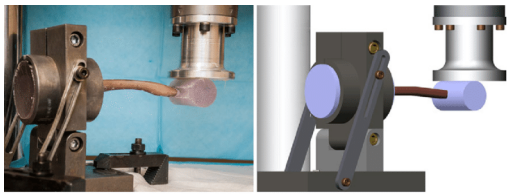
Materials Case Study

Development of a drone arm in aerospace Al alloy

- Set up of **design requirements** for **light-weight** and **stiff** drone arm within specific constraints: applying multi-objective derivative method analysis to steer positive **material substitution** from polymeric material to light Al metal alloys (e.g. Ashby material indexes, Ashby maps, etc.);
- Development of **optimized thermal treatments** for data acquiring on mechanical properties of candidate Al alloys for material change (machining and test of small tensile specimens);
- **Data acquiring** on design requirements, e.g. flexural properties and maximum load by cantilever tests.
- **Comparative analysis** by multi-objective non-derivative methodology (e.g. QFD analysis) for targeting **best candidate material.**

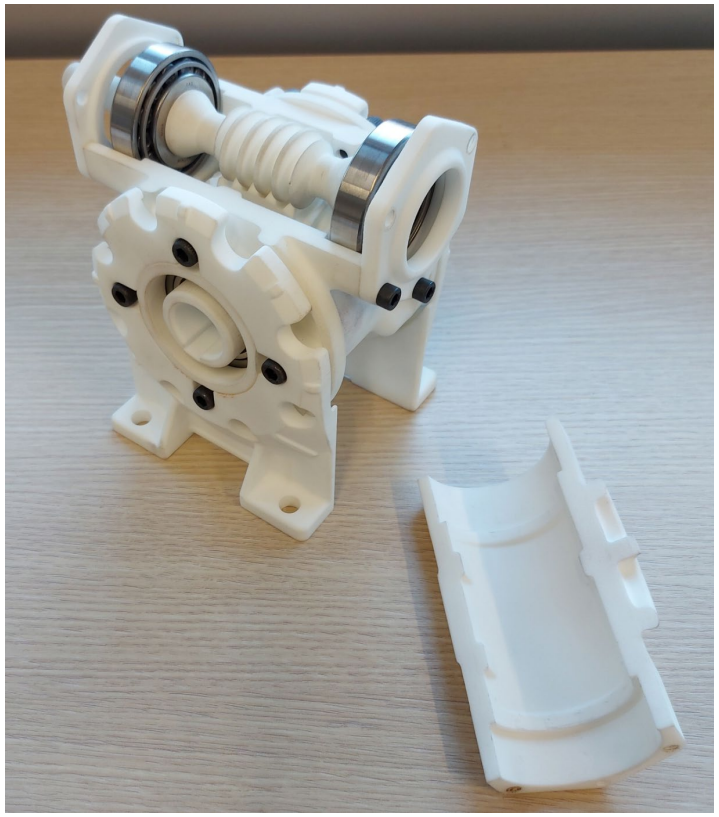






Product Design Case Study

- This case study aims at evaluating the 3D printing quality of selected components of the lab testing machine: the ETS5 Worm Gear Unit. The printed components should ensure their correct mounting on the machine. An estimation of the time required for printing and for applying eventual modifications of each component should be provided to verify the feasibility of this task within the activities of the lab.



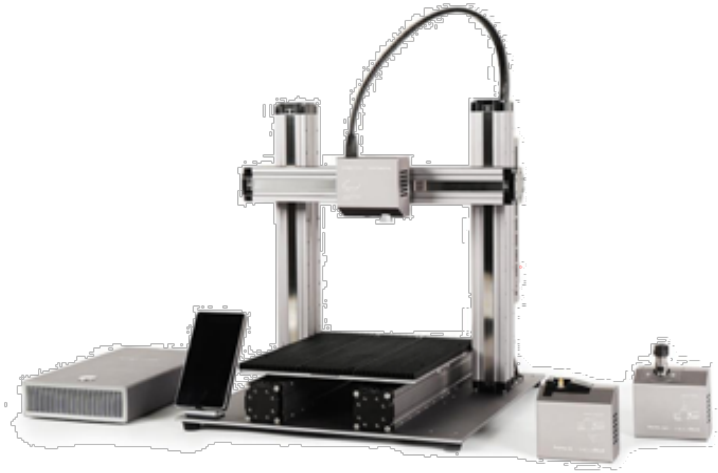
Dynamics Case Study

The scope of this case study is to design the **digital twin** of the original machine tool.

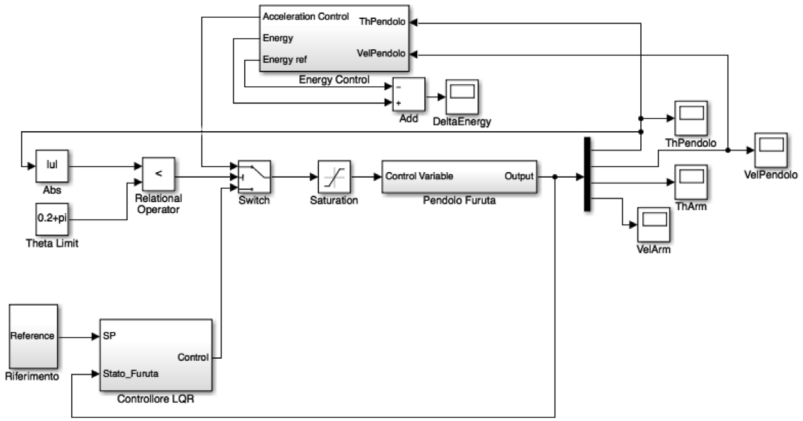
The work will be focalised on two main aspects:

- Simulink model of the machine considering all the different components
- FEM model of the structure to take into account the flexibility of the system

The developed model will be used to verify different control logics to optimally control the position/speed of the tool.



SNAPMAKER 2.0



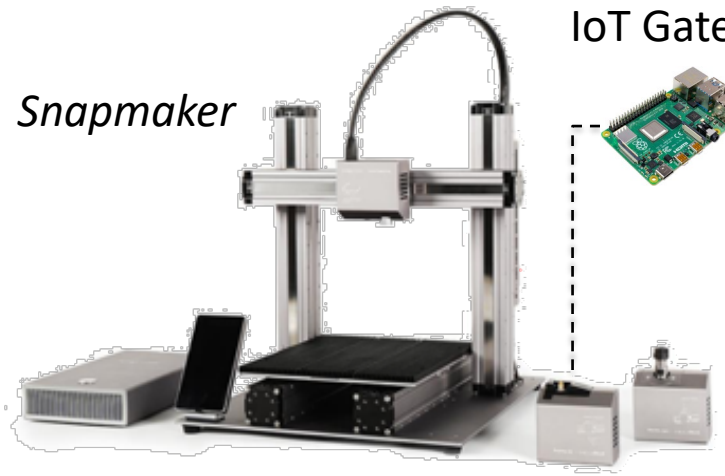
MATLAB® & SIMULINK®

Production Cell Digitization Case Study

The scope of this case study is to design the **digital interface** of the original machine.

The work will aim at achieving the following:

- Connection of machine to an IoT gateway
- Creation of a user interface
- Real-time data streaming
- Online Database setup



IoT Gateway

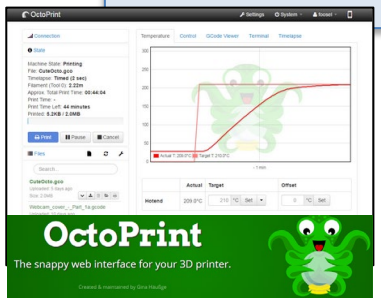
Web

STATUS: ON/OFF

SETUP: PARAMETERS

DIAGNOSTICS: FAILURES, BLOCKAGES…

CONTROLS: START/STOP/PAUSE



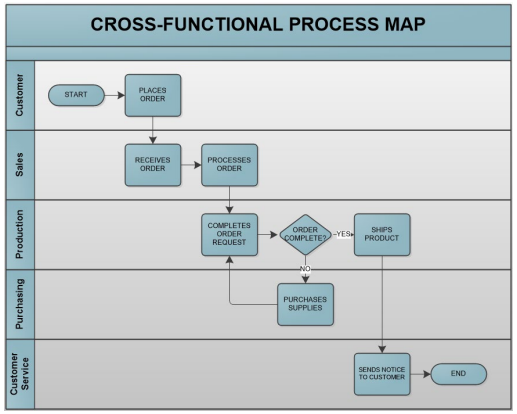
Users

User interfaces & Guidelines

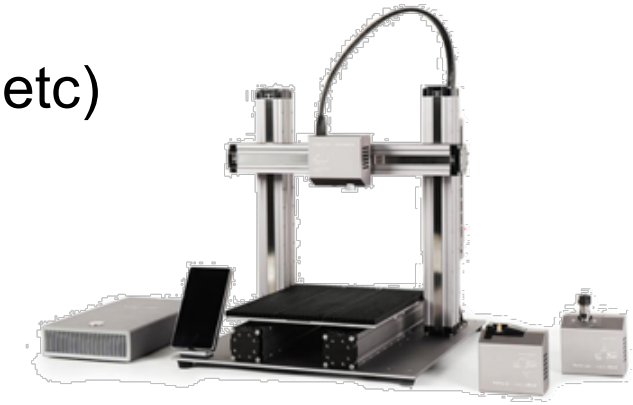
Goal: to develop the material for proper use of the resources in the production cell

Draft list of activities

- Process mapping



- How to use instructions (videos, docs, etc)



Layout Planning, Ergonomy & Safety Issues

Layout planning is deciding on the best and most **efficient** arrangement of all physical resources that will need space in a work area or a facility.

It will include:

- Desks
- Work centres and equipment
- Cabinets
- etc

The layout should also consider **ergonomy**

- Preventing work-related injuries
- Improving the efficiency and usability of cell
- Improving management of equipment and materials
- Complying with laws
- Promoting innovative ways of thinking

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