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Cooperating across borders in the Mediterranean

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NATIONAL TECHNICAL UNIVERSITY OF ATHENS

INNOMED-UP

Output 4.3

Clustering smart tools

NATIONAL TECHNICAL UNIVERSITY OF ATHENS

BIRZEIT UNIVERSITY

cooperativa sociale
CRESM
centro ricerche economiche e sociali per il meridione

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FUTURE PIONEERS
Empowering Communities

INNOMED-UP

Promoting UPcycling in Circular Economy through INNovation and education for creative industries in MEDiterranean cities

Work Package (WP4): SMEs Clustering Capacity Enhancement through Roadmaps & Smart Tools NTUA

Output 4.3: Clustering smart tools

Activities:	**A 4.3.1**	Design a Smart Bicycle and construct a Prototype
	A 4.3.2	Develop a Central Information System
	A 4.3.3	Design a Smart Garbage Bin and construct a Prototype
	A 4.3.4	Develop an Open source repository for circular designs and eco-design toolkits

Output Participating Partners:	**National Technical University of Athens (NTUA), Greece**	Lead Beneficiary (BEN) WP1 Coordinator
	Environmental Planning Engineering and Management (EPEM SA), Greece	Project Partner 1 (PP01)
	Municipality of Prato (MoP), Italy	Project Partner 2 (PP02)
	Centre for Economic and Social Research for the South of Italy (CRESM), Italy	Project Partner 3 (PP03)
	Municipality of Tunis, Tunisia	Project Partner 4 (PP04)
	Birzeit University (BZU), Palestinian Authority	Project Partner 5 (PP05)
	Future Pioneers for Empowering Communities' Members in the environmental and educational fields (FPEC), Jordan	Project Partner 6 (PP06)

This project has received funding from the 2014-2020 ENI CBC Mediterranean Sea Basin Programme, the Cross-Border Cooperation (CBC) initiative implemented by the European Union (EU) under the European Neighbourhood Instrument (ENI).

Thematic objective:	A.2 Support to education, research, technological development & innovation
Priority:	A.2.2 SMEs access to research and innovation
Duration:	September 1st, 2019 - August 31st, 2023 (48 months)
Countries:	**Greece**, Italy, Tunisia, Palestine, Jordan
Budget:	€ 3.199.096,35
ENI contribution amount:	€ 2.879.186,72
Website:	http://www.enicbcmed.eu/projects/INNOMED-UP

1 CLUSTERING SMART TOOLS EXECUTIVE REPORT (ACTIVITIES 4.3.1, 4.3.2, 4.3.3 & 4.3.4)

1.1 SMART TOOLS ACCORDING TO THE PROPOSAL

The following table contains the description of the clustering smart tools as were proposed in the framework of the INNOMED-UP Project, together with the Activities and Outputs under which they fall.

Table 1: Smart tools as described in the Project's Proposal

OUTPUT	ACTIVITY	ACTIVITY DESCRIPTION
Output 4.3: Clustering smart tools	Activity 4.3.1: Design a Smart Bicycle and construct a Prototype	The Smart Bike functions as a collector of waste for reuse, informing the CIS about its location and the condition of smart Garbage Bins. To perform the above operations, the Smart Bike will include an identification tag and an application software running on a smartphone. The design of the Smart Bike will allow its easy reproduction based on open source design. The prototype will be constructed and tested by NTUA and will be reproduced in five copies for the pilot clusters (O 5.1).
	Activity 4.3.2: Develop a Central Information System	A web-based Central Information System (CIS) will be developed to process the data sent by the Smart Bikes and Garbage Bins. Its function will be displaying the location of Smart Bikes and Garbage Bins, deciding whether to send vehicles to pick up reported waste, recording the history of the operations, etc. The CIS which will manage the fleet of Smart Bikes, based on a heuristic algorithm, will be automatically navigating them through messages to the users to collect waste efficiently.
	Activity 4.3.3: Design a Smart Garbage Bin and construct a Prototype	A Garbage Bin Prototype will be designed and constructed, embedding a special device that includes a distance measuring sensor (infrared or ultrasonic) that checks their condition (full or not). A wireless network will be included, reporting to Central Information System its ID, location and condition (full or not). Our target is to guarantee low power operation and high energy autonomy. The bins will be placed in households or businesses who will participate in the cluster.

OUTPUT	ACTIVITY	ACTIVITY DESCRIPTION
	Activity 4.3.4: Develop an Open source repository for circular designs and eco design toolkits	This repository of open source designs for circularity and eco-design toolkits will include firstly the open source designs of the above smart tools (Smart bicycle and Smart garbage bin). Apart from that, it is expected that innovative products though re- and up-cycling of waste will be designed in the framework of the program by cooperating CCIs and that their open-source designs will be shared at Med-level through this repository that will be included in the Networking Platform (WP2 / O 2.5).
Output 5.1: Pilot clusters	Activity 5.1.1: Re-Production of clustering smart tools in each case study and testing	Each pilot cluster will be organized with the support of the clustering tools developed in WP4 (O 4.3). The Smart bicycle will be reproduced in 12 copies (2/cluster). The smart garbage bin will be reproduced in 60 copies (10/cluster). The smart tools will communicate with the respective Central Information System. The reproduction of the tools will be done by the participating SMEs with the help of the open source designs uploaded in the Open source digital repository using tools and 3D printers.

NTUA team successfully developed the smart bin and the smart bicycle prototypes, which are available at the Open-Source[1] Repository for SMEs interested in adopting such tools to support their activities. Moreover, the web-based Central Information System (CIS)[2] and the application software[3] were also developed and available to support the clustering smart tools system.

However, as declared during the 4th Steering Committee organized by PP04, various issues arose concerning the reproduction of smart bicycles (Activity 5.1.1), mainly connected with different legislative framework among the different countries of the Partnership regarding waste transportation, vehicle standards, etc. In order to overcome this obstacle, it was decided that different means of waste transportation may be used, according to the specific needs of each cluster, since the main smart feature, i.e., the smart application, may still be used.

1.2 CLUSTERING SMART TOOLS INSTALLATION

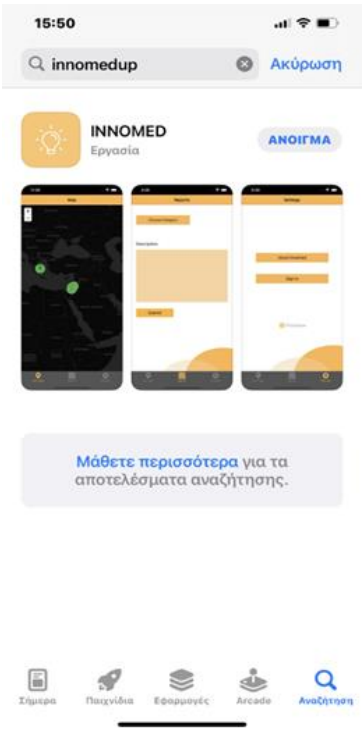
1.2.1 Smart Bike

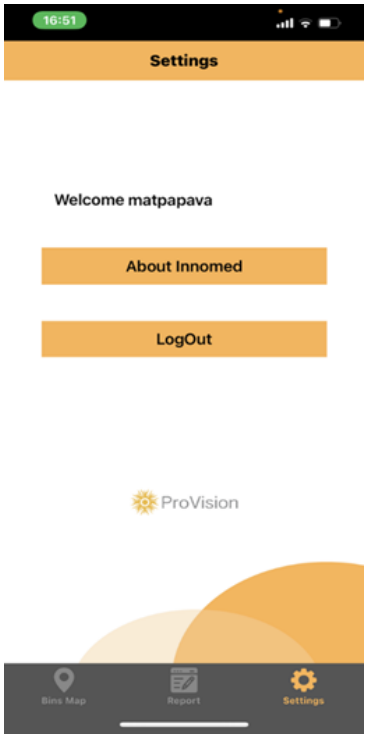
The design of the bike from the beginning was based on assembling a tricycle with parts obtained from retired old bikes. Ultimately, building a street-certified bike was not feasible in the European Union countries due to strict certification legislation. In Greece, since the European directive for the certification

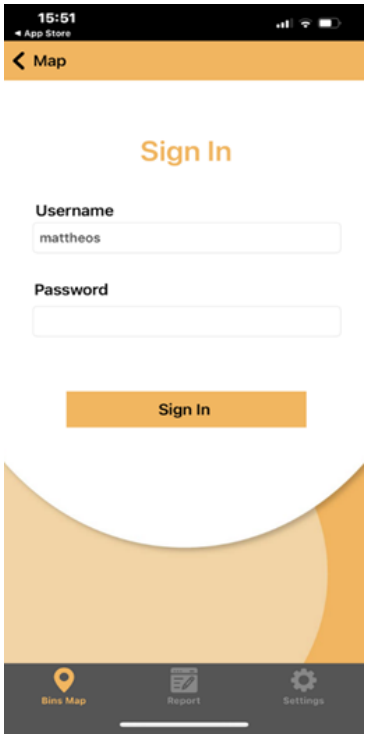
[1] http://innomed-up.eu/OSREP/
[2] https://innomed-up.birzeit.edu/
[3] https://play.google.com/store/apps/details?id=ps.provision.innomed&hl=el&gl=US

of bicycles had not yet been ratified at the time the construction took place, we managed to implement a tricycle with a place to load the removable container of the smart bin, made from recycled bicycle parts. From January 2024, however, it will not be able to circulate on the roads without certification.

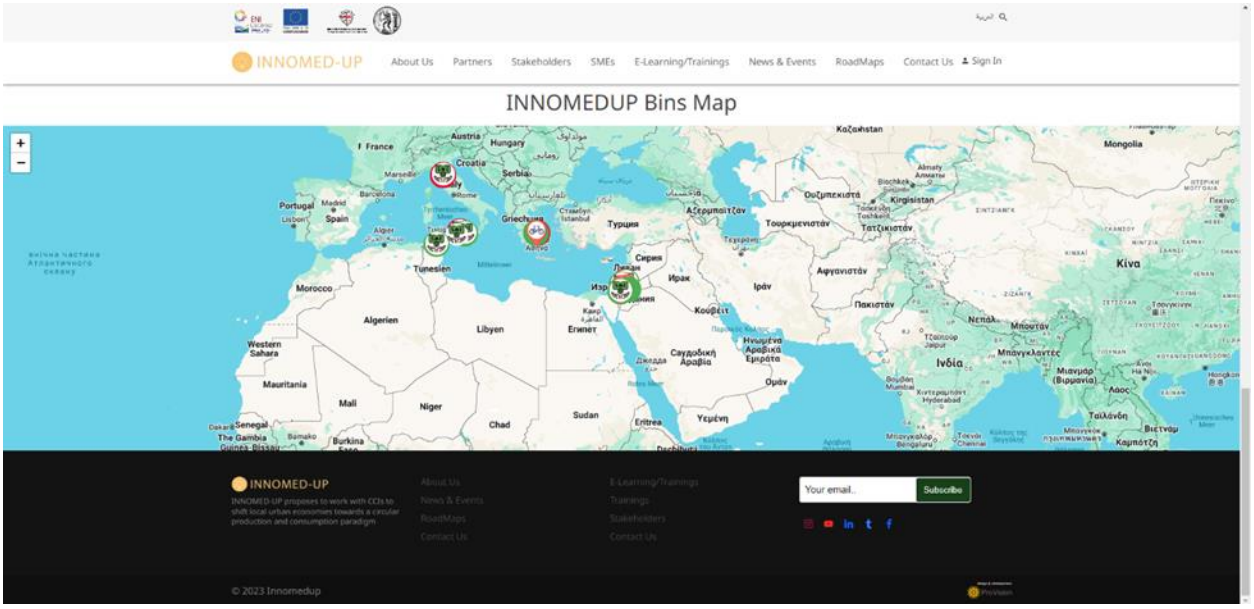
The intelligence of bin connectivity has long since been decided that it should be a smartphone application to incorporate as many advantages as possible of smart bin connectivity to the internet database. The application is available both on the iPhone and on the Android phones and allows each user to connect to the INNOMED-UP program platform to enter into synergy by collecting or accepting upcycling material, to be notified when there is enough material to pick it up and finally to receive the best route that will need to be followed to the location of receiving the materials of the Smart-bin. We are confident that the INNOMED-UP network will continue to grow, cultivating a Pan-European community of makers, inventors and entrepreneurs who push the boundaries of creativity and innovation.

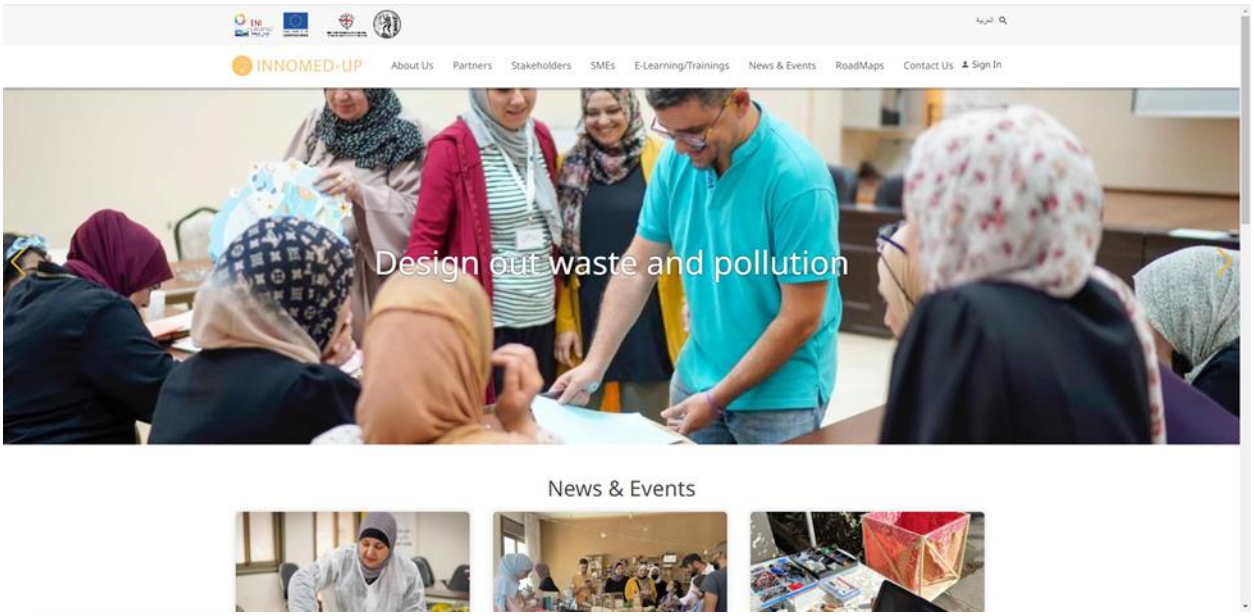






1.2.2 CIS – Platform





The Central Information System (CIS) is incorporated on the platform's functionality. The possibility of the Smart Bin's to send data and information regarding the weight and volume of the material hosted, appears on the administration panel, and on the Android/IOS application, so the partners and the Smart Bicycle riders are able to receive. Hence, on the platform https://innomed-up.birzeit.edu/ which is public, the SMEs, Smart Bins, and Smart Bicycles, corresponding to each City involved to the Partnership, are visible.

Birzeit University, along with NTUA, built the digital platform and the asynchronous e-learning platform where the project material, results, and involved target groups can be accessed. Also, tens of hours of asynchronous distance learning are available on the platform.

https://innomed-up.birzeit.edu/

The smart bins were allocated on the digital platform and the bicycle driver was provided with a username and a password for the application installed on his mobile to receive the alerts of the full bins and send reports.

The INNOMED-UP digital platform is an online collaborative place for CCI SMEs that communicate and network on Med-level exploring issues of circularity. At the same time, the INNOMED-UP platform serves as an asynchronous learning platform where the training material presented in WP6 will be uploaded and will be accessible not only to SMEs participating in the program but the whole CCIs community. Moreover, the platform will host a repository of open source designs as described in the O 4.3.

The INNOMED-UP Digital platform for CCI SMEs' training and networking has been prepared by PP05 BZU. The Platform is developed on Drupal CMS (Content Management System) and it is adequately functional while in phase of improvement and implementation: https://innomed-up.birzeit.edu/. The Platform provides the following functions: Public Website for the Project; Digital Portal (communication tools). This activity is behind schedule but it is currently under progress.

The Asynchronous e-learning platform has been prepared by PP05 BZU. The Platform is developed on Drupal CMS (Content Management System) and it is adequately functional while in phase of improvement and implementation: https://innomed-up.birzeit.edu/. The Asynchronous e-learning platform provides:

list of current, future, and historical trainings material, videos and gallery & E-Learning events are categorized and visible to users based on (Country, Type, or Spoken Language). BEN & PP6 (WP Coordinator) made a special effort to urge the partners to collect and upload the relative material.

1.2.3 Smart Bin

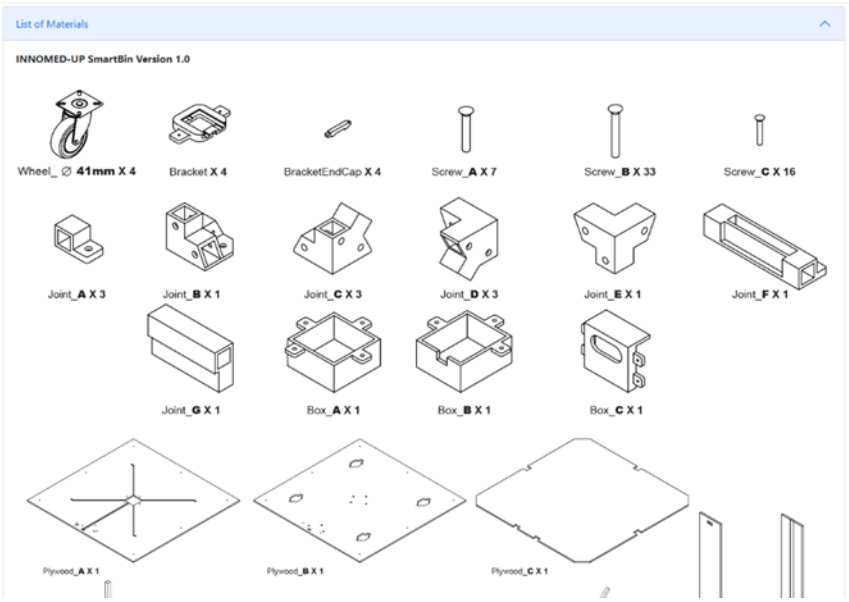
The design of the Smart-Bin is based on the adoption of the current DIY culture. The designed container is proposed of materials that a) are trivial to find in all areas of Southern Europe and the Mediterranean. (E.g., Wood Square Dowel Rods which exist in many variations of quality and are often recycled sections of larger wooden cross section.) b) no specialized manufacturing machinery is needed. As the accessibility of digital fabrication tools has improved, with 3D printers and other low-cost machines becoming more widely available, we focused on a design that could practically be built with very low-cost digital fabrication equipment. c) Integrated electronics can be purchased "off-the self" from many online stores, and careful hardware construction instructions and software installation instructions allow non-specialists to assemble the container.

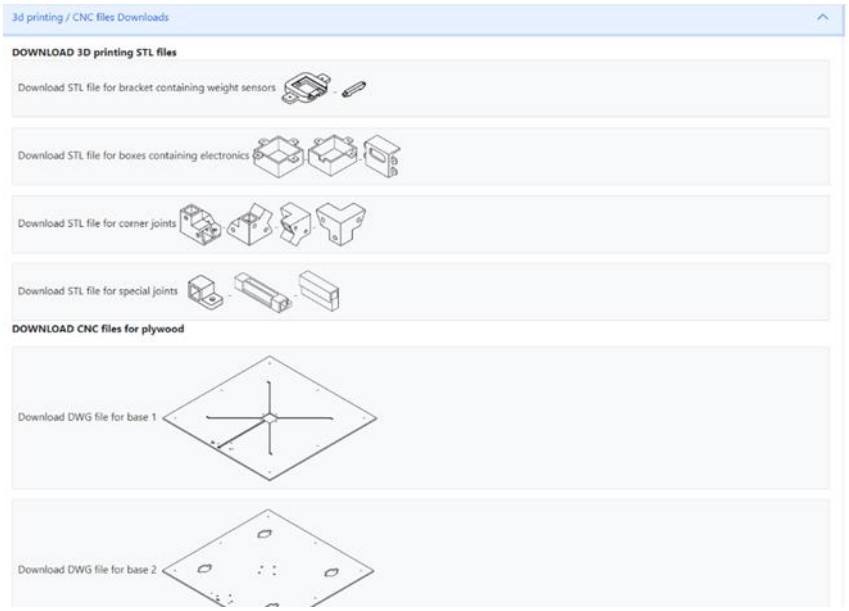
Referring to the Smart Bin, the design process is subject to the requirements of easy re-production by all partners. The production is made with easily obtained materials from the market (marine plywood, wooden beams and canvas) and with accessories printed on a standard 3d printer. Electronic components are also adapted around the standard ESP32 platform which is widely available worldwide at a very low price. The reproduction process of the Smart Tools is organized in such a way that any business can construct them at a very low cost.

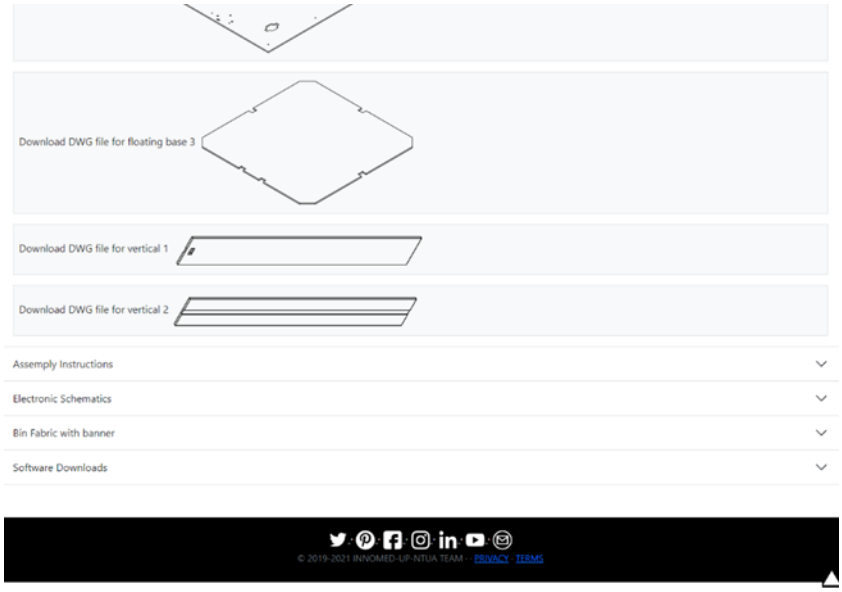
The container is assembled with 16 plastic parts printed on a 3D printer with common PLA filament, 16 square wooden rods cut with a simple saw, 5 plywood pieces and approx. 6 m2 of old upcycled fabric with which the material collection bag and the outer casing of the container are sewn. The openness of the process should be emphasized. The complete assembly process and the online point where one can obtain the cutting files and 3d printing files is on the Innomed-up platform. Both the design that delivers all the necessary files to be able to print or cut as well as detailed assembly instructions which can be found together with the downloads at the address: (http://innomed-up.eu/OSREP/).

1.2.4 Open Repository

The OPEN REPOSITORY is actually an online parallel platform where all the components for the Smart Tools construction are publicly available. On http://innomed-up.eu/OSREP/ are uploaded the needed files for the 16 plastic parts printed on a 3D printer with common PLA filament, 16 square wooden rods cut with a simple saw, 5 plywood pieces, and approx. 6 m2 of old upcycled fabric with which the material collection bag and the outer casing of the container are sewn. Moreover, the design prototypes for the Smart Bicycle, the Smart Bicycle App, and the design and listed components of the electronics to be installed on the Smart Bins, are available to download on the OPEN REPOSITORY. The openness of the process should be emphasized. The complete assembly process and the online point where one can obtain the cutting files and 3d printing files is on the Innomed-up platform. Both the design that delivers all the necessary files to be able to print or cut as well as detailed assembly instructions which can be found together with the downloads at the address: (http://innomed-up.eu/OSREP/).


List of Materials
INNOMED-UP SmartBin Version 1.0
Wheel_ ∅ 41mm X 4
Bracket X 4
BracketEndCap X 4
Screw_A X 7
Screw_B X 33
Screw_C X 16
Joint_A X 3
Joint_B X 1
Joint_C X 3
Joint_D X 3
Joint_E X 1
Joint_F X 1
Joint_G X 1
Box_A X 1
Box_B X 1
Box_C X 1
Plywood_A X 1
Plywood_B X 1
Plywood_C X 1


3d printing / CNC files Downloads
DOWNLOAD 3D printing STL files
Download STL file for bracket containing weight sensors
Download STL file for boxes containing electronics
Download STL file for corner joints
Download STL file for special joints
DOWNLOAD CNC files for plywood
Download DWG file for base 1
Download DWG file for base 2



1.2.5 Smart Tools - A: Bins, Bicycles, Applications

In order to sustainably establish the city clusters, the NTUA designed a series of smart tools that were piloted in the cities and are openly available for future use:

- A smart bin prototype
- A bicycle prototype
- A digital application that interconnects the parts of the cluster (available for smart phones)
- An open repository with designs and guidelines (http://innomed-up.eu/OSREP/)
- 10 bicycles, over 50 Smart Bins (Smart Tools)
- 1 platform, 1 open repository and 1 smart application
- https://innomed-up.birzeit.edu/

1.2.6 Smart Tools -B: Digital Platform and Asynchronous E-Learning for SMEs

Birzeit University, along with NTUA, built the digital platform and the asynchronous e-learning platform where the project material, results, and involved target groups can be accessed. Also, tens of hours of asynchronous distance learning are available on the platform.

https://innomed-up.birzeit.edu/

1.2.7 Links to Smart Tools articles

https://www.enicbcmed.eu/italy-innomed-installs-smart-bins-promote-circular-economy-city-prato

https://www.enicbcmed.eu/5th-innomed-newsletter-highlights-activities-concerning-circular-economy-and-cultural-creative

1.2.8 Links to Smart Tools Videos

https://www.enicbcmed.eu/discover-smart-bin-developed-innomed-project-boost-circular-economy-city-irbid-jordan

https://www.enicbcmed.eu/discover-smart-bin-developed-innomed-project-boost-circular-economy-city-hebron-palestine

https://www.enicbcmed.eu/innomed-project-reinforces-upcycling-through-smes-cultural-and-creative-sector-historic-center

https://www.enicbcmed.eu/innomed-circular-economy-open-market-held-municipality-tunis

1.3 SMART TOOLS IMPLEMENTATION

In this section, the current state of clustering smart tools implementation among partners is presented, Specifically, Table 2 contains the core elements regarding the proper installation and operation of smart tools and presents the implementation status per partner.

Table 2: Smart tools installation data per partner

Smart tools		BEN/PP01	PP02	PP03	PP04	PP05	PP06
Smart bin	Number of smart bins produced	10	10	10	10	10	10
	Correct loading of the program on the selected board (ESP)	√	√	√	√	√	√
	Construction of the Smart Bin with the 3d printed parts	√	√	√	√	√	√
	Installment of the electronics	√	√	√	√	√	√
	Registration of the Smart Bins on the digital platform	√	√	√	√	√	√
	Calibration and installation of the Smart Bin in the placement point	√	√	√	√	√	√
	Outcome - Information regarding the collected material	√	X	√	√	X	√
Smart Bicycle | Application	Reproduction of Smart Bicycle	√	X	X[1]	X[1]	X[1]	X[1]
	Number of Smart Bicycles	2	X	2	2	2	2

Smart tools		BEN/PP01	PP02	PP03	PP04	PP05	PP06
	Other proposed vehicle/mean of transportation	X	√[2]	X	√	X	X
	Download and usage of the Smart Bicycle Application	√	X[3]	√	√	√[3]	√

(1) The partner bought transportation vehicle (cargo trailer bike)

(2) Transportation of waste via a company specialized in textile waste collection

(3) Available but unclear if currently in use by the waste collection company (Prato) and drivers/SMEs (Birzeit)

1.4 SMART TOOLS PHOTOS FROM EACH PARTNER

NTUA (LB, Greece)

Figure 1: Smart bicycle in Athens' city center

Figure 2: Delivery and installation of smart bins by NTUA team

MUNICIPALITY OF PRATO (PP02, Prato, Italy)

Figure 3: Reproduction of smart bins by PP02

CRESM (PP03, Palermo, Italy)

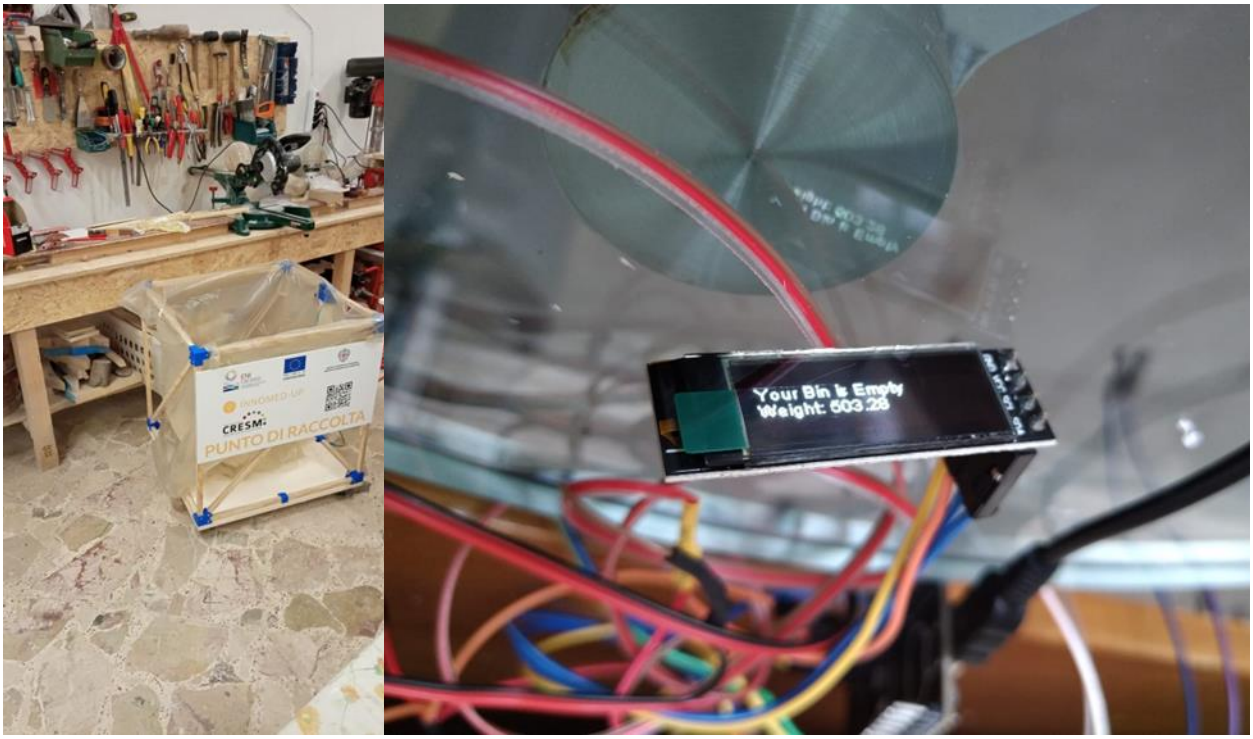


Figure 4: Smart bins and electronic parts by PP0

Birzeit University (PP05, Palestine)

Figure 5: Adjustments on bicycles by PP05

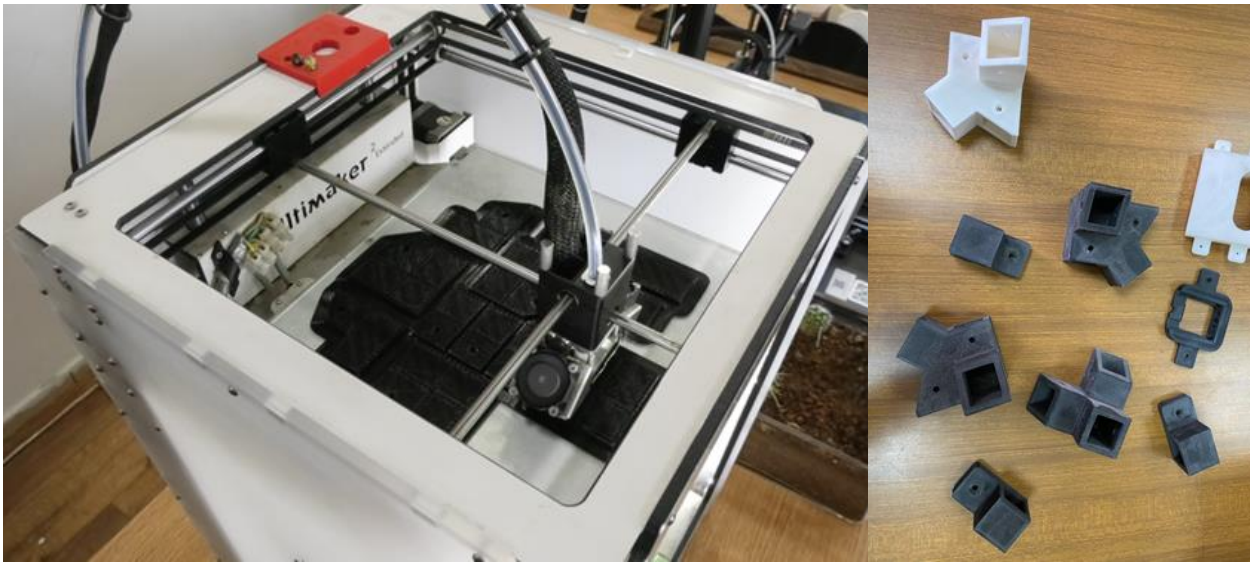


Figure 6: 3D Printing of smart bins' parts by PP05

Figure 7: Smart bins installation by PP05

FPEC (PP06, Jordan)

Figure 8: Smart bin and electronic parts by PP06

Figure 9: Cargo trailer bike and smartphone application by PP06