

# Testbed Catalogue

## AIOTI IG Testbeds

Release v1.1

30.11.2021

## Executive Summary

This report corresponds to the “Testbed Catalogue” under development within the IG Testbeds AIOTI group. The report comprises a set of testbed descriptions based on a specific format and has as aim to contribute to a coordinated view on testbeds derived from content provided by AIOTI partners; the use-cases being developed; the European competitiveness domains being addressed; global perspective on the interest of partners in terms of testbeds.

The main goal of the report is to act as a dissemination tool towards other AIOTI groups, and to assist in the development of coordinated efforts, e.g., use-case demonstrations, new testbed development.

## Table of Contents

List of Acronyms	8
Introduction	11
1.1 Testbed Description Meta-data	11
Use-cases	12
1.2 Climate Chain Coalition (CCC) Use-cases	12
1.2.1 Description	12
1.2.2 Key Concept and Technologies	12
1.2.3 Key Technological Components	13
1.3 Norgren Smart Pneumatic Valve Island Use-case	14
1.3.1 Description	14
1.3.2 Key Concept and Technologies	14
1.3.3 Key Technological components	14
1.4 SymboloTic IoT Flood Monitoring Use-case	16
1.4.1 Description	16
1.4.2 Key Concept and Technologies	16
1.4.3 Key Technological Components	16
1.5 SGS Cybersecurity Compliance Tool	18
1.5.1 Description	18
Proofs of Concept	19
1.6 Synelixix IoT Solutions	19
1.6.1 Description	19
1.6.2 Key Concept and Technologies	19
1.6.3 Key Technological Components	20
1.7 Verses DLT HSTP Spatial Web	21
1.7.1 Description	21
1.7.2 Key Concept and Technologies	21
1.7.3 Key Technological Components	21
1.8 DeWaardeFabriek DLT COMMSUSDEV	22
1.8.1 Description	22
1.8.2 Key Concept and Technologies	22
1.8.3 Key Technological Components	22
1.9 Blue Future Organization DAO	23
1.9.1 Description	23
1.9.2 Key Concept and Technologies	23
1.9.3 Key Technological Components	23
1.10 Links DLT Reclouthes	24

1.10.1	Description	24
1.10.2	Key Concept and Technologies	24
1.10.3	Key Technological Components	24
1.11	Links DLT Digital Handshake	26
1.11.1	Description	26
1.11.2	Key Concept and Technologies	26
1.11.3	Key Technological Components	26
1.12	Bovlabs DLT PoC	27
1.12.1	Description	27
1.12.2	Key Concept and Technologies	27
1.12.1	Key Technological Components	28
1.13	AIOTI DLT 2.xx Protocol performance	28
1.13.1	Description	28
1.13.2	Key Concept and Technologies	28
1.13.3	Key Technological Components	29
1.14	AIOTI DLT 3.xx Energy Efficiency	30
1.14.1	Description	30
1.14.2	Key Concept and Technologies	30
1.14.3	Key Technological Components	30
Testbeds		31
1.15	Aalto University Factory of the Future	31
1.15.1	Description	31
1.15.2	Key Concept and Technologies	31
1.15.3	Key Technological components	31
1.16	CERTH/HIT Thessaloniki Smart Mobility Living Lab	33
1.16.1	Description	33
1.16.2	Key Concept and Technologies	33
1.16.3	Key Technological components	33
1.17	Digital Catapult Future Networks Lab	34
1.17.1	Description	34
1.17.2	Key Concept and Technologies	34
1.17.3	Key Technological components	34
1.18	fortiss Lab Industrial IoT	35
1.18.1	Description	35
1.18.2	Key Concept and Technologies	35
1.18.3	Key Technological components	35
1.19	fortiss Lab Smart Energy	37
1.19.1	Description	37
1.19.2	Key Concept and Technologies	37
1.19.3	Key Technological components	37

1.20	Emergya FIWOO IoT Platform	39
1.20.1	Description	39
1.20.2	Key Concept and Technologies	39
1.20.3	Key Technological components	40
1.21	fortissimo Mobility Lab	41
1.21.1	Description	41
1.21.2	Key Concept and Technologies	41
1.21.3	Key Technological components	42
1.22	fortiss Neuromorphic Lab	43
1.22.1	Description	43
1.22.2	Key Concept and Technologies	43
1.22.3	Key Technological components	44
1.23	fortiss Lab Robotics	45
1.23.1	Description	45
1.23.2	Key Concept and Technologies	45
1.23.3	Key Technological components	46
1.24	Fraunhofer IIS L.I.N.K. - Positioning - Identification - Navigation Communication	46
1.24.1	1.1.1 Description	46
1.24.2	Key Concept and Technologies	46
1.24.3	Key Technological components	47
1.25	Huawei Edge Computing OPC UA over TSN Testbed	48
1.25.1	Description	48
1.25.2	Key Concept and Technologies	48
1.25.3	Key Technological components	48
1.26	ITI DATAROOM	49
1.26.1	Description	49
1.26.2	Key Concept and Technologies	49
1.26.3	Key Technological components	49
1.27	Oulu University 5G/6G Test Network	51
1.27.1	Description	51
1.27.2	Key Concept and Technologies	51
1.27.3	Key Technological components	52
1.28	Politecnico di Milano Industry 4.0 Lab	52
1.28.1	Description	52
1.28.2	Key Concept and Technologies	52
1.28.3	Key Technological components	53
1.29	PSNC Future Labs, Pioner-Lab, Agriculture testbed	54
1.29.1	Description	54
1.29.2	Key Concept and Technologies	54
1.29.3	Key Technological components	54

1.30	Proximus Video Analytics Testbed	55
1.30.1	Description	55
1.30.2	Key Concept and Technologies	55
1.30.3	Key Technological Components	55
1.31	Tekniker Smart Factory Hub	56
1.31.1	Description	56
1.31.2	Key Concept and Technologies	56
1.31.3	Key Technological components	56
1.32	Ubiwhere Nervous System Living Lab	57
1.32.1	Description	57
1.32.2	Key Concept and Technologies	57
1.32.3	Key Technological components	57
1.33	Universidad de Murcia Gaia-5G	58
1.33.1	Description	58
1.33.2	Key Concept and Technologies	58
1.33.3	Key Technological components	58
1.34	University of Murcia PP-IDM	59
1.34.1	Description	59
1.34.2	Key Concept and Technologies	59
1.34.3	Key Technological components	59
1.35	UPM Smart City spaces of the Future	60
1.35.1	Description	60
1.35.2	Key Concept and Technologies	60
1.35.3	Key Technological components	61
1.36	UPM Integration of IoT with Tactical Cloud	62
1.36.1	Description	62
1.36.2	Key Concept and Technologies	62
1.36.3	Key Technological components	62
1.37	UPM Smart Drones	63
1.37.1	Description	63
1.37.2	Key Concept and Technologies	63
1.37.3	Key Technological components	63
1.38	Video Systems APICUS-PLT	64
1.38.1	Description	64
1.38.2	Key Concept and Technologies	64
1.38.3	Key Technological components	64
1.39	Virtech SofiaLab	65
1.39.1	Description	65
1.39.2	Key Concept and Technologies	65
1.39.3	Key Technological components	65

1.40	VizLore DLT Labs	66
1.40.1	Description	66
1.40.2	Key Concept and Technologies	66
1.40.3	Key Technological components	67
1.41	Solar Lab RES Cluster	67
1.41.1	Description	67
1.41.2	Key Concept and Technologies	67
1.41.3	Key Technological components	68
1.42	AIRQ DAO	69
1.42.1	Description	69
1.42.2	Key Concept and Technologies	69
1.42.3	Key Technological components	69
	Testbeds Analysis	70
	Summary	72
	Editors and Contributors	73
	About AIOTI	74

## List of Acronyms

Acronym	Meaning
5G	5 <sup>th</sup> Generation of Cellular Systems
6G	6 <sup>th</sup> Generation of Cellular Systems
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
AP	Access Point
AR	Augmented Reality
AV	Artificial Vision
BLE	Bluetooth Low Energy
DLT	Distributed Ledger Technologies
EPC	Evolved Packet Core
HTC	High Technology Computer
ICT	Information and Communications Technology
IoT	Internet of Things
IT	Information Technology
ITS	Intelligent Transportation Systems
LTE	Long Term Evolution
MEC	Multi-access Edge Computing
NB-IoT	Narrow Band IoT technology
NFV	Network Functions Virtualization
NR	New Radio
NSA	Non-standalone
OT	Operational Technology
PoC	Proof-of-Concept
RAN	Radio Access Network

RRH	Remote Radio Head
TDD	Time Division Duplex
TSN	Time Sensitive Networking
UAV	Unmanned Aerial Vehicle
VR	Virtual Reality
Wi-Fi	Wireless Fidelity
ZDM	Zero Defects Manufacturing

## List of Figures

Figure 1: Synelixis SynField Product line .....	19
Figure 2: Domains addressed by the testbeds. ....	70
Figure 3: Word cloud formed with the use-cases proposed in the testbeds. ....	71

## List of Tables

Table 1- Testbed introductory table. ....	11
---	----

## Introduction

This report describes a series of testbeds that have been collected from the AIOTI members that subscribe to the AIOTI IG Testbed. The aim of the report is to assist as a dissemination vehicle of the existing testbeds to the AIOTI community and beyond.

In addition to the description of testbeds, the report provides additional information concerning the testbeds, e.g., use-cases envisioned to be supported by the testbeds; European competitiveness domains addressed; type of Licenses, whether the testbeds are open to partner access or not.

The report is organized as follows. In this section, the description meta-data is described next. Sections 2, 3, 4 describe the different testbeds organized per maturity level. Section 5 covers an analysis in terms of European competitiveness domain, use-case, technologies available, and licensing. Section 6 concludes the document.

### 1.1 Testbed Description Meta-data

Each testbed is described in a specific sub-section, where the title provides the partner acronym and the testbed title. An introductory table represented in Table 1 provides relevant information, such as contacts, to assist in the interaction with the responsible partner. The testbeds have been grouped based on the IG Testbeds Methodology document. Then, within each category, the presentation of the testbeds is organized per alphabetical order, based on the name of the testbed.

Table 1- Testbed introductory table.

[Institution's Logo]	[Partner Name]	[City, Country]
Testbed URL		
Domains:	[European competitiveness Domain(s), Agriculture, Energy, Transport, Manufacturing, Space, Society, Health]	
Use-cases	[specific use-cases proposed by partner]	
Contact	[Contact name and E-mail]	
License:	[Type of licensing, e.g., MIT, Eclipse, proprietary; if there are patents please state so]	
Partner access:	[Access to partners: local, remote, based on a specific agreement, etc.]	
Testbed stage	[Use-case; Proof-of-concept; Deployed testbed]	

The following fields are then provided to describe the testbed:

- Testbed summary: overview on the aims, activities, and functional parts of the testbed. Includes the key technologies applied; benefits; use-cases relevant to IoT and Edge computing.
- Key Aspects Demonstrated: describe the key technological blocks addressed by the proposal for concept and technologies.
- Key Technological Components: describe the novel technological components; hardware and software.

## Use-cases

### 1.2 Climate Chain Coalition (CCC) Use-cases

	Climate Chain Coalition (CCC)	Ottawa, Canada
Testbed URL	www.climatechaincoalition.io	
Domains:	Cross-domain, climate action	
Use-cases	Energy, Agriculture, Land use, Industry, Finance, Building, Transportation	
Contact:	climatechaincoalition@gmail.com	
License:	n.a.	
Partner access:	local and remote, based on a specific agreement	

#### 1.2.1 Description

The CCC Testbed series are set to demonstrate practical use cases from the Climate Chain Coalition, a global multi-stakeholder membership of over 270 organizations in over 50 countries (“CCC Members”). CCC Members use a variety of DLTs (ex: Ethereum, Hyperledger, Algorand, Chia, Tezos, Stellar, IOTA, Bitcoin) in combination with other digital technologies. The DLT-enabled digital solutions are deployed for a variety of use case applications (ex: carbon markets with tokenization and transactions, emissions accounting and MRV, supply chains and product carbon footprints, adaptation to climate impacts, innovative climate finance). Demonstrations and reports with insights into the technical layers allow observers to properly understand how DLT is applied in combination with the IoT and IT stack.

#### 1.2.2 Key Concept and Technologies


Concept	The AIOTI DLT 1.06 CCC Testbeds are CCC Member-driven ‘Use case demonstrators. Each case in the 1.06 Testbed series is dedicated to one CCC Member use case. Approximately 10% of the CCC membership is
---------	---

	anticipated to be involved with a demonstration. Each participating CCC Member will demonstrate its own use case(s), and some CCC Members are anticipated to be involved in a second phase to collaborate to demonstrate interoperability of digital solutions across the “carbon value chain” and to support a global ‘single market’.
Technologies	Convergence of IoT, DLT, AI, Digital Twins, and legacy IT components

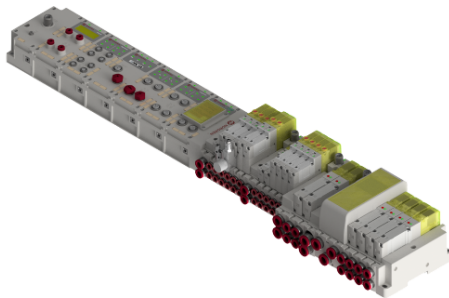
### 1.2.3 Key Technological Components

Hardware	On-Premises, Edge and Cloud combined
Software	Legacy IT and IoT platforms combined with different DLT protocols.

## 1.3 Norgren Smart Pneumatic Valve Island Use-case

	Norgren (IMI Precision Engineering)	Birmingham, UK
Testbed URL	N/A	
Domains:	Manufacturing	
Use-cases	Any OEM machine	
Contact:	chris.patient@imi-precision.com	
	francesca.dematteis@imi-precision.com	
License:	IP protected, patent pending	
Partner access:	Yes, locally, and remotely upon completion	

### 1.3.1 Description



Use-case under development: pneumatic smart valve island with integrated sensing capabilities, edge data processing; local (on-local-display and/or PLC) and/or remote data visualization, including on the cloud. Currently, product in prototype phase; physical demo rig available. Patent pending.

Helping customers keep operational costs low by monitoring the whole pneumatic system (up-and-down-stream); helps avoiding downtime, identifying, predicting faults and provide advice on how to fix them; predicting components end-of-life and help users replacing faulty products fast; also helps keeping costs low by monitoring compressed air consumption, identifying, and stopping leakages.

Ideal product for any OEM, particularly on machines where pneumatics is critical. Suit any sector and any application. Modular and flexible solution to suit virtually any specific customer need, thanks to a 'pick-and-choose' style menu of features and intelligent capabilities.

### 1.3.2 Key Concept and Technologies


Concept	Use case for smart pneumatics, starting from the very heart of a pneumatics system, thus the valve island. Test & learn about AI, machine learning, 5G, wireless technology, APIs
Technologies	5G, AI, wireless technology

### 1.3.3 Key Technological components

Hardware	Pneumatic valve island with integrated sensors, measuring pneumatics KPIs, (e.g., pressure, flow), predicting life cycle, monitoring air consumption,
----------	---

	monitoring components up-/down-stream, faults identification; IIoT gateway (OPC-UA and MQTT communication).
Software	Software solutions (e.g., dashboards, algorithms, smartphone app) to provide actionable insights and pneumatics utilization best advice.

## 1.4 SymbloTic IoT Flood Monitoring Use-case

	SymbloTic	Bjelovar, Croatia
Testbed URL	https://symbiotic.hr	
Domains:	Agriculture, Smart Cities	
Use-cases	Flood detection and monitoring	
Contact:	<a href="mailto:davor.predavec@symbiotic.hr">davor.predavec@symbiotic.hr</a>	
License:	Yes	
Partner access:	Yes	

### 1.4.1 Description

The AIOTI DLT 1.08 SymbloTic Flood detection and monitoring Testbed is set to demonstrate how IoT devices can improve the flood detection on the ground, notifying relevant staff over various channels, giving them possibility to see the data in an instant (public IoT data) and inform citizens where they can find other relevant information.

### 1.4.2 Key Concept and Technologies

Concept	Use-case: testing IoT devices in the flood test tank and later in the river to define the accuracy and improve it by combining 2 or 3 sensors mutually. Integrating with the existing Disaster Management platform is key, so we'd like to find the partners that are looking to integrate the IoT data into their environment, hence reducing the costs of staff, training, and time, while improving the disaster management processes.
Technologies	Notifications: by many various channels (SMS, email, WhatsApp, Signal, Telegram, Messenger, MS Teams, etc.) we can send a relevant information to whomever interested (there can be a good link with e-wallets/blockchain) Data analytics: within IoT platform (event-based thresholds, charts, visualization) / Power BI data analytics / Sending data to other servers and/or platforms by our API or HTTP requests.

### 1.4.3 Key Technological Components

Hardware	Hardware: an autonomous IoT device (batteries, PCB) equipped with different sensors (contact and contactless with water).
----------	---

Software	Software: in-house developed software within IoT devices. IoT Platform that aggregates the data and make visualization very quickly.
----------	--

## 1.5 SGS Cybersecurity Compliance Tool

Contact:	Jacques Kruse Brandao, jacques.kruse-brandao@sgs.com
License:	
Partner access:	Yes

### 1.5.1 Description

Report on the implementation experience with regards to composite certification with the intension to demonstrate compliance to legislation like RED through the implementation of requirements related to standards like EN 303645/ TS103701, upcoming EN 17640 for fixed-time evaluation as well as to existing and upcoming certification schemes from the CSA.

## Proofs of Concept

### 1.6 Synelixis IoT Solutions

<b>SYNELIXIS</b>	Synelixis Solutions S.A. (SYN)	Europe, Greece
Testbed URL	<a href="https://www.synelixis.com/internet-of-things/">https://www.synelixis.com/internet-of-things/</a>	
Domains:	Manufacturing, Agriculture,	
Use-cases	Precision agriculture	
Contact:	Theodore Zahariadis, <a href="mailto:zahariad@synelixis.com">zahariad@synelixis.com</a> , Konstantina Fotiadou, <a href="mailto:fotiadou@synelixis.com">fotiadou@synelixis.com</a>	
License:	n.a.	
Partner access:	Yes	

#### 1.6.1 Description

SynField, is a Cloud based smart precision agriculture and smart/remote irrigation platform, aggregating weather, leaf and soil information in vineyards, orange, olives, coffee, and tea fields. Currently small networks of SynField are installed in more than 150 vineyards and 30 olive trees in Greece, Italy, Spain, Germany, Denmark, and Finland and in 10 coffee and tea plantations in south India. In details, SynField system targets small-medium sized farms, while it offers the following three main services:



Figure 1: Synelixis SynField Product line

SynAir is a versatile sensor platform that accommodates a multitude of Air Quality sensors. The SynAir device, cannot operate by itself, and thus it should be connected to a SynField device, to read and forward the sensors' data to the SynField portal. Currently, three basic SynAir versions are available, i.e., SynAir CO2, SynAir City, SynAir City+, supporting the detection of the following features: temperature, relative humidity, CO2, Particulate Matter, VOC, NO2, CO, among others.

#### 1.6.2 Key Concept and Technologies

Concept	Precision Agriculture & Sustainability, Supply Chain Intelligence, Cybersecurity & Risk Management, IoT & Connected Intelligence, Edge & Cloud Computing, Blockchain, Artificial Intelligence & Machine Learning, SynField Platform Development
Technologies	<a href="https://www.synelixis.com/internet-of-things/">https://www.synelixis.com/internet-of-things/</a>

## 1.6.3 Key Technological Components

Hardware	SynField, SynAir, SynOdos, SynRealy <a href="https://www.synelixis.com/">https://www.synelixis.com/</a>
Software	SynField

## 1.7 Verses DLT HSTP Spatial Web

	VERSES	Eindhoven, Netherlands
Testbed URL	<a href="https://www.ff2020.eu/">https://www.ff2020.eu/</a>	
Domains:	Transversal	
Use-cases	Convergence of IoT, DLT and AI	
Contact:	info@verses.io	
License:	Open source	
Partner access:	yes	

### 1.7.1 Description

The VERSES Testbed is set to demonstrate the Hyper Spatial Modelling Language (HSML) and Hyperspace Transaction Protocol (HSTP) using COSM (Spatial Operating system) that enables interoperable, semantically compatible connections between connected software and hardware and includes specifications for: 1) a spatial range query format and response language for requesting data about objects within a dimensional range (spatial, temperature, pressure, motion) and their content; 2) a semantic data ontology schema for describing objects, relations, and actions in a standardized way; 3) a verifiable credentialing and certification method for permissioned create, retrieve, update, and delete (CRUD) access to devices, locations, users, and data; and 4) a human and machine-readable contracting language that enables the expression and automated execution of legal, financial and physical activities.

### 1.7.2 Key Concept and Technologies

Concept	Standard for Spatial Web Protocol, Architecture and Governance
Technologies	COSM (Context-aware Spatial Operating System) Hyper Spatial Modelling Language (HSML), Hyperspace Transaction Protocol (HSTP)

### 1.7.3 Key Technological Components

Hardware	Autonomous drones, sensors, smart devices, and robots
Software	Various software (services, platforms, applications, artificial intelligence systems)

## 1.8 DeWaardeFabriek DLT COMMSUSDEV

 <b>The Value Factory</b> Shaping a Sustainable Future	DeWaardeFabriek	Tilburg, Netherlands
Testbed URL	N/A	
Domains:	Smart cities, climate action, community building	
Use-cases	Community sustainability development, supported by IoT solutions (CommSusDev)	
Contact:	erik@dewaardefabriek.nl	
License:	-	
Partner access:	yes	

### 1.8.1 Description

The DLT 1.04 COMMSUSDEV Testbed is set to demonstrate the value, reliability, and scalability of converging IoT and DLT solutions in real-life community sustainability development. The solutions sought after should meet criteria as: scalable, open source, GDPR-proof and to be defined. Use-cases range from large-scale home retrofit to low-energy, high comfort and health homes, comfort and health performance tracking and control, smart contract execution of comfort and health performance, green infrastructure performance tracking incl. smart contracting, social interaction support smart support solutions to increase resident-based micro-exchange of products and services.

### 1.8.2 Key Concept and Technologies

Concept	<p>“Large-scale homes retrofit funding”: Includes tokenization of real estate, comfort and health monitoring and related smart contracting.</p> <p>“Increase social cohesion through increased social participatory exchange”: Neighbors are encouraged to share their needs and/or offers (products, services etc.) to help each other out, engage low-income people to participate through ‘earning value’ for the service they offer (valorized / non-valorized). Several aims: increase social interaction through helping, increase resource use (=reducing consumption) through lending/sharing.</p>
Technologies	Converged IoT and DLT, tokenization, micropayments, smart contracting

### 1.8.3 Key Technological Components

Hardware	Solar cell, heat pump, ventilation system, air quality sensor, health sensor, cloud storage, virtualization
Software	To be defined

## 1.9 Blue Future Organization DAO

 TheBlueFuture   ALGAES	Blue future Organization SL	Canary Islands, Spain
Testbed URL	www.thebluefuture.org	
Domains:	Farming	
Use-cases	Farm-to-Fork, Farm-to-Finance, Climate action	
Contact:	kunfud@gmail.com	
License:		
Partner access:	yes	

### 1.9.1 Description

The BFO DAO testbed is set to demonstrate how Distributed Ledger Technologies enables “Farm-to-Fork” in aquaculture as a foundation to enable financial instruments and investments for acceleration into the blue economy. BFO is set to provide insights into the technical layers allowing observers to properly understand how the DLT is applied into the IT stack. BFO also demonstrates the autonomous reporting mechanism with XBRL as facilitator for financial and non-financial information.


### 1.9.2 Key Concept and Technologies

Concept	BFO is a climate impact driver accelerating Macro and Micro Algae farming. Its ecosystem demonstrates a sustainable market mechanism for the Blue Economy. Secured by DLT and enabled by rapid digital transformation, aquafarms provide trusted information, take advantage of emerging technologies, and get easy access to growth finance.
Technologies	Combined IoT, DLT and XBRL financial & non-financial reporting

### 1.9.3 Key Technological Components

Hardware	On-Premises, Edge and Cloud combined
Software	Multiple DLT protocols and XBRL financial & non-financial reporting

## 1.10 Links DLT Reclothes

	LINKS FOUNDATION	Torino, Italy
Testbed URL	<a href="https://medium.com/overtheblock/reclothes-a-decentralized-solution-for-second-hand-clothes-recycles-in-the-fashion-industry-ca2061080e3c">https://medium.com/overtheblock/reclothes-a-decentralized-solution-for-second-hand-clothes-recycles-in-the-fashion-industry-ca2061080e3c</a>	
Domains:	Society	
Use-cases	A Decentralized Solution for Second-hand Clothes Recycles in the Fashion Industry	
Contact:	<a href="mailto:Alfredo.favenza@linksfoundation.com">Alfredo.favenza@linksfoundation.com</a> , <a href="mailto:Giacomo.corrias@linksfoundation.com">Giacomo.corrias@linksfoundation.com</a>	
License:	No	
Partner access:	Yes	

### 1.10.1 Description

RECLOSED is a DLT testbed is set to demonstrate a blockchain-based solution (built on top of Hyperledger Besu) favoring the second-hand clothes recycles in the fashion industry. Reclothes allows a company operating in the fashion sector to implement a decentralized, transparent, and secure mechanism to record information relating to business relationships among partners and people interested in selling their second-hand clothes and/or buying second-hand upcycled clothes. To promote cooperation in the circular economy process, the solution implements a “double incentive” mechanism by adopting two different fungible token implementations. Leveraging private transaction processing tools, the consortium partners can define their commercial agreements and carry out transactions in confidence, without releasing any information unauthorized third parties.

### 1.10.2 Key Concept and Technologies

Concept	A decentralized solution for second-hand clothes recycles in the fashion industry. Designed as an enterprise blockchain-based network on <a href="#">Hyperledger Besu</a> ; allows confidential transactions visible only among business partners while keeping a transparent public history of quantities, processes, events, and payments; encourages individuals' participation in the circular economy through a double-incentive using two <a href="#">ERC20</a> token implementations, automating payments and rewarding mechanisms; provides a public interface for people who wants to support the eco-friendly fashion industry by sending second-hand clothes and/or buying upcycled clothes.
Technologies	Smart Contracts, Tokenization

### 1.10.3 Key Technological Components

Hardware	-
----------	---


Software

Open Repositories:

<https://github.com/Innovation-Advisory-Links-Foundation/ReClothes-Backend>

<https://github.com/Innovation-Advisory-Links-Foundation/ReClothes-Frontend>

## 1.11 Links DLT Digital Handshake

	LINKS Foundation	Torino, Italy
Testbed URL	<a href="https://medium.com/overtheblock/fighting-uncertainty-a-decentralized-solution-for-transparent-and-frictionless-digital-handshakes-553de1dfc852">https://medium.com/overtheblock/fighting-uncertainty-a-decentralized-solution-for-transparent-and-frictionless-digital-handshakes-553de1dfc852</a>	
Domains:	Society	
Use-cases	A Decentralized Solution for Transparent and Frictionless Digital Handshakes	
Contact:	<a href="mailto:Alfredo.favenza@linksfoundation.com">Alfredo.favenza@linksfoundation.com</a> <a href="mailto:Giacomo.corrias@linksfoundation.com">Giacomo.corrias@linksfoundation.com</a>	
License:	No	
Partner access:	Yes	

### 1.11.1 Description

The AIOTI DLT 1.10 LINKS DIGITAL HANDSHAKE Testbed is set to demonstrate a blockchain platform aiming at helping gig economy workers to conduct business transactions with untrusted parties by leveraging smart contracts and dispute resolution mechanisms. The solution exploits the intrinsic benefits of DLTs to guarantee a verifiable process with automated payment and fair dispute resolution. The dispute resolution mechanism leverages a custom token and a decentralized escrow service to guarantee a fair and fast completion of the business transaction. The prototype is built on top of the EOSIO blockchain platform.

### 1.11.2 Key Concept and Technologies


Concept	<p>A blockchain-based solution for making digital handshakes guaranteeing transparency on identity, code, and payments.</p> <ul style="list-style-type: none"> <li>• Building a new form of trust in the digital handshake process (from platform to code) through an EOSIO blockchain-based solution.</li> <li>• Fair and decentralized dispute resolution with a pseudo-random selection of jurors for reducing the cost-benefit ratio.</li> <li>• Automatic token payments through a decentralized and bulletproof escrow service.</li> </ul>
Technologies	Smart contracts, tokenization, DLT-based dispute resolution

### 1.11.3 Key Technological Components

Hardware	-
Software	Open Repositories:

<a href="https://github.com/Innovation-Advisory-Links-Foundation/DigitalHandshake-Backend">https://github.com/Innovation-Advisory-Links-Foundation/DigitalHandshake-Backend</a> <a href="https://github.com/Innovation-Advisory-Links-Foundation/DigitalHandshake-Frontend">https://github.com/Innovation-Advisory-Links-Foundation/DigitalHandshake-Frontend</a>
--

## 1.12 Bovlabs DLT PoC

	Bovlabs SAS	Aix En Provence, France
Testbed URL	<a href="https://www.environnement-magazine.fr/cleantech/article/2021/09/13/136062/aixmarseilleprovence-ambitionne-etre-territoire-choix-pour-les-innovations-durables">https://www.environnement-magazine.fr/cleantech/article/2021/09/13/136062/aixmarseilleprovence-ambitionne-etre-territoire-choix-pour-les-innovations-durables</a> , <a href="http://www.bovlabs.com">www.bovlabs.com</a>	
Domains:	Energy, Mobility	
Use-cases	<a href="#">Solarcamp project</a>	
Contact:	JK: +82 1068276562, +33 767527808, Fabien: +33 675137770	
License:	Specific contract with the Camp/SNCF G&C	
Partner access:	Public project with simulations	

### 1.12.1 Description

The Bovlabs PoC is set to demonstrate Ethereum Blockchain. Proof of Authority Based Consensus; 3 million transactions recorded in the first project; 450 transactions per second are supported; Smart agents uses light nodes to transact energy transactions; Smart contracts used for trade and execution (written using Solidity); ERC 20 Tokens used for transacting energy peer to peer.

### 1.12.2 Key Concept and Technologies


Concept	<p>Bovlabs provides a platform to manage and control EV chargers. Our goal is to maximize utility for operators and EV owners. In doing so, charging cycles are optimized based on energy price, demand chargers, demand response programmers, along with driver inputs (for example, parking duration). Bovlabs developed an innovative system for SNCF G&amp;C responsible for the management of EV charging stations at passenger train stations. This was done in collaboration with our partners - Nissan, Accenture, the Camp and VINCI Energies - specifically including V2G capabilities. The results were significant - bring more cost effective and optimized - giving rise to greener and more attractive EV charging services.</p>
---------	---

Technologies	Ethereum Blockchain; Proof of Authority Based Consensus; Microservices Architecture; Using Spring Boot and Spring Cloud; Java, Python, Nodejs; MySQL; REST; ML; OCPP 1.6; Web apps.
--------------	---

### 1.12.1 Key Technological Components

Hardware	Bovlabs Smart Agent - Our smart agents integrate with any DERs (like solar, battery storage, EVSE) to record secure P2P energy transactions within the blockchain node embedded within the agent. This creates a distributed, decentralized dataset and with distributed intelligence at edges (ML) creates Virtual Power Plants.
Software	Our solution helps to build a sustainable EV charging station by reducing its OPEX by 20-30%. We integrate with EV charging stations and optimize cost through smart charging and P2P energy trading. Our algorithm uses Peak/Off peak Demand, Energy Prices, Parking utilizations, Renewable energy integration, Grid events (TSO/DSO) and creates a unique charging profile.

## 1.13 AIOTI DLT 2.xx Protocol performance

 Alliance for Internet of Things Innovation	AIOTI WG DLT	Belgium
Testbed URL	www.aioti.eu	
Domains:	Cross-domain	
Use-cases	Industrial implementations	
Contact:	tom@viniblock.com	
Partner access:	yes	

### 1.13.1 Description

Distributed Ledger Technologies (DLT) has emerged with the promise to establish trust and enable new business models on autonomous systems. The exact implementation and performance of the many available DLT protocols still remains to be formally assessed. Therefore, the AIOTI DLT working group agreed to set-up a series of DLT 2.xx Testbeds for the systematic and objective evaluation of different protocols currently considered market ready.

### 1.13.2 Key Concept and Technologies


Concept	The DLT 2.xx test campaigns are executed following International Software Qualification Testing Board (ISTQB) standards and include a state of the art benchmark methodology that includes assessing the protocols both on business impact metrics (transactions-per-second, up-time, scalability) and DLT specific metrics. The integrity of the
---------	---

	<p>assessments is furthermore ensured by the timeline of installations being supported by the protocol suppliers and tests being executed by objective AIOTI DLT members in the presence of protocol representatives and objective observers.</p> <p>The outcome of the different test campaigns comes in the form of a factual report including the different DLT protocols and performance comparisons.</p>
Technologies	Hyperledger, Ethereum, IOTA, Ripple and Cardano

### 1.13.3 Key Technological Components

Hardware	On-Premise, Low-power devices, Edge & Cloud
Software	DLT Toolbox combined with open source Software Testing tools.

## 1.14 AIOTI DLT 3.xx Energy Efficiency

 Alliance for Internet of Things Innovation	AIOTI WG DLT	Belgium
Testbed URL	www.aioti.eu	
Domains:	Cross-domain	
Use-cases	Industrial implementations	
Contact:	tom@viniblock.com	
Licence:		
Partner access:	yes	

### 1.14.1 Description

Despite tremendous improvements, Distributed Ledger Technologies (DLT) continues to suffer a poor reputation when it comes to energy efficiency. This is mainly caused by the measurements taken around the Proof-of-Work consensus mechanism in the first landed protocols.

Therefore, the AIOTI DLT working group agreed to set-up a series of DLT 2.xx Testbeds for the systematic evaluation of the footprint and energy efficiency of different protocols currently considered market ready.

### 1.14.2 Key Concept and Technologies


Concept	The DLT 2.xx test campaigns are executed following the International Software Qualification Testing Board (ISTQB) standards and include a state of the art benchmark methodology to assess the protocols footprint and energy-efficiency. The integrity of the assessments is furthermore ensured by both the installations and tests being executed by objective AIOTI DLT members in the presence of protocol representatives as well as objective observers. This procedure warrants that all protocols will be tested under similar system resource conditions. The outcome of the different test campaigns will result in the form of a factual XBRL report per protocol, in addition to a comprehensive comparison between the different DLT protocols.
Technologies	Hyperledger, Ethereum, IOTA, Ripple and Cardano

### 1.14.3 Key Technological Components

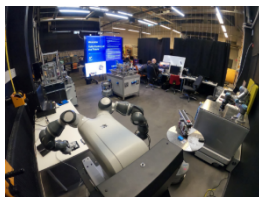
Hardware	On-Premise, Low-power devices, Edge & Cloud
Software	DLT Toolbox combined with open source Software Testing tools and XBRL.

## Testbeds

### 1.15 Aalto University Factory of the Future

	Aalto University	Finland
Testbed URL	<a href="https://www.aalto.fi/en/futurefactory">https://www.aalto.fi/en/futurefactory</a>	
Domains:	Manufacturing, Energy, Agriculture, Mobility, Logistics	
Use-cases	Smart manufacturing, energy, and agriculture domain use cases: Predictive maintenance, human robot interaction, collaborative robots, flexible production, Low electric vehicles.	
Contacts:	Dr Udayanto Dwi Atmojo, <a href="mailto:udayanto.atmojo@aalto.fi">udayanto.atmojo@aalto.fi</a> Prof. Valeriy Vyatkin, <a href="mailto:valeriy.vyatkin@aalto.fi">valeriy.vyatkin@aalto.fi</a>	
License:	We commit to open science, open research software: <a href="https://version.aalto.fi/gitlab/afof">https://version.aalto.fi/gitlab/afof</a>	
Partner access:	Yes	

#### 1.15.1 Description



The Aalto Factory of the Future<sup>1</sup> is a facility for innovation and education of future industrial automation, industry 4.0 and beyond. It is a space shared by humans, robots, and production stations, which serves as a platform for projects in advanced information technologies applied to future production systems. It focuses on achieving revolutionary high flexibility by exploiting the architecture of modular autonomous intelligent production units. We have access to enabling technologies for production systems that include AI, IIoT, wireless (5G, Wi-Fi 6, LoraWAN) connected to Aalto 5G Test Network, edge/fog/cloud computing paradigms, VR/AR.

#### 1.15.2 Key Concept and Technologies

Concept	Distributed automation system in hyper flexible production system based on modular production units
Technologies	IT/OT integration ranging from IEC 61131-3, IEC 61499, OPC UA, 5G, WiFi6, TSN, LoRA, Digital twin, Edge / Cloud computing, smart wearables, mobile AGVs, HPC, 5G, Wi-Fi 6, LoraWAN, Edge computing.



#### 1.15.3 Key Technological components

Hardware	Festo Didactic (Festo CP Lab, Festo Modular Production System), AGVs with industrial robots mounted (Mobile Industrial Robot MIR100, UR3, ABB Yumi, Festo Robotino, Milvus Robotics SEIT100), HTC Vive VR, Artec 3D
----------	---

<sup>1</sup> <https://www.youtube.com/channel/UCkWiZDPsajleYHWgUsjYEag>

	Scanner, vertical farming demonstrator, Schneider Electric PLC, Raspberry Pi RevPi Kunbus, Nokia AirScale
Software	IEC 61499 (Schneider Electric Ecostruxure, Eclipse 4DIAC), IEC 61131-3 (CodeSys), OPC UA (open62541, ProSys OPC UA), FactoryIO, Visual Components, Microsoft Azure Cloud.

## 1.16 CERTH/HIT Thessaloniki Smart Mobility Living Lab

  <p><b>CERTH</b> CENTRE FOR RESEARCH &amp; TECHNOLOGY HELLAS</p> <p><b>CERTH/HIT</b> Hellenic Institute of Transport</p>	CERTH/HIT	Greece
Testbed URL	<a href="https://www.smartmlab.imet.gr/">https://www.smartmlab.imet.gr/</a>	
Domains:	Smart Cities, Mobility	
Use-cases	Real time traffic data in Thessaloniki (cars and trains); fleet management, etc.	
Contact:	<a href="mailto:jose@certh.gr">jose@certh.gr</a>	
License:	Microsoft 365, PowerBI, Visual Studio 2019 Enterprise, SQL Server 2017 Enterprise, Hyper-V Manager, Android Studio, Visum, SUMO, MATLAB and others depending on the activities	
Partner access:	Yes	

### 1.16.1 Description

Thessaloniki Smart Mobility Living Lab aggregates data from its local eco system in Thessaloniki via different types of sources. Through the fusion of the various datasets, new technologies, mobility services and prototype applications for passengers and vehicles are implemented.

### 1.16.2 Key Concept and Technologies

Concept	Data collection and fusion, Data storage and processing, Data Analysis, models, and visualization/simulation. Mobility services and prototype applications for passengers and freight vehicles
Technologies	Transport simulation, Discrete Event simulation, Machine Learning, Deep Learning, Digital Twin, Big Data, Artificial Intelligence, Operational Research, Software & web development, Data basis, Object orientated programming languages (Python, .Net), MATLAB.

### 1.16.3 Key Technological components

Hardware	n.a.
Software	Smart sensors, Big data analytics tools, Modeling and simulation environments, transportation models/algorithms, Open data platform (HIT Open Data portal).

## 1.17 Digital Catapult Future Networks Lab

	Digital Catapult	United Kingdom
Testbed URL		
Domains:	Smart Cities, Health, etc.	
Use-cases	n.a.	
Contact:	Maria Fonseca, Proposal Manager, Collaborative R&D <a href="mailto:maria.fonseca@digicatapult.org.uk">maria.fonseca@digicatapult.org.uk</a>	
License:	n.a.	
Partner access:	Yes	

### 1.17.1 Description

Future Networks Lab brings together network, services, platform, and solutions providers in a technology-neutral space to experiment with IoT and 5G technologies. The network has enabled over 700 innovators to experiment with IoT technologies, leading to new products and services being brought to market in the UK and abroad.

### 1.17.2 Key Concept and Technologies

Concept	Digital Catapult has partnered with Siemens, IBM, Arrow and Servicenow to support the UK's dedicated facility for leading edge network technologies: the Future Networks Lab. Alongside some of this industry's leading players, we are helping companies of all sizes access the latest networks technologies, development opportunities and advice for practical adoption, all to help de-risk innovation and show how these technologies can be rolled out in practice, not just in theory.
Technologies	5G, LoRaWan, Sigfox, NB-IoT, Nwave

### 1.17.3 Key Technological components

Hardware	5G London node, UK 5G testbeds, including 5G Brighton
Software	5G core, MEC, etc.

## 1.18 fortiss Lab Industrial IoT

<b>fortiss</b>	fortiss GmbH	Munich, Germany
Testbed URL	<a href="https://www.fortiss.org/en/research/living-lab/detail/iiot-lab">https://www.fortiss.org/en/research/living-lab/detail/iiot-lab</a>	
Domains:	Manufacturing, Energy, Smart Cities, Logistics, etc.	
Use-cases	BFThing: OT-IT automated integration; TSMatch: IoT data to service automated matching; TSNWiFi: Wired/Wi-Fi 6 industrial networking with TSN capabilities; Mobilek8s: Dynamic container orchestration; IoT-ICN: Decentralised Publish-Subscribe Communication for IoT	
Contact:	Rute C. Sofia, <a href="mailto:sofia@fortiss.org">sofia@fortiss.org</a>	
License:	Eclipse, GPLv2, GPLv3	
Partner access	Yes, locally, and remotely	

### 1.18.1 Description



The IloT Lab has as motivation to be an experimental and training interoperable and open playground for fortiss, and for partners (academia and industry). The IloT Lab comprises a set of demonstrators that, interconnected, provide an end-to-end perspective of mechanisms that are useful in the context of Industrial IoT. The aim of the concepts

integrated in the lab relate to the exploration of novel communication and computation architectures to deploy and orchestrate heterogeneous and decentralized services and resources efficiently, robustly, and possibly predictively.

### 1.18.2 Key Concept and Technologies

Concept	Open, interoperable lab for next generation IloT applications and systems. OT-IT interoperability aspects; automated data matching between IoT sources and IoT services; industrial networks based on wired/TSN and Wi-Fi 6 (scheduling and time synchronization); dynamic container orchestration (based on ML); ICN
Technologies	Wi-Fi 6/Wi-Fi7; TSN/Ethernet; Web of Things/OWL/semantic technologies; IoT communication protocols and architectures, e.g., OPC UA, MQTT, AMQP, ICN.

### 1.18.3 Key Technological components

Hardware	IoT IP-enabled devices, e.g., sensors, Raspberry Pis with sensors, Beaglebones, etc.; Festo stations; Mobile robots; Wi-Fi 6 enabled APs (Intel NUC AX200/201; Xiaomi AR 3600, UP Core) and stations; TSN switches; end-user devices, e.g., smartphones, tablets, laptops; cameras.
----------	---

Software	Specific open-source software developed by fortiss for each use-case; TSN Linux; OPC UA; MQTT brokers; Mendix; Named data networking; Pytorch; k8s/Docker.
----------	--

## 1.19 fortiss Lab Smart Energy

<b>fortiss</b>	fortiss GmbH	Munich, Germany
Testbed URL	<a href="https://www.fortiss.org/en/research/living-lab/detail/smart-energy-living-lab">https://www.fortiss.org/en/research/living-lab/detail/smart-energy-living-lab</a>	
Domains:	Energy, Mobility	
Use-cases	Energy Management Systems, Energy System Modelling, Energy System Simulation and Optimization	
Contact:	Dr. Markus Duchon (duchon@fortiss.org)	
License:	Apache 2.0, GPLv3	
Partner access:	Yes	

### 1.19.1 Description

The fortiss Energy Lab, demonstrates research results and challenges related to current and future developments in the field of energy systems. The available demonstrators deal with various application cases and show how real problems can be addressed with findings from science and research and allow them to be presented to a wide audience in an easy-to-understand and vivid way. The demonstrators are continuously developed and adapted to current problems. With our lab environment we address existing challenges in the context of research and industrial projects or in the form of student and scientific work. In the fortiss Energy Lab, we work on topics such as the modeling of software systems, into the physical aspects. Here, we investigate opportunities and methods for designing and modeling complex systems as a basis for optimization, monitoring and control, in which the modeling of physical context and prognosis techniques from the area ML/KI are applied. Another focus area deals with evaluating system behaviors and optimizing energy systems. By using our co-simulation environment, hardware in the loop experiments can be conducted and the interactions and control mechanisms of cooperating systems can be analyzed and evaluated.

### 1.19.2 Key Concept and Technologies

Concept	Open, software-based monitoring and control of decentralized energy systems. Architectures, communication, and home automation protocols. Modelling and (co-)simulation of complex energy systems.
Technologies	SESSIM, openEMS/iEMS, Matlab/Simulink, SGAM, SCADA, openAI gym, OPC-UA, EnOcean, Modbus, MQTT

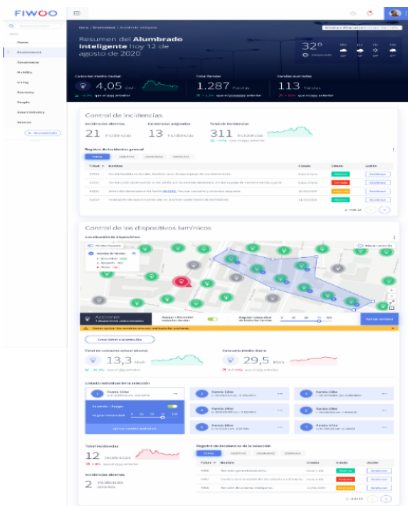
### 1.19.3 Key Technological components

Hardware	EnOcean sensors and actuators, IPSwitch, Pac Sentron electricity meters, Smart electric thermal storage (PCM based), electricity storage (LiFePO4), thin-layer photovoltaics, solar logger
----------	--

Software	fortiss software (service-oriented architecture for critical infrastructure monitoring, iEMS) or openEMS, Co-Simulation environment (SESSIM)
----------	--

## 1.20 Emergya FIWOO IoT Platform

<b>FIWOO</b>	EMERGIA	Spain
Testbed URL	<a href="http://www.fiwoo.eu/en">www.fiwoo.eu/en</a>	
Domains:	Smart Cities, Agriculture, Manufacturing, Health, Logistics	
Use-cases	<a href="#">Smart dashboards - Fiwoo</a>	
Contact:	<a href="mailto:mgimenez@emergya.com">mgimenez@emergya.com</a>	
License:	Contact Emergya.	
Partner access:	Yes	



### 1.20.1 Description

FIWOO, the first IoT-Editor platform based on FIWARE in the market, that helps you to design your IoT ecosystem thanks to a Cloud platform with a simple user interface. It allows the connection of your data, applications, devices, sensors and all kinds of hardware, in a single environment.

FIWOO is a horizontal, open, modular, scalable, robust, secure, interoperable, and integrating platform based on FIWARE for the management of applications and IoT services.

The IoT-Editor implies that the user is the center of the whole ecosystem. Following the 'no-code' philosophy, FIWOO makes its full potential available to you with

powerful visual tools and simple wizards that allow you to create verticals and components without launching a single line of code.

### 1.20.2 Key Concept and Technologies

Concept	<p>FIWOO is the first IoT-Editor on the market, which allows users to create any entity within the whole system without the need for computer knowledge. Everything you see can be created without a single line of code.</p> <p>Any user can create their panels, connect their devices, and even generate intelligent rules through a simple graphic interface</p>
Technologies	<p>Open platform based on an open source, supported by a large community and endorsed by European Union; end-to-end encryption; micro-service architecture; catalogue of indicators: Based on UNE 178202 and UNE-ISO 37120.</p>

## 1.20.3 Key Technological components

Hardware	FIWOO connects to any type of IoT device
Software	FIWARE is an open-source initiative backed by European Commission and the universal standard for the development of intelligent solutions and services.

## 1.21 fortissimo Mobility Lab

<b>fortiss</b>	fortiss	Munich, Germany
Testbed URL:	<a href="https://www.fortiss.org/en/research/living-lab/detail/fortissimo">https://www.fortiss.org/en/research/living-lab/detail/fortissimo</a>	
Domains:	Automotive, Aerospace, Health	
Use cases:	Complex, safety-critical cyber-physical systems; Model-based systems engineering, incremental integration testing; fault-injection testing.	
Contact:	Tiziano Munaro (munaro@fortiss.org).	
License:	LGPL v3.0 (Simulation)	
Open to partners	Yes (Simulated: online; Physical: on-site)	

### 1.21.1 Description



The fortissimo Mobility Lab demonstrates how model-based systems engineering (MbSE) concepts can be leveraged to design and implement safe, adaptive, and reliable software and system architectures within a flexible development process. The demonstrator platform includes physical rovers as well as their digital twins: the fortissimo Rovers are based on heavily modified scale 1:10 RC cars, equipped

with a LIDAR, ultrasound sensors, and an RGB camera. The fortissimo Simulation closely replicates the dynamics and sensor properties of the physical rovers using the Gazebo simulation environment, while providing a standardized interface for their behavior specifications by means of the FMI standard. In both cases, the automotive use case includes advanced driver assistance systems (ADAS) and autonomous driving (AD) functions. The fortissimo Mobility Lab is unique in its ability to demonstrate the model-based engineering of safety critical cyber-physical systems – from its conception to its verification and validation.

### 1.21.2 Key Concept and Technologies

Concept	MBSE concepts for designing (e.g., the SPES methodology), developing (e.g., product line management), integrating (e.g., Co-Simulation), and testing (e.g., defect-based testing) complex cyber-physical systems.
Technologies	AutoFOCUS3; co-Simulation by means of the Functional Mock-up Interface (FMI)

### 1.21.3 Key Technological components

Hardware	Converted RC cars (scale 1:10); Raspberry Pis, Tinkerforge sensor and actuator platform (ultrasound, lidar, engine management unit), 3D-Printed hardware racks, RGB cameras, Microsoft Xbox Bluetooth controllers.
Software	Simulated: FMI, ROS, Gazebo, FMI adapter for ROS. Physical: AutoFOCUS3, Ansible, Ubuntu, custom drivers, libraries, and glue code linking generated code to the target hardware

## 1.22 fortiss Neuromorphic Lab

<b>fortiss</b>	fortiss GmbH	Germany
Testbed URL	<a href="https://www.fortiss.org/forschung/forschungsfelder/detail/neuromorphic-computing">https://www.fortiss.org/forschung/forschungsfelder/detail/neuromorphic-computing</a>	
Domains:	Manufacturing; Space; Health	
Use-cases	Mobile Robotics, Space, Human Machine Interfaces, Machine Vision; Adaptive swimming robot control, Neurorobotics simulation.	
Contact:	Axel von Arnim (vonarnim@fortiss.org)	
License:	Apache	
Partner access	Yes, locally, and remotely	

### 1.22.1 Description



The Neuromorphic Lab showcases one use case of neuromorphic computing, namely in mobile robotics. In this use case, a Lamprey like robot is being controlled by a spiking neural network over neuromorphic hardware (the experimental Loihi chip from Intel). The robot is swimming in simulation, controlled

by a network powering a series of coupled oscillators that move each joint in a coherent manner, over super low energy hardware. This demonstrator proves the potential of neuromorphic hardware in edge AI applications where energy efficiency is a key factor. Further use cases, like industrial robotic arms, low-latency event-based vision, in-car human machine interaction is investigated by the Neuromorphic Computing team.

### 1.22.2 Key Concept and Technologies

Concept	The Lamprey like robot controller has been trained with the Neural Engineering Framework (Nengo) to generate oscillations at its links that generates an efficient swimming movement. In the Lab, a recorded sequence of controller action is replayed live, enabling the user to visualize the robot while moving in real time, to navigate through the scene, observe the neural network activity.
Technologies	Robotic simulation, neuromorphic hardware, central pattern generation, Hopf oscillators, Neural Engineering Framework

## 1.22.3 Key Technological components

Hardware	Intel Loihi experimental neuromorphic chip
Software	Neurorobotics Platform, Gazebo Simulator, ROS, Nengo

## 1.23 fortiss Lab Robotics

<b>fortiss</b>	fortiss GmbH	Germany
Testbed URL	<a href="https://www.fortiss.org/en/research/living-lab/detail/acra4dt">https://www.fortiss.org/en/research/living-lab/detail/acra4dt</a>	
Domains:	Manufacturing	
Use-cases	Intuitive instruction of robot systems; Robot program synthesis from declarative goal specifications; Autonomous manufacturing execution systems; Automated anomaly detection.	
Contact:	Alexander Perzylo, <a href="mailto:perzylo@fortiss.org">perzylo@fortiss.org</a>	
License:	Depends on the case – contact for further information.	
Partner access:	Yes	

### 1.23.1 Description

The fortiss Robotics lab is focused on research and innovation on robot-based automation solutions and collaboration with interested stakeholders. It aims at addressing real-world problems and transferring the latest academic achievements into industrially relevant demonstration platforms and use cases. The implemented showcases are used to evaluate, validate, and disseminate research results to a broad audience ranging from industrial partners and other academic institutions to interested students. They further act as an open platform for discussions and joint developments on applied research.

The focus is on robotic systems engineering, in particular the intuitive instruction of robot work cells, the semantic interoperability of manufacturing resources for knowledge-based autonomous production, as well as model-based software development for robotics. Within the fortiss Robotics Lab, experiments are conducted that serve to validate theoretical research results.


### 1.23.2 Key Concept and Technologies

Concept	Development of ontology-based semantic description languages for formal representation of automation knowledge, automatic reasoning components for interpreting semantic models, semantic digital twins of manufacturing resources, novel approaches to intuitive robot programming and work cell (re)configuration; autonomous manufacturing execution systems.
Technologies	RDF, RDF-S, OWL, OWL reasoners, SPARQL, SHACL, ROS, OPC UA, UA node set information modeling, graph databases.

## 1.23.3 Key Technological components

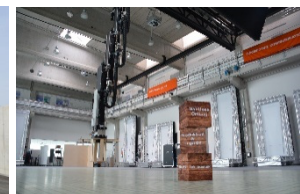
Hardware	Universal Robots UR5s, Kuka LBR iiwas, various vacuum and 2-finger parallel grippers, tool changers, automatic spindle system, F/T sensors, 2d/3d cameras, robot-mounted RGB projectors, 3D printers for rapid prototyping.
Software	Robotics Library ( <a href="https://www.roboticslibrary.org/">https://www.roboticslibrary.org/</a> )

## 1.24 Fraunhofer IIS L.I.N.K. - Positioning - Identification - Navigation Communication

	Fraunhofer IIS	Nurnberg, Germany
Testbed URL	<a href="https://www.iis.fraunhofer.de/en/profil/standorte/linkhalle.html">https://www.iis.fraunhofer.de/en/profil/standorte/linkhalle.html</a>	
Domains:	Industry/Logistic, manufacturing, Smart City, Health, automotive	
Use-cases	Industry 4.0; intra-logistics; vehicle access systems, advanced driver assistance systems (ADAS); sports tracking; validation	
Contact:	Dr. Wolfgang Felber: wolfgang.felber@iis.fraunhofer.de Nicolas Witt: nicolas.witt@iis.fraunhofer.de	
License:	Depends on the case – contact for further information	
Partner access:	yes	

### 1.24.1 1.1.1 Description

In the “L.I.N.K. Test and Application Center” at its Nuremberg location, Fraunhofer IIS provides a realistic and application-



oriented environment for developing, demonstrating, and evaluating pioneering technologies and applications in the fields of positioning, identification, navigation, and communication. It contains of various reference positioning systems including a 5G campus network to evaluate new communication and localization aspects of actual standardization discussions.

### 1.24.2 Key Concept and Technologies



Concept	Positioning for IIoT; indoor/outdoor/seamless positioning for logistic applications (including a truck drive through and loading ramps)
---------	---

Technologies	5G campus network installation, large volume motion capture, precise motion reference systems, automatic measurement campaigns (robots)
--------------	---

### 1.24.3 Key Technological components

Hardware	Interior space of almost 1400m <sup>2</sup> (44m x 33m x 9m) and outdoor space of almost 10000 m <sup>2</sup> ; whole volume 3D- positioning system (robot); 6DOF reference systems: iGPS (submillimeter accuracy), Qualisys (large volume MoCap, 30x20x6 m); Synchronized Reference IMUs: XSens, cometa Wave Track; Automated test setups for large scale, repeatable testing; 5G campus network; grandmaster clock
Software	PTP, NTP; Qualisys Track Manager 2021

## 1.25 Huawei Edge Computing OPC UA over TSN Testbed

 	Huawei, EECC, Fraunhofer FOKUS, Schneider, B&R etc.	Munich, Berlin
Domains:	Manufacturing	
Use-cases	TSN based OT and IT converged industrial automation networks; IEC 61499 and TSN for smart manufacturing; Edge-Cloud Synergy AI (Kubeedge, Atlas etc.)	
Contact:	konglingbo@huawei.com	
License:	n.a.	
Partner access:	Yes	

### 1.25.1 Description

Converged OT and IT network through TSN technology, carrying heterogeneous traffics, such as automation control, optical inspection, and video surveillance, from the field to the edge. Both the need of Time-critical control traffic and bandwidth consuming traffic can be met. Edge AI for industry using IEF framework for deployment and IEC 61499 for industry component integration.

### 1.25.2 Key Concept and Technologies

Concept	Heterogeneous traffics (Automation control, video, events) and industrial protocols (OPC UA, IEC 61499, Modbus-TCP) carried on the unified TSN network, where the delay and reliability requirements can be met by centralized auto-configuration.
Technologies	TSN data plane using combined Priority/Time-aware scheduling and shaping; TSN control plane integrated with network calculus algorithms; brownfield device compatibility solutions; Edge AI integrated industrial automation control.

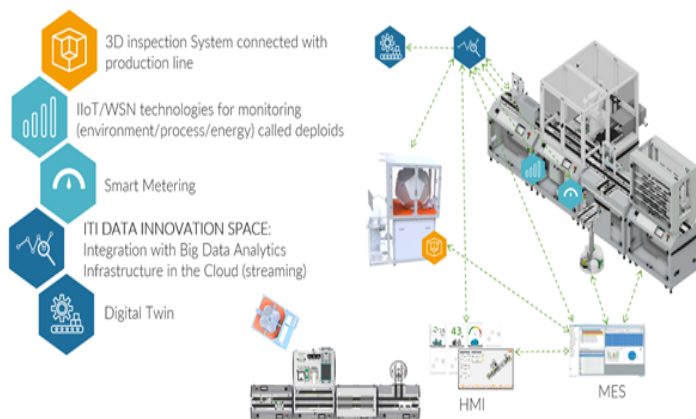
### 1.25.3 Key Technological components

Hardware	TSN-IP switches (S67xx; S57xx); Edge computing gateway (AR502H); Any-to-ETH gateway prototype; Miniature automobile production line; Automated Optical Inspection and video surveillance cameras.
Software	OPC UA supervisory control; IEC 61499 controller; TSN centralized controller; Network Calculus algorithm; Kubeedge; Mindspore (for AI)

## 1.26 ITI DATAROOM

	ITI - Instituto Tecnológico de Informática	Spain
URL:	<a href="https://www.iti.es/noticias/iti-inaugura-el-primer-centro-demostrador-del-pais-especializado-en-datos-para-la-industria-4-0/">https://www.iti.es/noticias/iti-inaugura-el-primer-centro-demostrador-del-pais-especializado-en-datos-para-la-industria-4-0/</a>	
Domains:	Manufacturing.	
Use-cases	Multilevel energy monitoring; Horizontal and vertical data integration; big data analytics; 3D quality control; Digital twining; VR logistics laboratory; AR in warehouse management	
Contact:	<a href="mailto:innovacion@iti.es">innovacion@iti.es</a>	
License:	Free Access for demonstration. Pay per use for experimentation	
Partner access:	Yes	

### 1.26.1 Description



DATAROOM is a Laboratory for demonstration and experimentation with Data for Industry 4.0, consisting of flexible manufacturing cells, robotics, automated warehouses, quality control. DATAROOM is the result of integrating all the results ITI is generating around industry 4.0 in one site. Its mission is to help companies to understand how to

collect, manage and exploit Data in a production plant, and which tools and applications are available for it.

### 1.26.2 Key Concept and Technologies

Concept	Complete Data Cycle: Data Collection, Data Communication, Data Integration and Storage, Data Analysis, Data Simulation. Applications in predictive maintenance, anomaly detection, energy efficiency.
Technologies	WSN, IIoT, OPC-UA, Machine Learning, Deep Learning, Digital Twin, Big Data, Cloud Computing, Artificial Intelligence, Edge Computing, VR/AR.

### 1.26.3 Key Technological components

Hardware	Modular production system (CP Factory); Robot Assembly Cell with Mitsubishi RV-4FL, Industrial Inspection cell (Zero Gravity 3D); AGV (Robotino); AR glasses
----------	--

Software	Festo MES, collaborative robot by MITSUBISHI, Radiatus by ITI <sup>2</sup> , Data Hub by ITI <sup>3</sup> , Deploids <sup>4</sup> by ITI; Zerogravity3D <sup>5</sup> by ITI; IIoT protocols, e.g., Profinet, OPC UA, MQTT, etc; Kafka; multiple file formats, etc.
----------	--

---

<sup>2</sup> <https://radiatus.iti.es/>

<sup>3</sup> <https://datahub.iti.upv.es/>

<sup>4</sup> <https://www.deploids.com/>

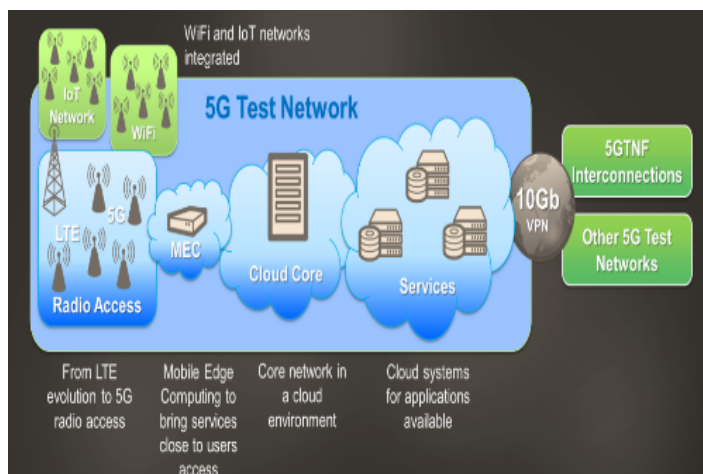
<sup>5</sup> <https://www.zerogravity3d.com/en/>

## 1.27 Oulu University 5G/6G Test Network

	University of Oulu, Centre for Wireless Communications (CWC) 	Oulu, Finland
Testbed URL	<a href="https://www.oulu.fi/university/news/5g-6g-test-network">https://www.oulu.fi/university/news/5g-6g-test-network</a>	
Domains:	ICT; Energy; Manufacturing.	
Use-cases	Wireless connectivity and beyond for Smart Campus, Energy, Smart Living, Robotics, ITS and other verticals	
Contact:	ari.pouttu(at)oulu.fi, olli.liinamaa(at)oulu.fi, konstantin.mikhaylov(at)oulu.fi	
License:	Varies depending on the components used and activities – contact for more information	
Partner access:	yes	

### 1.27.1 Description

5G/6G Test Network represents a campus-wide cellular network<sup>6</sup>. The network features the full portfolio of 5G terminals, higher frequency bands, cognitive management functionalities, system testing tools for new connectivity solutions and versatile vertical applications. The network evolution follows the research and standardization progress, acting as verification



platform for theoretical 5G/6G research. The cellular network is complimented by an extensive mMTC/IoT connectivity network.

### 1.27.2 Key Concept and Technologies

Concept	The test network enables experiments for the next-generation wireless connectivity and its use for vertical applications. Its key components are wireless connectivity; AI/ML, processing, several vertical applications (energy, smart campus...).
Technologies	5G/6G and other radio access technologies (LPWAN (e.g., LoRaWAN), WPAN (e.g., BLE), WBAN (e.g., UWB), V2X). Edge computing, AI/ML, drones/robots.

<sup>6</sup> <http://5gtn.fi/>

### 1.27.3 Key Technological components

Hardware	5 Macro and 20+ Pico base stations: 5G NR, LTE, NB-IoT and LTE-M; hundreds of Sim-cards; EPC and OpenEPC; 700 BLE beacon positioning; LoRaWAN network with 2000 sensors; ITS-G5/802.11p V2X OBU and RSU; 3 edge servers; rich set of measurement equipment
Licenses	Frequency licenses: B1, B7, B28, B43

## 1.28 Politecnico di Milano Industry 4.0 Lab

	Politecnico di Milano	Milan, Italy
Testbed URL	<a href="https://www.industry40lab.org/">https://www.industry40lab.org/</a>	
Domains:	Manufacturing	
Use-cases	Production monitoring, programming, and optimization; Asset management and maintenance; Energy consumption optimization; Circular Economy; VR/AR for empowered operators; 5G.	
Contact:	Giacomo Tavola ( <a href="mailto:giacomo.tavola@polimi.it">giacomo.tavola@polimi.it</a> ), Walter Quadrini ( <a href="mailto:walter.quadrini@polimi.it">walter.quadrini@polimi.it</a> )	
License:	Eclipse, Apache, OPC	
Partner access:	Yes	

### 1.28.1 Description



Industry 4.0 Lab is aiming to create a tangible physical entity where the research activity in the innovative manufacturing management and planning approaches can be carried out in conjunction with a practical implementation in a “real-like” environment. Key components implemented include a fabrication line based on the I4.0 paradigm and open architectures, including robotic stations, collaborative robot and AGVs. Implemented scenarios encompass various

research areas as production monitoring, programming and optimization, asset management and maintenance, energy consumption optimization, circular economy, VR/AR for empowered operators, 5G technologies.

### 1.28.2 Key Concept and Technologies


Concept	AI, AR, and collaborative robotics supporting application development for advanced sustainable manufacturing; demonstration of 5G technologies adoption in manufacturing.
---------	---

Technologies	AR; IIoT communication protocols; ML for MFG; LTE/5G
--------------	--

### 1.28.3 Key Technological components

Hardware	Fully automated line with OPC UA integrated PLCs for production and energy monitoring and control. Programmable Robot, Collaborative Robot, AGV, Raspberry Pis with sensors, smartphones, tablets, laptops, wearable devices (HoloLens, Vuzix). 5G modems, fiber connection.
Software	OPC UA; MQTT, Kafka, MATLAB, MongoDB, k8s/Docker.

## 1.29 PSNC Future Labs, Pionier-Lab, Agriculture testbed

 <small>Poznan Supercomputing and Networking Center affiliated to the Institute of Bioorganic Chemistry, PAS</small>	PSNC	Poland
Testbed URL	<a href="https://futurelabs.psnc.pl/en/projekty/">https://futurelabs.psnc.pl/en/projekty/</a>	
Domains:	Smart Cities, Health, Agriculture	
Use-cases	Smart Campus, Smart Spaces, Smart Parking, Smart Vending, Smart Farming	
Contact:	marcinp@man.poznan.pl	
License:		
Partner access:	yes	

### 1.29.1 Description

PSNC FutureLabs are the living labs in education, eHealth, smart City. Each of the labs provides different kinds of technologies, etc. PIONIER-lab - is the largest Polish Research Infrastructure roadmap project, with one of the laboratories - Smart Campus as Smart City. It builds the testbed of 12 smart campuses in Poland, with thousands of sensors and infrastructure around smart spaces, parking, monitoring, energy, and others. The testbed will be available through the IoT/edge platforms for experimentation.

### 1.29.2 Key Concept and Technologies

Concept	Access to data from distributed network of sensors, access to living lab building and spaces, access to data from Agrometeo network of stations
Technologies	IoT, Edge computing, HPC, Machine Learning, Deep Learning, Big Data, Cloud Computing, AI, Edge Computing, Virtual Reality, Augmented Reality


### 1.29.3 Key Technological components

Hardware	Sensor infrastructure; automatic air quality testing stations; Agrometeo stations; smart metering/monitoring equipment; robotics platforms and arms; cameras. 42 camera motion capture kit, Grass valley rio kit, pablo neo panel, sony bvm-x300 OLED monitors, phabrix rx500 analyzer (rasterizer), 24-speaker ambisonic installation, scanners (e.g., Arri Scan)
Software	Access to the PSNC computing infrastructure and DataCenter (PSNC is the major HPC and DataCenter in Poland) services and software stacks for AI/ML/DL, BigData, etc.

<sup>7</sup> <https://pionier-lab.pionier.net.pl/laby/>

<https://www.pcass.pl/projekty/edwin/>

## 1.30 Proximus Video Analytics Testbed

	Proximus	Brussels, Belgium
Testbed URL	www.proximus.be	
Domains:	Smart cities, smart retail	
Use-cases	People counting, occupancy detection, crowd management, vehicle detection, sound analytics	
Contact:	Anissa Sefsaf	
License:	-	
Partner access:	yes	

### 1.30.1 Description

The Proximus Testbed is set to demonstrate the usage of video analytics and mmWave technology to detect line crossing, people counting, loitering and spill detection, occupancy measurements, crowd estimation and vehicle detection. On top of that, people can be categorized as male or female and adults vs. kids. By measuring the speed and walking direction, we can determine if passers-by are motorized or by foot. Using sound sensors, we can deliver sound analytics categorization like vehicle detection, glass breaking detection, etc. The generated data is displayed on a customized dashboard using a trustworthy interface to prove the correctness of the data.


### 1.30.2 Key Concept and Technologies

Concept	People counting, occupancy detection, crowd management, vehicle detection, sound analytics
Technologies	Video analytics, mmWave technology, sound analytics

### 1.30.3 Key Technological Components

Hardware	Regular cameras, AI appliance, 3D cameras, mmWave sensors and sound detectors
Software	Azure IoT HUB

## 1.31 Tekniker Smart Factory Hub

 MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE	Tekniker	Spain
Testbed URL	<a href="https://smartfactorycell.tekniker.es/">https://smartfactorycell.tekniker.es/</a>	
Domains:	Manufacturing	
Use-cases	Manufacturing, Tribology	
Contact:	Roberto González Velázquez, roberto.gonzalez@tekniker.es	
License:	Contact Tekniker	
Partner access:	yes	

### 1.31.1 Description

Unified platform for the integration of services in a smart factory. The platform provides a single web interface to information acquired from testbeds, machine-tools, robots, special machines and tribometers. Depending on the asset, different types of information is provided (operational, process, condition, quality).

### 1.31.2 Key Concept and Technologies

Concept	Integration of services for the smart industry.
Technologies	Machining processes, robotic automation, test benching, tribological studies, additive manufacturing; Machine operation data, process data, condition data, quality data.

### 1.31.3 Key Technological components

Hardware	Machine-tools, special machines, industrial robots, test benches, tribometers
Software	National Instruments, IFM, OPC UA, CNC proprietary drivers, .NET, Java, Apache NiFi, SQL Server; Mongo DB, PostgreSQL, InfluxDB, R

## 1.32 Ubiwhere Nervous System Living Lab

<b>ubiwhere</b>	Ubiwhere	Aveiro, Portugal
Testbed URL	<a href="https://city-nervous-system.ubiwhere.com/">https://city-nervous-system.ubiwhere.com/</a>	
Domains:	Smart Cities, Smart Campus, Connectivity	
Use-cases	Awareness of the presence of VRUs in potentially dangerous situations; Intelligent and dynamic video caching; Collision risk warning	
Contact:	innovation@ubiwhere.com	
License:	n.a.	
Partner access:	Yes	

### 1.32.1 Description

Ubiwhere’s Nervous System Living Lab is ready to welcome early adopters of 5G technologies to experiment with their solutions in a realistic end-to-end 5G environment. Hardware providers, RAN providers, app developers, students, researchers, startups, scale-ups are all welcome on board to experiment with their solution in this realistic environment. Moreover, the Nervous System Living Lab acts as a platform for every stakeholder to better understand the 5G ecosystem. This initiative’s primary goal is to allow people to make the most of the lab’s data. Some actors might want to do data analysis on the network, and others might want to test their solutions in realistic environments or just want to understand the network’s possibilities.

### 1.32.2 Key Concept and Technologies

Concept	5G integration.
Technologies	OpenRAN; 5G network/core

### 1.32.3 Key Technological components

Hardware	5G NR Small Cells (N78 3.5 GHz) - 5G SA; 4G Small Cells (B42 3.5 GHz, B7 2600 MHz, B3 1800 MHz) - 5G NSA; Edge nodes; IoT sensors; C-V2X equipment; user Equipments
Software	Virtualized EPC (4G & 5G); ETSI NFV/MEC Orchestrator & Platform; SLA monitoring & enforcement

## 1.33 Universidad de Murcia Gaia-5G

	Universidad de Murcia	Murcia, Spain
Testbed URL	<a href="https://ants.inf.um.es/en/gaialab">https://ants.inf.um.es/en/gaialab</a>	
Domains:	Energy, Smart Cities	
Use-cases	Smart Cities, Smart Campus	
Contact:	ANTS research group, UMU	
License:	n.a.	
Partner access:	yes	

### 1.33.1 Description

Gaia-5G is a testbed for 5G, computing and networking technologies, covering the whole campus in LoRaWAN, 802.11p and 5GNR coverage with our own network equipment. We also have distributed computation facilities linked via dedicated fiber links and a CWDM ring, with two open stack deployments, two hyperconvergence nodes, a Kubernetes environment and a PVE virtualization environment. The Gaia-5G Living campus is a deployment of IoT on the main university campuses with hundreds of sensors collecting data ranging from building / public transport occupancy, weather and air quality to photovoltaic production and wastewater processing parameters.

### 1.33.2 Key Concept and Technologies

Concept	Practical demonstration of new communication technologies and computing paradigms over 5G, LoRa, etc.
Technologies	5GNR, LoRa, LoRaWAN, 802.11p, WiMAX; MEC

### 1.33.3 Key Technological components

Hardware	RSU / OBU and low power ARM MEC embedded demonstrators
Software	ETSI MEC, RADIO Mobile online, OpenFlow, PTP, etc.

## 1.34 University of Murcia PP-IDM

	University of Murcia	Murcia, Spain
Testbed URL		
Domains:	Smart cities, Privacy-preserving Identity Management	
Use-cases	Chain-enabled PP-IDM	
Contact:	skarmeta@um.es	
License:	Open source (Apache 2.0)	
Partner access:	Yes	

### 1.34.1 Description

The Chain-enabled PP-IDM Testbed is set to demonstrate the collaboration of distributed ledger technologies DLTs and privacy-preserving technologies (PETs) for achieving trustworthy environments where users are in control of their identity and can access services with guarantees of data minimization and not being tracked by services nor identity providers.

### 1.34.2 Key Concept and Technologies

Concept	Users can obtain p-ABC credentials from a distributed infrastructure (OLYMPUS based) that secures critical points increasing the trust in all the scenarios. The IdM platform using smart contracts can unambiguously register existing identity providers and even keep track of service providers and their policies. Each service provider must communicate what information it consumes, and this is recorded in the DLT for later use. In this way, users can know in advance what data a registered service provider consumes and whether the policy it has finally demanded from them is the one it initially declared.
Technologies	DLT, privacy-preserving Attribute Based Credentials (p-ABC), distributed identity management. Convergence between DLT and distributed IdM for trust increase. Smart Contracts

### 1.34.3 Key Technological components

Hardware	Cloud storage, virtualization, smartphones
Software	Hyperledger Fabric, OLYMPUS framework

## 1.35 UPM Smart City spaces of the Future

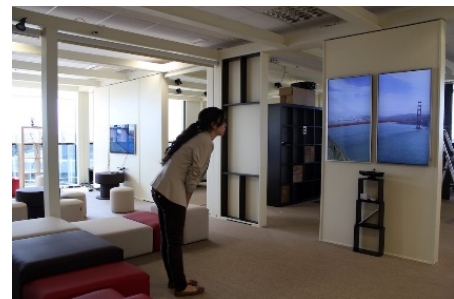
	UPM	Spain
Testbed URL	<a href="https://iptc.upm.es/facilities-and-technological-and-scientific-services">https://iptc.upm.es/facilities-and-technological-and-scientific-services</a>	
Domains:	Smart Spaces, Sustainability, Smart Healthcare, Tourism, Commerce.	
Use-cases	Smart Cities, Smart Living Spaces, Connected Buildings, Flying IoT, Smart Transport, Security and Defense, Emergency Response.	
Contact:	<a href="mailto:anamaria.bernardos@upm.es">anamaria.bernardos@upm.es</a>	
License:	Varies depending on the components used and activities – contact for more information.	
Partner access:	Yes	

### 1.35.1 Description



The Experience Lab of the Spaces of the Future is a 160sq space for demonstration and service testing development located within CAIT Building at UPM Montegancedo Campus (Madrid, Spain). It is composed of reconfigurable semi-open rooms, specifically conceived to test

personalized service concepts and interactive spaces. At the Lab, there are different technology enablers on top of which different service concepts have been trialed: IoT platforms on edge, multiuser indoor positioning systems based on hybrid sensors, a platform to provide multidevice collaborative augmented reality experiences, systems for multimodal natural (gesture-based, voice-based) interaction, concepts of smart objects (e.g., smart windows) and technologies for command-and-control centers.



### 1.35.2 Key Concept and Technologies

Concept	Edge platforms, indoor positioning, augmented reality, gesture-based, voice-based interaction, ultra-wall interaction, multisensor tracking, personalized services
Technologies	IoT, artificial intelligence, behavior analysis algorithms, data fusion, microservices platforms

### 1.35.3 Key Technological components

Hardware	High resolution ultra-wall, Arduino boards, smart cameras, interaction sensors (leap motion, Kinect, etc.), HoloLens, mobile devices, TV screens, Bluetooth beacons, ultrawideband beacons, servers,
Software	MQTT, Kafka, Docker, MongoDB, Python, OpenCV, others.

## 1.36 UPM Integration of IoT with Tactical Cloud

	UPM	Spain
Testbed URL	<a href="https://iptc.upm.es/facilities-and-technological-and-scientific-services">https://iptc.upm.es/facilities-and-technological-and-scientific-services</a>	
Domains:	Smart Cities, Transport, Security and Defense	
Use-cases	Disaster recovery, security, surveillance	
Contact:	<a href="mailto:anamaria.bernardos@upm.es">anamaria.bernardos@upm.es</a>	
License:	Varies depending on the components used and activities – contact for more information.	
Partner access:	Yes	

### 1.36.1 Description

Tactical Edge environments are those such as disaster scenarios or battlefields in which professionals (e.g., emergency first-responders, firemen or soldiers) usually have limited computing and communication resources, while having to deal with situations that evolve rapidly and unpredictably and high level of stress and need for risk control. The more and more, professionals are equipped with wearable IoT systems, both for self-control, situation assessment and information retrieval. There is a need for virtualizing resources and embedded them in specific tactical architectures that cannot be configured as a standard-cloud centralized service, but on edge and in a distributed manner. In this demonstration, hierarchical data processing for a defense use case: the soldier wears a smart helmet connected to a tactical cloud architecture, that enables to receive data from external sensors (embedded in drone platforms, vehicles, etc.) in a communications environment that is continuously modified. A prototype of the installation is built for the European Defense Agency, but multiple applications for Law Enforcement Agencies and other partners are feasible.

### 1.36.2 Key Concept and Technologies

Concept	Wearable IoT, Edge computing, resilient networks.
Technologies	Data fusion, artificial vision, microservices architectures, IoT

### 1.36.3 Key Technological components

Hardware	AR wearable helmet (HoloLens), routers, servers, ultra-wall (3x3 screens), wearable stress sensors, mobile devices.
Software	MQTT, Kafka, Docker, MongoDB, Python, cloud services, OpenCV.

## 1.37 UPM Smart Drones

	UPM	Madrid, Spain
Testbed Link	<a href="https://iptc.upm.es/facilities-and-technological-and-scientific-services">https://iptc.upm.es/facilities-and-technological-and-scientific-services</a>	
Domains:	Security, Maintenance, Logistics, Transport	
Use-cases	Smart Drones, Unmanned Traffic Management, Security, Maintenance, Logistics, Transport	
Contact:	<a href="mailto:anamaria.bernardos@upm.es">anamaria.bernardos@upm.es</a>	
License:	Varies depending on the components used and activities – contact for more information.	
Partner access:	Yes	

### 1.37.1 Description

This testbed deployed in Montegancedo Campus is ready to demonstrate services deployed over fleet of drones (demos are carried out with >3 drones). The key asset is the software platform that controls the fleet service lifecycle, from mission configuration to real-time data visualization and sensor-based anomaly detection. Drones are governed as IoT sensing platforms, equipped with in-flight sensors, environmental sensors, and specific cameras (thermal cameras, LiDAR, etc.), mounted in depending on the use case. Different service scenarios have been deployed over the platform: infrastructure monitoring (e.g., for telecom towers), emergency response (for onsite fast evaluation of an emergency and first-aid kit delivery) and security applications (capacity control in bounded areas). Real-time artificial vision algorithms on-board and on the edge are used to monitor the service. Monitoring tools include specific applications for mobile devices, but also interactive solutions for command-and-control centers.


### 1.37.2 Key Concept and Technologies

Concept	Drone fleet management & automation, real-time sensing
Technologies	Data fusion, artificial intelligence, artificial vision, optimization algorithms, tracking and navigation, adaptive interfaces.

### 1.37.3 Key Technological components

Hardware	Drones, mobile devices, thermal cameras, LiDAR, ultra-wall.
Software	MQTT, Kafka, Docker, MongoDB, Python, cloud services, OpenCV.

## 1.38 Video Systems APICUS-PLT

	Video Systems	Italy
Testbed URL	<a href="http://www.videosystems.it/en">www.videosystems.it/en</a>	
Domains:	Manufacturing	
Use-cases	Glass container Agile quality control, Non-ferrous casting components quality control, mechanical parts surface quality control	
Contact:	Alessandro Liani, a.liani@videosystems.it	
License:	n.a.	
Partner access:	yes	

### 1.38.1 Description



APICUS demonstrator platform includes physical anthropomorphic robot equipped with a set of machine vision systems dedicated to quality control tasks. The demonstrator uses machine vision technologies powered by deep-learning engine to quality control task of components manipulated by the robot. The pilot demonstrates integration of edge and cloud

technologies that uses IIoT to share information for complex Agile manufacturing scenarios simulation. The station is connected to Cloud-based AI learning system based on Docker technology and NVidia GPUs accelerations. Different pilots are ready to test on various manufacturing sectors (Hollow Glass, high precision mechanical, foundry, furniture, field of household appliances, automotive).

### 1.38.2 Key Concept and Technologies

Concept	AI, Machine vision, Robotics, IIoT, Cloud computing. robotics, edge computing, embedded systems
Technologies	Video Systems embedded machine vision systems, anthropomorphic robot, GPUs cluster

### 1.38.3 Key Technological components

Hardware	Denso VS mod. 087G, On Robot grippers, NVidia GPUs cluster, Video Systems embedded vision devices, Video Systems stereo vision unit, photometric based surface quality control unit
Software	Image processing modules, IngeniumPredictiveAIEngine

## 1.39 Virtech SofiaLab

	Virtech	Bulgaria
Testbed URL	<a href="https://sofia-da.eu/en/">https://sofia-da.eu/en/</a>	
Domains:	Smart Cities, Energy, Health	
Use-cases	smart city, energy efficiency, smart buildings, active and healthy aging, e-health, sustainable development, e-mobility	
Contact:	r.nikolov@virtech.bg	
License:	n.a.	
Partner access:	yes	

### 1.39.1 Description

Experimental living lab facilities in smart energy, smart buildings, active and healthy aging, e-health, sustainable development, smart mobility (e.g., smart EV charging).


### 1.39.2 Key Concept and Technologies

Concept	Big Data and AI enhanced smart services, GDPR compliant data exchange, interoperability.
Technologies	Open-source platforms: FIWARE, openHAB, dataU

### 1.39.3 Key Technological components

Hardware	Tablets, scanners, 3Dd Oculus Rift glasses
Software	VR/AR edutainment, game design tools; 2D and 3D games

## 1.40 VizLore DLT Labs

	VizLore Labs Foundation	Novi Sad, Serbia
Testbed URL	<a href="https://vizlore.com/barter/">https://vizlore.com/barter/</a>	
Domains:	Smart city, smart building, e-mobility, agri-food, supply chain	
Use-cases	Blockchain-Assisted Real-time Transaction Execution and Repository framework; Crypto-currency based micro-payments for IoT services in various domains' machine to machine micro-payments integrated with IoT automation processes; Trust management processes in food supply chains; Food safety and quality tracking through complex food supply chains.	
Contact:	<a href="mailto:Milenko.tosic@vizlore.com">Milenko.tosic@vizlore.com</a> , <a href="mailto:sasha.pesic@vizlore.com">sasha.pesic@vizlore.com</a>	
License:	Yes	
Partner access:	Yes	

### 1.40.1 Description

The Blockchain-Assisted Real-time Transaction Execution and Repository framework (BARTER) Testbed is set to demonstrate a blockchain framework built on top of Hyperledger Fabric, Dash and VizLore's ChainRider service. It is a micro-payment enabler service that can be exploited to support a range of use-cases that need a secure and scalable M2M micro-payment solution, specifically designed for the IoT. Another part of the VizLore DLT Lab is the FT-CHAIN testbed. This testbed is built by Freie University of Berlin and VizLore Labs Foundation in a bilateral research project – set to demonstrate quality and safety tracking of food through complex food supply chains combining federated learning, DLT and IoT.


### 1.40.2 Key Concept and Technologies

Concept	<p>BARTER is a decentralized private blockchain infrastructure with deployed smart contracts for automated micro-payments and data storage, allowing autonomous interaction between IoT ecosystem entities in carrying out everyday business workflows. Regulations, ethics, and business rules can be incorporated through smart contracts, which are stored on BARTER's Hyperledger blockchain and provide REST API interface for integration with IoT devices in a secure manner.</p> <p>FT-Chain combines IoT system for food quality measurements (spectrometry methods), IOT system for environmental sensing, Hyperledger Fabric based ledger for trusted data sharing between parties and federated learning framework for high performance data analysis and decision making. The goal is to emulate complex processes and dependencies in food supply chains that might result in food quality degradation and contamination.</p>
Technologies	Converge IoT & DLT, micropayments, process automation, IoT platform with edge controllers, smart contracts

### 1.40.3 Key Technological components

Hardware	VizLore IoT controllers – part of VizLore IoT platform – see <a href="https://smartaccess360.com/">https://smartaccess360.com/</a>
Software	Hyperledger Fabric, ChainRider (chainrider.io), Dash, Bitcoin, H2020 PhasmaFOOD project SW platform.

## 1.41 Solar Lab RES Cluster

	Enercoutim	Portugal
Testbed URL	<a href="https://www.enercoutim.eu/demo-platform/">https://www.enercoutim.eu/demo-platform/</a> <a href="https://www.enercoutim.eu/solar-lab/">https://www.enercoutim.eu/solar-lab/</a>	
Domains:	Energy, Smart Buildings	
Use-cases	Energy Production Optimization, Flexibility Management, Building Infrastructure Management	
Contact:	n.samovich@enercoutim.eu	
License:	n.a.	
Partner access:	Yes	

### 1.41.1 Description

The Solar Lab is a Net Zero Energy Building (NZEB) that offers conditions to test energy systems, such as microgrid approach, IoT infrastructures, EV charging and other integrated components. Located in the municipality of Alcoutim, Algarve region - highest solar radiation in Europe. The Solar Lab is equipped with a PV installation, an EV charger, a weather station (high resolution sensors) DNI, UVE and other equipment, indoor sensors for IEQ monitoring, smart appliances for use as electric loads and Wi-Fi communication, electric energy storage unit. DEMO site was within H2020 projects SHAR-Q (smart energy) and VICINITY (IoT) and currently on BD4RNG (Big Data for Next Generation Energy) where concepts like interoperability between distributed energy systems and decentralized IoT infrastructure, were explored, tested, and demonstrated to the stakeholders.

### 1.41.2 Key Concept and Technologies

Concept	Solar Demonstration Platform:
Technologies	Solar Lab: IoT platform, Smart Energy components, Smart EV Charging, IEQ sensors, technologies for system flexibility, testing of battery charging states, grid connection tests, local weather forecasting. Solar Demonstration Platform: Organizing 5G testbed, testing, integration.

### 1.41.3 Key Technological components

Hardware	Solar Lab: PV system (11.7 kWp), batteries, EV charger Solar Demonstration Platform: CPV system (4 MWp), solar trackers
Software	Solar Lab: Dynamic Building Audit, P2P energy trading platform. Solar Demonstration Platform: Smart Clean O&M; Optimizing and improving management and prediction of DER; Energy sector digital twin.

## 1.42 AIRQ DAO

	AIRQ DAO Foundation vzw	Brussels, Belgium
Testbed URL	www.airqdao.eu	
Domains:	Smart cities, Climate action	
Use-cases	Autonomous system – Air quality sensor network	
Contact:	tom@airqdao.foundation	
License:	no	
Partner access:	yes	

### 1.42.1 Description

The AIOTI DLT 1.02 AIRQ DAO Testbed demonstrates the convergence of IoT and DLT into an autonomous system based on the AIOTI High Level Architecture (HLA) for data markets. Co-creation, micropayments and (smart contract) revenue-splits enable a 'self-sustaining' and financially autonomous IoT sensor network.

### 1.42.2 Key Concept and Technologies

Concept	The AIOTI HLA into practice. ("Co-creation & Revenue split") Each air quality sensor integrates with the DLT network via a dedicated wallet. Local engaged citizens subscribe to notification services via micropayments. The sensor receives monthly payments, and an automated revenue split rewards the data aggregator, service providers and the AIRQ DAO foundation. If the sensor can earn its own value after two years, a smart contract orders his replacement. As such, only valuable sensors are maintained, and the network becomes (financially) self-sustainable.
Technologies	Converged IoT & DLT, tokenization, micropayments, and smart contracting

### 1.42.3 Key Technological components

Hardware	Solar cells, Air quality sensors, Cloud storage and virtualization
Software	Ethereum vs. Cardano

## Testbeds Analysis

The testbed catalogue consists of a total of 40 collected testbeds, where 4 are in a use-case stage; 8 are in a proof-of-concept stage; 28 correspond to deployed testbeds. Figure 2 provides a relative perspective of the application of the testbeds per domain. As shown, most testbeds cover use-cases in Smart Cities (37.5%) and Manufacturing domain (35%). The testbeds provided by the IG testbed members cover the different domains in a sound way.

A word cloud covering the different proposed use-cases is provided in Figure 3.

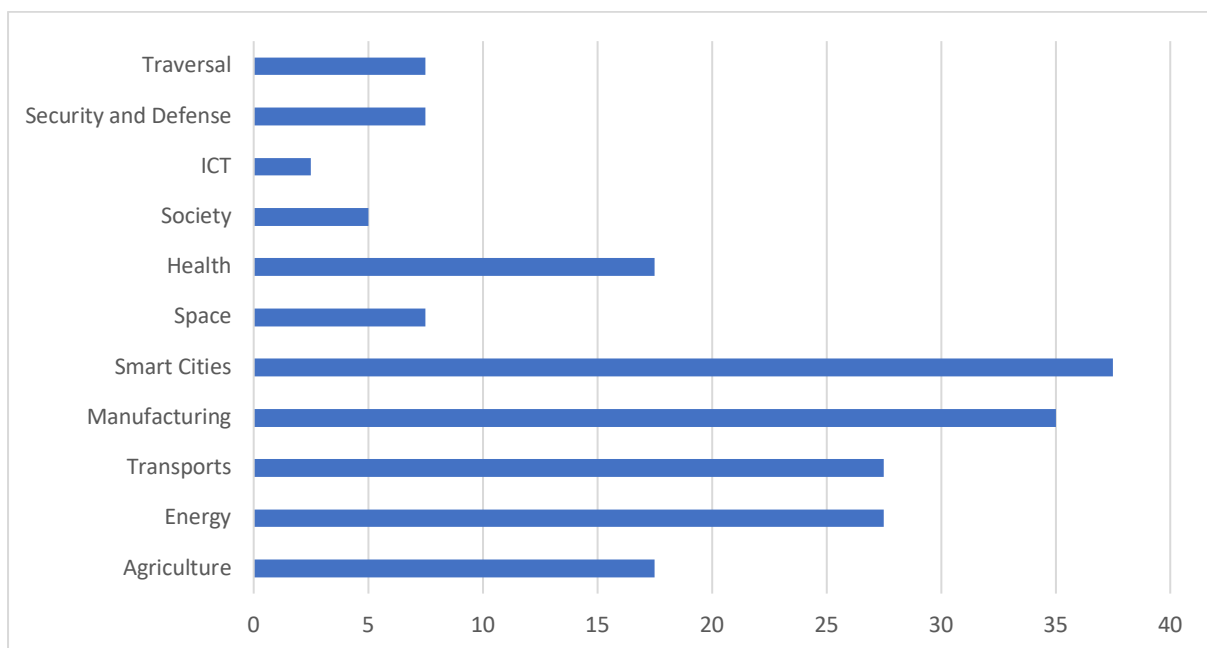


Figure 2: Domains addressed by the testbeds.



## Summary

This report provides a catalogue of testbeds categorized in accordance with the AIOTI testbed categorization methodology. The testbeds have been provided by members of the IG Testbeds working group, and by members of other AIOTI working groups.

The aim of the document is to serve as a dissemination vehicle across AIOTI, assisting in the further development of cooperation involving AIOTI members.

## Editors and Contributors

Person	Role	Affiliation
Rute C. Sofia	Editor	Fortiss GmbH
Jose Cabral	Author	Fortiss GmbH
Charles Sturman	Author	Huawei Technologies
Francesca Aryee-Dematteis	Contributor	Norgren
Axel von Arnim	Contributor	Fortiss GmbH
Alexander Perzylo	Contributor	Fortiss GmbH
Tom De Block	Contributor	AIOTI DLT
Lingbo Kong	Contributor	Huawei Technologies
Alessandro Liani	Contributor	Video Systems Srl
Konstantin Mikhaylov	Contributor	University of Oulu
Giacomo Tavola	Contributor	Politecnico di Milano

## About AIOTI

AIOTI is the multi-stakeholder platform for stimulating IoT Innovation in Europe, bringing together small and large companies, start-ups and scale-ups, academia, policy makers and end-users and representatives of society in an end-to-end approach. We work with partners in a global context. We strive to leverage, share and promote best practices in the IoT ecosystems, be a one-stop point of information on all relevant aspects of IoT Innovation to its members while proactively addressing key issues and roadblocks for economic growth, acceptance and adoption of IoT Innovation in society.

AIOTI's contribution goes beyond technology and addresses horizontal elements across application domains, such as matchmaking and stimulating cooperation in IoT ecosystems, creating joint research roadmaps, driving convergence of standards and interoperability and defining policies. We also put them in practice in vertical application domains with societal and economic relevance.