Ref. Ares(2021)1654877 - 05/03/2021

D 1.2
Report summarizing main contributions to other WPs – First iteration

Action acronym	ConnectedFactories 2
Action Full Title	Global-leading smart manufacturing through digital platforms, cross-cutting features and skilled workforce
Grant Agreement Number	873086
Instrument	CSA: Coordination and Support Action
Deliverable Number	[D1.2]
Deliverable Title	Report summarizing main contributions to other WPs – First iteration
Work package	#1
Work package leader	TECNALIA R&I
Dissemination level[1]	Public
Type[2]	R
Due date according to DoA	M15
Actual submission date	March 5th 2021

[1] PU: Public, CO: Confidential, only for members of the consortium (including the Commission Services)

[2] RE: Report, OT: Other; ORDP: Open Research Data Pilot

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

VERSION MANAGEMENT		
	Name	**Beneficiary**
Author(s):	Luis Usatorre	TECNALIA
Contributor(s):	Alison Krauskopf, Olga Meyer, Jorge Martins, Katri Valkokari, Chris Decubber, Carlos Montalvo. Kosmas Alexopoulos, Ulrich Seldeslachts, Luis Usatorre	MTC, Fraunhofer (FHG), VTT, EFFRA, TNO, LMS, LSEC, TECNALIA
Reviewed by:	Göran Granholm	VTT

List of Abbreviations:

The following is a list of initialisations and acronyms used within the body of this report.

TERMS, ABBREVIATIONS AND ACRONYMS	
CCF	Cross-Cutting Factor
CF1	Connected Factories 1
CF2	Connected Factories 2
CSA	Coordinated and Support Action
DMP	Digital Manufacturing Platform
EC	European Commission
GA	Grant Agreement / General Assembly
GDPR	General Data Protection Regulation
WP	Work package
ZDM	Zero Defects Manufacturing

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Table of Content

1 Introduction 9

1.1 Cross Cutting Factors definition 13

1.2 Cross Cutting Factors subdivision 14

1.3 Structured Wiki 14

1.4 Examples from projects (mapping of projects) introduction 14

1.5 Reference documents introduction 16

1.6 Digital Manufacturing Platform (DMP) Cluster 16

1.6.1 Events: 18

1.6.2 DMP Cluster meetings: 20

2 Added value and business models 22

2.1 General observations on added value and business models. 22

2.2 Reference documents on added value and business models 23

2.3 Examples from projects (mapping of projects) 24

2.3.1 EFPF- European Connected Factory Platform for Agile Manufacturing 27

2.3.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality 29

2.3.3 ZDMP – Zero Defect Manufacturing Platform 29

2.3.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences. 30

2.3.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks. 32

2.3.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories 34

3 Industrial agreement and Legal aspects 36

3.1 General observations on legal aspects. 36

3.1.1 Types of industrial relations 36

3.1.2 Challenges of I4.0 for data protection 36

3.1.3 Context of industrial “contract” agreements in relation to data generation, storage, transfer and analytics 37

3.2 Reference documents on legal aspects data protection and data flows. 38

3.2.1 European Data Strategy 38

3.2.2 European Data Governance (European Governance Act) 40

3.2.3 OECD Guidelines 40

3.2.4 European Data Protection Directive 41

3.2.5 Article 16 of the Treaty on the Functioning of the European Union 42

3.2.6 The General Data Protection Regulation 42

3.2.7 European Cybersecurity Act 43

3.2.8 Cybersecurity: EU COM Briefing 43

3.3 Industrial contract types 43

3.3.1 Digital industrial agreement common elements 48

3.3.2 Strategic alliances and Joint Venture common features (applicable to research ventures) 50

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 873086.

3.4 Examples from projects (mapping of projects) *51*
3.4.1 EFPF- European Connected Factory Platform for Agile Manufacturing 51
3.4.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality 51
3.4.3 ZDMP – Zero Defect Manufacturing Platform 51
3.4.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences. 51
3.4.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks. 51
3.4.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories 52

4 Standards 53

4.1 General observations on standardization. *53*

4.2 Reference documents on standards *54*

4.3 DMP Cluster WG1 Standardization *56*
4.3.1 Goals 56
4.3.2 Tasks 56
4.3.3 Meetings 60

4.4 Examples from projects (mapping of projects) *62*
4.4.1 EFPF- European Connected Factory Platform for Agile Manufacturing 62
4.4.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality 64
4.4.3 ZDMP – Zero Defect Manufacturing Platform 66
4.4.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences. 67
4.4.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks. 68
4.4.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories 69

5 Interoperability 70

5.1 General observations on interoperability *70*
5.1.1 INTEROPERABILITY at RAMI 4.0 Vertical layers 71
5.1.2 Interoperability at RAMI 4.0 Horizontal Hierarchy levels 75
5.1.3 Interoperability in IIRA: Layered databus and architectural pattern 77
5.1.4 Interoperability approaches and goals mapped on RAMI 4.0 80
5.1.5 Interoperability requirements 82

5.2 Reference documents on interoperability. *84*

5.3 Examples from projects (mapping of projects) *88*
5.3.1 EFPF- European Connected Factory Platform for Agile Manufacturing 88
5.3.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality 91
5.3.3 ZDMP – Zero Defect Manufacturing Platform 91
5.3.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences. 91
5.3.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks. 92
5.3.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories 95

6 CyberSecurity 96

6.1 General observations on cybersecurity *96*

6.2 Reference documents on cybersecurity *96*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

6.3 Examples from projects (mapping of projects) *96*
6.3.1 CS standards for projects to consider 97
6.3.2 CS standards, standardisation participation – cross project analysis (part 2) 97
6.3.3 H2020-ICT-08-2019 : Security and resilience for collaborative manufacturing environments 100
6.3.4 DT-ICT-02-2018 : Robotics – Digital Innovation Hubs (DIH) - TRINITY 104
6.3.5 EFPF- European Connected Factory Platform for Agile Manufacturing 107
6.3.6 QU4LITY – Joining forces towards an European Industrial Autonomous Quality 108
6.3.7 ZDMP – Zero Defect Manufacturing Platform 109
6.3.8 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences. 109
6.3.9 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks. 109
6.3.10 SHOP4CF – Smart Human Oriented Platform for Connected Factories 109

7 Humans and manufacturing 111

7.1 General observations on human aspects. *111*

7.2 Reference documents on human aspects. *112*

7.3 Examples from projects (mapping of projects) *112*
7.3.1 EFPF- European Connected Factory Platform for Agile Manufacturing 112
7.3.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality 112
7.3.3 ZDMP – Zero Defect Manufacturing Platform 113
7.3.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences. 113
7.3.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks. 114
7.3.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories 114

8 Conclusions 116

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

List of Figures

Figure 1: Connected Factories cross-cutting factors (CCF). 9
Figure 2: WP1 relationships 10
Figure 3: CF2 work package breakdown 11
Figure 4: Connected Factories pathway development 11
Figure 5: Different CCFs use in pathways 12
Figure 6: CF2 WPs relationship 13
Figure 7: Inter-relationship between CF1 and CF2 WP1. 13
Figure 8: Wiki view 15
Figure 9: DMP cluster WGs 17
Figure 10: Information as a third dimension of CIRCULAR ECONOMY 23
Figure 11: Mapping of the projects 25
Figure 12: Mapping of business models 26
Figure 13: EFPF architecture 28
Figure 14: KYKLOS4.0 collaborative architecture 31
Figure 15: DigiPrime collaboration network 32
Figure 16: DIGIPRIME federated view 33
Figure 17: DIGIPRIME CANVAS 34
Figure 18: Type of agreements 36
Figure 19: Industrial Digital Contract agreements 44
Figure 20: Venn diagram of technology, standards and interoperability. 53
Figure 21: Common standards mapping matrix (sample) 58
Figure 22: Current progress of the CWAs and standardization guidelines 59
Figure 23: EFPF - Standardization focus objectives (Source: EFPF, D11.11, Vs.1.0, p.9) 63
Figure 24: Standardization areas identified across RAMI 4.0 layers (Source: QU4LITY, D9.5, p.13) 65
Figure 25. ZDMP standardization goals (Source: ZDMP, D4.6a, Fig. 1) 66
Figure 26: 2030 vision for I4.0 (Source: Plattform 4.0) 70
Figure 27: Interoperability layers in RAMI 4.0 71
Figure 28: Interoperability comparison: MIDIH and RAMI 4.0 72
Figure 29: MIDH approach 72
Figure 30: Data mapped in RAMI 4.0 73

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Figure 31: MIDIH data approach 73
Figure 32: MIDIH data approach mapped in RAMI 4.0 74
Figure 33: AAS approach to interoperability 74
Figure 34: AAS approach mapped in RAMI 4.0 75
Figure 35: RAMI 4.0 horizontal layers - Hierarchy levels in RAMI 4.0 75
Figure 36: Sketch of different levels 76
Figure 37: Horizontal interoperability 77
Figure 38: IIRA-RAMI 4.0 relationship 77
Figure 39: Three Tier IIoT system architecture 78
Figure 40: RAMI 4.0 and the the 3Tier IIoT 78
Figure 41: Three-tier architecture and the functional domain mapping. 79
Figure 42: IIRA mapping 79
Figure 43 IIRA layered databus architecture 80
Figure 44: Mapping IIRA layered databus architecture in the RAMI 4.0 hierarchical layer 80
Figure 45: IIRA system characteristics 83
Figure 46: EFPF ecosystem architecture 89
Figure 47: Interoperable Data SPine 89
Figure 48: Interop SOA 90
Figure 49: Interop Data model 90
Figure 50: EFPF interoperability implementation 91
Figure 51: KYKLOS4.0 General Architecture 92
Figure 52: DIGIPRIME data management 93
Figure 53 The DigiPrime Data Platform Infrastructure (left picture) and the lifecycle of the DigiPrime data model (right picture) 93
Figure 54: DIGIPRIME key IT components 94
Figure 55: DIGIPRIME semantic infrastructure 94
Figure 56: DIGIPRIME services interoperability schema 95
Figure 57 assessment of CyberSecurity standards being used by the COLLABS project, indicating the main use of NIST and IEC62443, adding the perspective from UNECE 98
Figure 58 : assessment of security, safety and CyberSecurity standards investigated and applied in the SECOIIA-project, © SECOIIA project, 2021 100
Figure 59 : overview of the current SECOIIA CyberSecurity approach in progress identifying a wide area of focus areas for CyberSecurity both from a functional – operational perspective, system perspective,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

persons/personas perspective and trying to apply various technology, process and skills-considerations. © SECOIIA project 2021 101

Figure 60 : the CyberSecurity solutions approach by SECOIIA aiming to deliver impact on various interaction levels and for different identified entities which are involved in the manufacturing activities. © SECOIIA project 2021 101

Figure 61 overview of the multi-layer CyberSecurity approach on the different business challenges derived from the different manufacturing environments © COLLABS project 2021 102

Figure 62 the COLLABS three-layered architecture and the interconnectivity of different CS-components © COLLABS project 2021 103

Figure 63 : COLLABS technologies that will be applied in a series of scenario's, scenario's which can be run in the pilot manufacturing companies, but equally in other manufacturing and digital manufacturing environments. © COLLABS project 2021 103

Figure 64 : COLLABS insight in the functioning of the CyberSecurity runtime components and the relation between the core functionalities of the CyberSecurity activities that can relate to a wider CyberSecurity framework © COLLABS project 2021 104

Figure 65 the original assessment of the various components of the TRINITY project presented an alarming image of the CyberSecurity state of the various use cases during the first review period. This resulted in a holistic approach to all pilot actions to design ways to further improve the CyberSecurity standing © TRINITY project 2021 105

Figure 66 : series of actions to be followed by Digital Manufacturing transformation activities to harden the security layers of the various industrial components for automation and production. Specific attention was paid to the utilization of robotic systems which are either legacy environments working on industrial pc which have not been hardened, or the use of open source ROS (Robotic Operating System) – which is only gradually improving on CyberSecurity © TRINITY project, 2021 107

Figure 67: ACE Operator 4.0 Topology (modified from Romero et al (2016)). 111

List of Tables

Table 1: DMP Cluster projects overview. 16

Table 2. Crossover from DMP Clusters to CF2 WP1 Tasks. 17

Table 3: Key standards identified in CF2. 54

Table 4: Relevant CSA activities in the DMP Cluster. 60

Table 5: Interoperability approaches 81

Table 6: Interoperability goals 82

Table 7: Recent publications regarding interoperability 88

Table 8: Mapping of ICT-07 projects in CS standards 98

Table 9: New CS standards incorporated 99

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

1 Introduction

The aim of this work package is to identify and establish a structured understanding of key factors and new cross-cutting aspects on digitalization as well as reinforcing existing ones already defined in Connected Factories previous Coordinated and Support Action (CSA) project.

Connected Factories 1 (CF1) identified a number of key enablers and cross-cutting factors (CCF). These have been further refined in Connected Factories 2 (CF2) as shown in Figure 1

- Digital Tools and Technology (Technology – building blocks),
- Skills and Knowledge Transfer (previously skills and engineering tools and skills for the operation of the technologies),
- Business Models and Strategy (previously Business models / financial investment),
- Value Assessment and Optimisation (previously Added value / optimisation focus),
- Standards and Standardisation,
- Interoperability,
- Security.

These serve both as generic guidance for enterprises wishing to engage in a pathway towards digitalisation, and as a mapping/analysis framework for existing projects that serve as case studies. CCFs are key enablers that need to be systematically addressed in all the respective activities and deliverables.

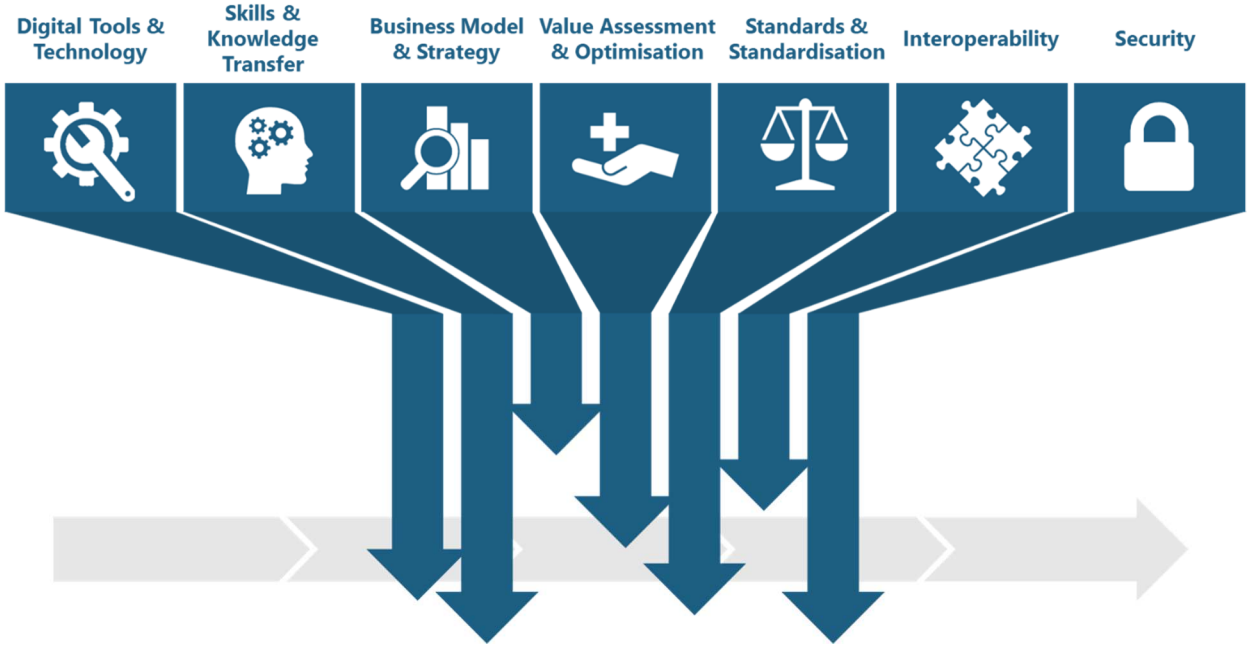


Figure 1: Connected Factories cross-cutting factors (CCF).

CF2 Work Package 1 (WP1) will focus on the following aspects that feed these CCFs:

- Added value and business models (Section 2);
- Industrial agreements and legal aspects (Section 3);

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- Standards and Standardisation (Section 4);
- Interoperability (Section 5);
- Cybersecurity (Section 6);
- Humans in manufacturing (Section 7).

WP1 (Cross-cutting Factors) has a close relationship with WP2 (Workshops), WP3 (Pathways) and WP5 (Skills and Transfer of Knowledge), as detailed in Figure 2 and Figure 3.

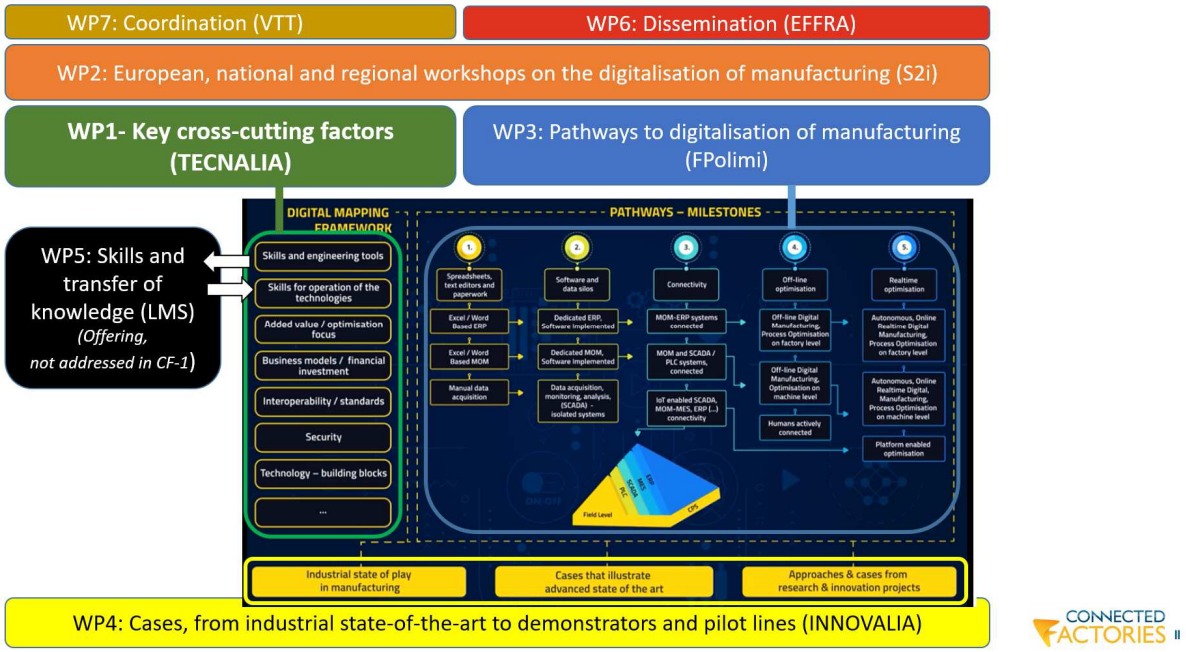


Figure 2: WP1 relationships

Within this framework, WP1 will study the building blocks that WP2 will use to develop the pathways. Those pathways will be broken down into five stages or levels of increasing maturity. The pathway will then be mapped across several key operations and milestones will be identified for each operation at each level (see Figure 3 and Figure 4).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

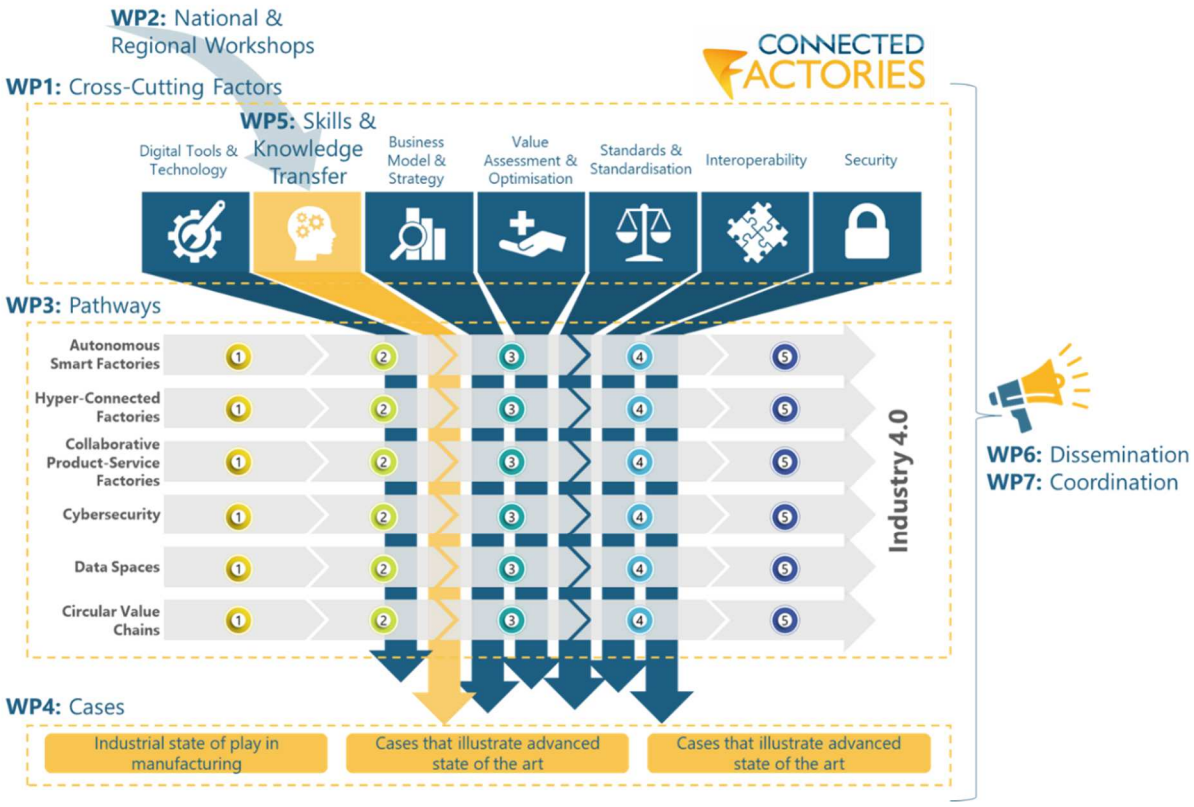


Figure 3: CF2 work package breakdown.

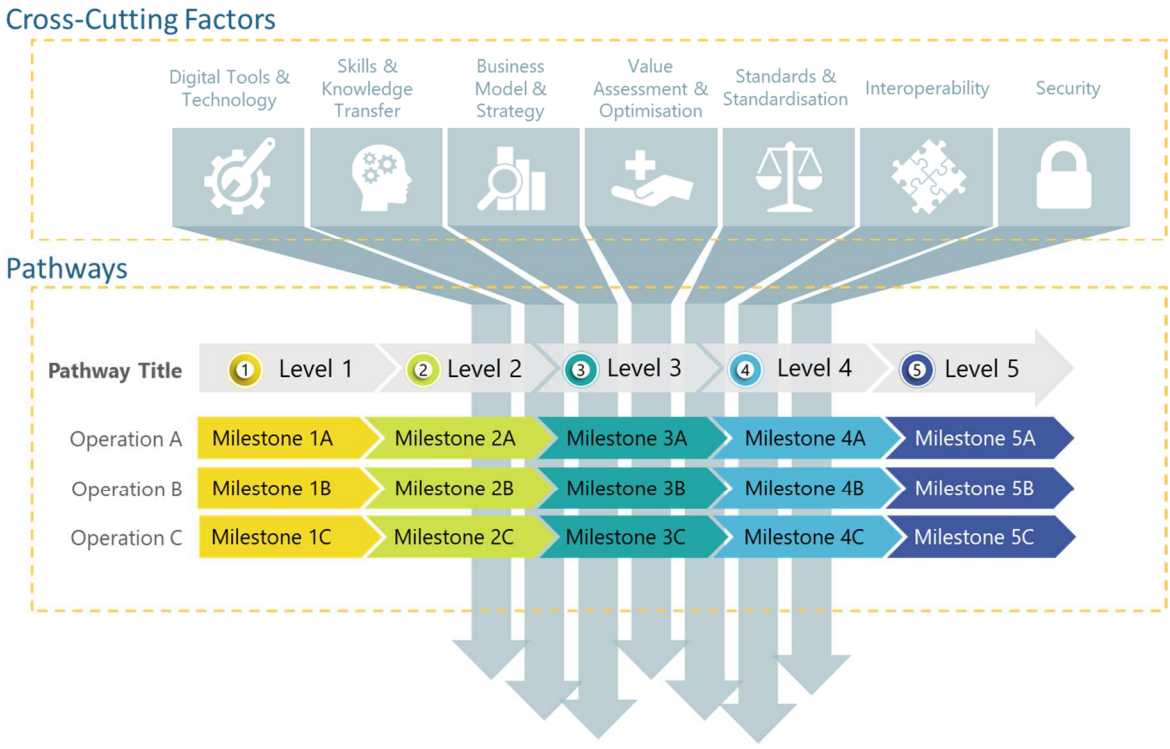


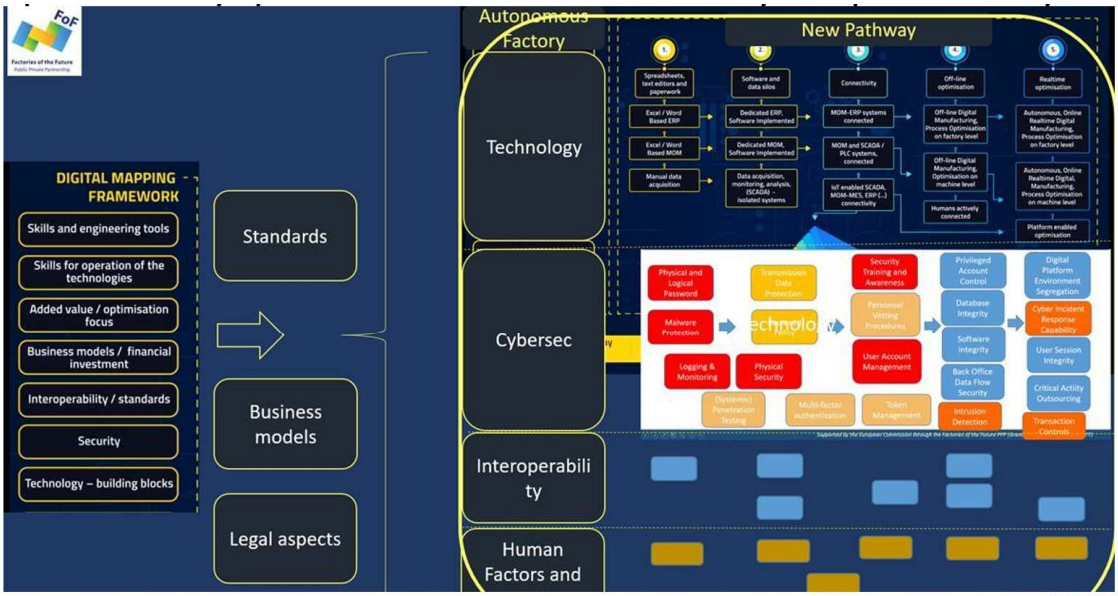
Figure 4: Connected Factories pathway development.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

At the beginning of the project, several questions were identified:

- Will the CCFs shape the building blocks of the pathways or become separate pathways?
- Are the CCFs common to all pathways or specific to certain ones?

An initial approach taken by CF2, as shown in Figure 5, was to identify standards, business models or legal aspects as key support tools for all of the pathways, to separate cybersecurity as an individual pathway, and to further investigate 'Interoperability' and 'Human Factors' as new pathways.



Supported by European Commission grant number 873086

Figure 5: Different CCFs use in pathways

In any case, it was agreed that answering these questions falls outside the scope of WP1. The role of WP1 role is to both feed WP2 and WP3 and receive feedback from them via national and regional workshops. See the explanation on the Figure 6 below:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

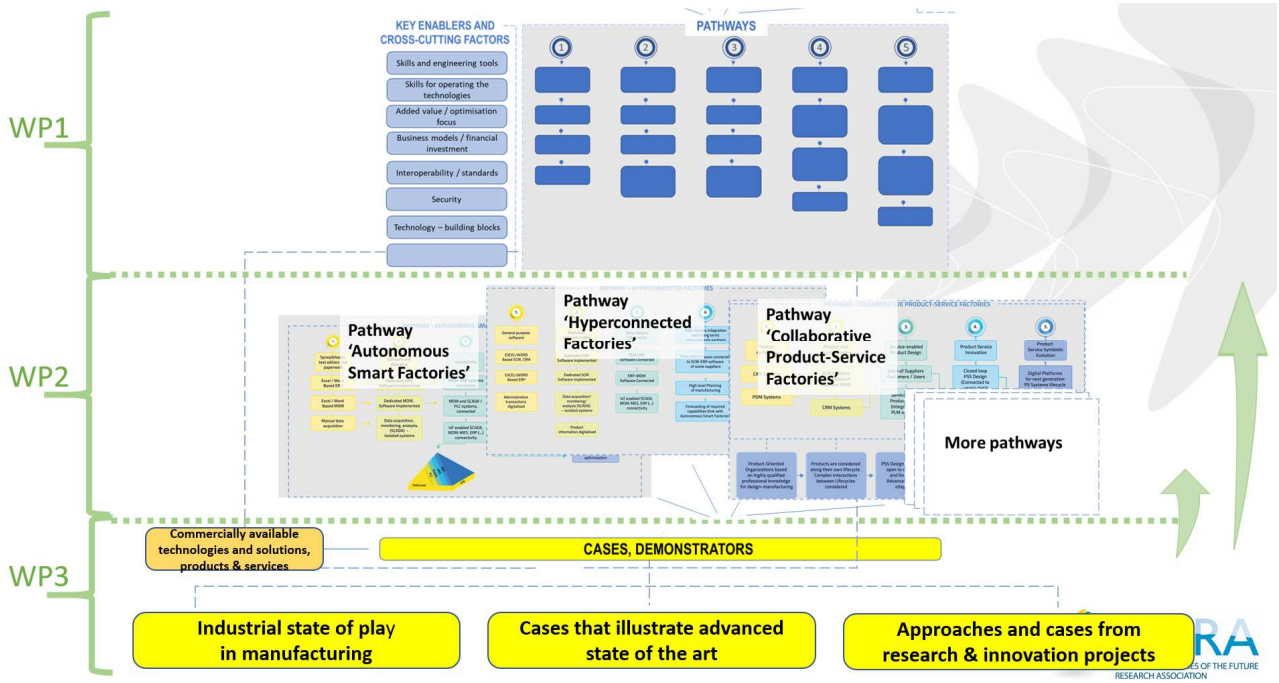


Figure 6: CF2 WPs relationship

This WP will build on top of Connected Factories 1 (CF1) outputs on business models, ownership, standardisation, security and liability. Some of the CCFs have already been discussed in CF1. Others are new. The relationship between CF1 and CF2 WP1 is depicted in Figure 7 below:



Figure 7: Inter-relationship between CF1 and CF2 WP1.

1.1 Cross Cutting Factors definition

The meaning of 'cross-cutting factors' within the context of the ConnectedFactories projects (1&2) and in particular in relation to the pathways to digitalisation of manufacturing has been described in CF1 - 'Deliverable 4.7 Revised set of consolidated pathways':

> *There are a lot of **cross-cutting aspects that enable progress along the pathways,** such as engineering skills and tools and also skills that are required for operating and managing the digital systems and tools.*
>
> *Another example are the many **technological building blocks** need to be put into place and need to be integrated: from data communication infrastructure such as fieldbuses, industrial wireless or*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

cabled networks to data storage, simulation tools, high performance computing, big data technologies, artificial intelligence, etc…

The ConnectedFactories project endeavours to cover all or at least the most important of these different aspects, which is implemented also as a self-standing ***structured glossary, which*** *is embedded in the structured wiki of the EFFRA Innovation Portal.*

1.2 Cross Cutting Factors subdivision

Each sections of this deliverable is structured according to CCF subdivision. In most of the cases, the CCF has been subdivided in a different way from the one already done in CF1. The reasons are thoroughly explained in each chapter.

1.3 Structured Wiki

The wiki is the part of the portal that includes the structured items ('taxons') with an short explanation and some references to key resources. The wiki is accessible at: https://portal.effra.eu/wiki.

The wiki is software and has been identified as D.1.1 OTHER in the DoW. **D1.1** describes the modifications on the wiki for each of the CCFs.

Projects and their use case can be described (mapped) using these items (taxons) as framework and this is then visible in different ways in the EFFRA Innovation Portal (for instance like this).

In this deliverable 1.2, this mapping is initially presented. It must be highlighted that some of the projects are just started so the information is still not relevant, so that only some project and cases have been mapped on the portal. (This information can even be extracted from the portal).

1.4 Examples from projects (mapping of projects) introduction

There is a need for a solid structured approach for describing and analysing solutions and approaches to digitalisation of manufacturing, including the deployment of digital manufacturing platforms. Therefore, one of the activities of the ConnectedFactories Coordination Action is **gathering of the key information** about projects, enablers, and cross-cutting aspects.

For example, **engineering skills and tools** are required and employees need to have adapted skills for operating and managing the digital systems and tools.

Another important aspect is the **value or benefit** obtained while progressing towards the right hand side of the pathway. For instance, the factory would gain responsiveness and speed, improved quality and reduced down-time, resource-efficiency. These gains do not only apply to the milestones on the right side, but also to the milestones that are situated on the left-hand side.

These benefits will need to be compared to the financial resources or **investment needed**.

From a more technical point of view, **interoperability** is extremely relevant; not only since systems and since tools will very likely come from **different vendors**, but also since many **legacy systems** have to be integrated. In addition, many **technological building blocks** need to be put into place and need to be integrated: from data communication infrastructure such as fieldbuses, industrial wireless or cabled networks to data storage, simulation tools, high performance computing, big data technologies, artificial intelligence, etc…

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Security is a requirement that may become increasingly important while progressing on the pathway. (More information about a workshop held in October 2018 can be found here)

The following video presents a guidance on how to Map projects and use cases on the cross-cutting aspects (which builds on the content of WP3) and Cases with commercial approaches.

https://www.youtube.com/watch?v=sodfn_RI5u4

The following links lead to search results on project level and result-demonstrator level on the EFFRA Innovation Portal for a number of aspects that are crucial .to the development and deployment of digitalisation in manufacturing:

- Cybersecurity – **project search** – **results and demonstrator search**
- Interoperability – **project search** – **results and demonstrator search**
- Business model aspects – **project search** – **results and demonstrator search**
- Humans and digitalisation aspects – **project search** – **results and demonstrator search**
- Architectures – **project search** – **results and demonstrator search**

Cross-cutting aspects are described through a comprehensive set of structured lists, which also can be seen as a self-standing 'structured glossary'. These lists are included in the structured Wiki (see picture below) of the EFFRA Innovation portal, such that the collection and sharing of information about R&D projects, demonstrators and use cases is more structured and accessible.

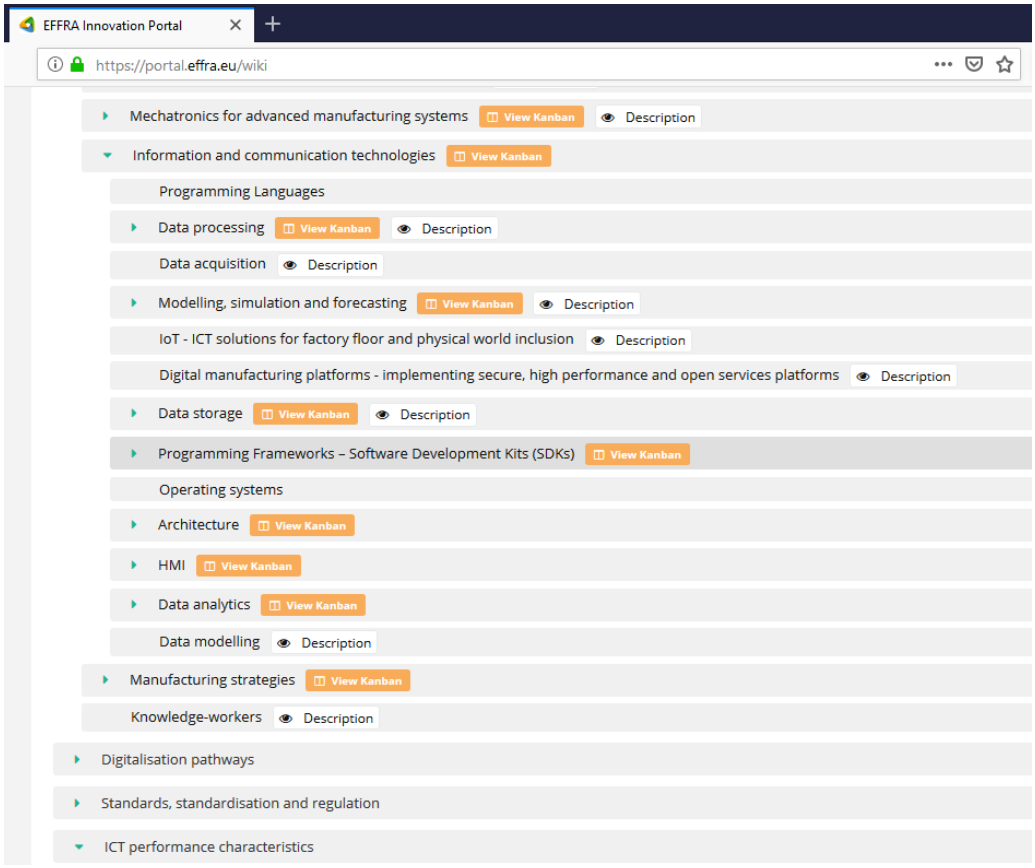


Figure 8: Wiki view

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

1.5 Reference documents introduction

In each of the chapters, the reference documents related to each CCF are named.

In the following video, it is possible to view how to Create reference documents as results and tag these as ReferenceDocuments: https://www.youtube.com/watch?v=l8eb8uT_S1s

1.6 Digital Manufacturing Platform (DMP) Cluster

Projects financed under the call "H2020-DT-ICT-07-2018- 2019 have created a cluster called "Digital Manufacturing Platforms for Connected Smart Factories". Its objective is to define a common cluster strategy for cooperating, dissemination and outreach of the cluster projects results.

The following Table 1 shows the projects' names, acronyms, coordinators and their details.

Name	Acronym	Coordinator	Logo	Coordinator contact
European Connected Factory Platform for Agile Manufacturing	eFactory	AIDIMME - Instituto Tecnologico Valencia	eFactory	Maria Jose Nunez; Usman Wajid
Zero Defect Manufacturing Platform	ZDMP	Information Catalyst	ZERO DEFECTS Manufacturing Platform ZDMP	Stuart Campbell
Joining forces towards an European Industrial Autonomous Quality	Qu4lity	ATOS	QU4LITY	Jorge Rodriguez
An Advances Circular and Agile Manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualised consumer preferences	Kyklos 4.0	TECNALIA	KYKLOS 4.0	Jason Mansell
Digital Platform for Circular Economy in Cross-sectorial Sustainable Value Networks	digiPRIME	POLIMI	DigiPrime	Marcello Colledani
Smart Human Oriented Platform for Connected Factories	SHOP4CF	TECHNISCHE UNIVERSITAET MUENCHEN	SHOP4CF	Meri Maghlakelidze

Table 1: DMP Cluster projects overview.

Initially, the DMP cluster had defined the following working groups (WGs):

- WG1 Standardisation; (direct match with CF2 CCFs)
- WG2 Dissemination; *
- WG3 Joint Research; *
- WG4 Performance; *
- WG5 Business; *(direct match with CF2 CCFs)
- WG6 Open Calls; *
- WG7 Platforms; *
- WG8 Pilots; *

** for cross-domain DT topics OPEN DEI CSA can be addressed*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

During the initial phase of the DMP cluster, there were direct links amongst these working groups and the CF2 WP1 cross-cutting factors. CF2 took the opportunity to discuss this undertaken during the joint meetings that were held with representatives of the DMP cluster and CF2 task leads. As the result, the mapping matrix has been established and the responsible task leads could be identified for the further transfer activities (see the Table 2).

DMP CLUSTER		CF2 WP1 TASKS	
WG	**LEADER**	**TASK**	**LEADER**
•WG1 Standardisation; *	Ingo Martens Olga Meyer	**•Task 1.3 Standards (task lead Fraunhofer)**	OLGA MEYER
•WG2 Dissemination; *	Joao Sarraipa UNINOVA	**WP6 - Dissemination**	EFFRA
•WG3 Joint Research; *	Joao Sarraipa UNINOVA Usman Wajid (ICE)		
•WG4 Performance; *	Usman Wajid (ICE) Luis Usatorre (DIGIPRIME)		
•WG5 Business; *	Gerardo Pagalday IKER	**•Task 1.1 Added value and business models (task lead VTT)**	**•VTT** -INNOLAB +INESC+STEINBEISS + RISE
•WG6 Open Calls; *	Carmen Polcaro INNOVALIA		
•WG7 Platforms; *	Usman Wajid (ICE)		
•WG8 Pilots; *	Carmen Polcaro INNOVALIA	**WP3 - Use cases**	INNOVALIA
		•Task 1.2 Industrial agreement and **Legal aspects**	TNO
		•Task 1.4 Interoperability (task lead Tecnalia)	TEC +FHG +CEA + UNOTT
		•Task 1.5 Cybercsecurity (task lead LSEC)	LSEC
		Task 1.6 Humans and manufacturing (task lead LMS)	**LMS** +MTC+SIRRIS+I.4.0+POLIMI

Table 2. Crossover from DMP Clusters to CF2 WP1 Tasks.

So, in recent discussions of the DMP cluster, the WGs have been accordingly realigned. Find here down (Figure 9) the new structure:

DMP Cluster Working Groups

- ❑WG1 - Standardisation
- ❑WG2 - Dissemination
- ❑WG3 - Scientific and Socio Economic Impact.
- ❑WG4 - Experimentation
- ❑WG5 - Platforms and Architectures

Figure 9: DMP cluster WGs

Find here down a list of the main events and workshops interacting CF2 and DMP cluster.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

1.6.1 Events:

1.6.1.1 Standards for digital manufacturing Webinar:

When: 20 October 2020

Short description: The Webinar focused on use cases and best practices that illustrate how standards are used in research & innovation in digital manufacturing. Special attention has been dedicated to the added value as well as gaps and needs.

- 236 Registrants
- 128 Participants

Agenda: https://cloud.effra.eu/index.php/s/3ZSPeg9tsLr0IXw

09:30 – 09:45	Participants connecting to the webinar
09:45 – 09:55	Opening – Overview of the Agenda
09:55 – 10:10	Industrial requirements for standards in manufacturing by Michel Iñigo Ulloa, MONDRAGON Corporation
10:10 – 10:30	ISO 10303 in EU projects like Kyklos4.0, Arrowhead Tools, Change2Twin by Kjell Bengtsson, Jotne
11:30 – 11:40	Standardisation and Research & Innovation, Luc Van den Berghe, CEN- CENELEC
11:40 – 11:50	The Digital Manufacturing Platform Cluster (DMP Cluster) and standardisation, Olga Meyer, Fraunhofer IPA
10:50 – 11:35	More use cases and pilots: how standards are used, identified gaps EFPF, Standards as trusted glue to federate digital platforms in the digital manufacturing domain, Karl Grün, Austrian Standards ZDMP, Standardisation Activities and the Role of CEN-CENELEC Workshop Agreements, Christian Grunewald, DIN QU4LITY, Application of Reference Architecture Model (IDS-RAM), Giulia Giussani, IDSA
11:35 – 11:50	The new edition of the German Standardisation Roadmap Industry 4.0 by Olga Meyer, Fraunhofer IPA, head of the Working Group Standardization Roadmap at Standardization Council Industrie 4.0
11:50 – 12:05	Cybersecurity standards and de-facto standards relevant for digital manufacturing by Ulrich Seldeslachts, LSEC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

12:05 – 12:10	Collection and analysis of standards by ConnectedFactories, Chris Decubber, EFFRA
12:10 – 12:30	Q&A

Presentations: https://cloud.effra.eu/index.php/s/gPgyduCZldwbY6g

Recordings: https://www.youtube.com/playlist?list=PLpaccoqg8rxav7-sdcOIkTuDMe-Kb7g7

1.6.1.2 Cybersecurity Workshop:

When: 20 January 2021

Short description: The online workshop has provided an insight into the recent developments of projects that focus on cybersecurity in manufacturing: SeCoIIA and COLLABS project and into how cybersecurity aspects are addressed in other projects that focus on the digitalisation of manufacturing and the deployment of digital platforms. In addition, the workshop has provided an insight into European and international industrial cybersecurity standard (including de-facto) developments.

- 118 Registrants
- 65 Participants

Agenda: https://cloud.effra.eu/index.php/s/pbiKdHxSlMvFmd8#pdfviewer

09:45-10:00	Participants connecting to the webinar and opening with the overview of the agenda
10:00-10:10	Welcome & introduction by **Ulrich Seldeslachts**, CF2 - LSEC
10:10-11:40	**European industrial CS standard (and de-facto) developments:** - ENISA Industrie 4.0 developments & CyberAct Certification : **Renate Verheijen**, ENISA - Current focus of the working group and sub-working group and on international cooperation: **Detlef Houdeau,** Member of the Networks Systems Security, Platfform Industrie 4.0, Germany -
11:40-14:20 11:40-13:20	**European Digital Manufacturing Projects activities on CyberSecurity & Certification** - **Digital Manufacturing Project work on Cybersecurity** 1. QU4LITY, **Trujillo Salvador** & **Jose Francisco Ruiz** 2. ConnectedFactories2 3. SHOP4CF, **Morten Kühnrich** 4. ZDMP, **Artem Nazarenko**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

13:20-14:20	5. Other European projects with relevant security standardization works Panel discussion - **European Cybersecurity for Manufacturing projects** 1. CyberSecurity developments and Standards analysis by SECOIIA, **Reda Yaich** 2. CyberSecurity developments towards standardization by COLLABS, **Armand Puccetti** Panel discussion
14:20-16:00	**International industrial CS standard developments** - SBOM – Security Bill of Materials, **Allan Friedman**, NTIA - CSA IoT Taking Control of IoT - **Brian Russell**
	Panel discussion
16:00	**Close the webinar**

Presentations: https://cloud.effra.eu/index.php/s/pbiKdHxSlMvFmd8

Recordings: https://www.youtube.com/playlist?list=PLpaccoqg8rxaSN-DbE3frMjJBEBUE7h7a

1.6.2 DMP Cluster meetings:

- **DMP Cluster meeting**
  - When: 25 September 2019, During the World Manufacturing Forum
  - General information: among the 3 DT-ICT-07-2018 projects Qu4lity, ZDMP, EFPF
- **DMP Cluster + CF2 meeting** (online) - facilitated by ConnectedFactories 2
  - When: 12 March 2020
  - General information: 38 Registrants - 35 Participants
- **DMP Cluster + CF2 meeting** (online) - facilitated by ConnectedFactories 2
  - When: 4 June 2020
  - General information: 58 Participants
- **DMP Cluster + CF2 meeting** (online) - facilitated by ConnectedFactories 2

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- When: 25 September 2020
- General information: 48 Participants

- **DMP Cluster + CF2 meeting (online)** - facilitated by ConnectedFactories 2
  - When: 2/3 December 2020
  - General information:
    - 02 December 2020 – 45 participants
    - 03 December 2020 – 49 participants
  - Presentations:
    - 02 December 2020:
      - https://cloud.effra.eu/index.php/apps/files?dir=/CF2_Cluster/Meetings/20201202_CF_DMP_Cluster_Plenary&fileid=8941
    - 03 December 2020:
      - https://cloud.effra.eu/index.php/apps/files?dir=/CF2_Cluster/Meetings/20201203_CF_DMP_Cluster_Plenary&fileid=8948
  - Recordings: https://www.youtube.com/playlist?list=PLpaccoqg8rxah7W6Nzi_yjTwHXL01uF6U

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2 Added value and business models

Implementation of digital technologies in manufacturing companies is very much related with the renewal of their business models, or digitalization is seen as a means to implement the business model at hand.

The purpose of the section is to review and understand the prevailing and future business models[3] that are relevant to manufacturing in order to understand their linkage to other success factors. These future business models include examples of the following: cloud-based business models, platform-based business, product-service models, manufacturing as a service as well as business models related to transition towards Circular Economy (CE). Strategic perspectives and cost- and benefit-sharing between actors in CE will be payed attention to, i.e. different earning logics such as renting, payment according to performance, use, profit, availability.

The benefits and difficulties of adopting new business models enabled by digitalisation and circular economy will be analysed further. Therefore, commonalities and differences in the digitalization process of different types of companies in different markets and different sectors will be investigated (see section 2.3 positioning of the cluster projects). As for the other key enablers and crosscutting factors, there is a section on Business models in the structured wiki of the EFFRA Innovation Portal. Based on the analyses, the portal will be enriched with a number of new examples of business model change enabled by digital transformation.

Task 1.1 has deepened and updated the insight into the role of business models for digitalised manufacturing and in particular in relation to the deployment of digital manufacturing platforms and CE business models.

2.1 General observations on added value and business models.

In traditional manufacturing network, operations of suppliers, lead producers (such as OEMs) and customers are seen as independent sequential tasks, which form a value chain. Already since the 1990s, however, this pattern has been changing and the theoretical discussion has emphasised the transfer from value chains to value networks. The trend among customers, lead producers (OEMs), and suppliers seems to be to engage in forward transfer in their value chains. This means that customers, lead producers or OEMs outsource manufacturing (give up earlier value chain phases), and their suppliers have increased services (add later value chain phases and give up some of the earlier phases). Concurrently, the interpretation of value has changed, and the intangible aspects of value added have emphasized.

Interdependency of operations and co-creation between the actors have been emphasized from several theoretical viewpoints, such service and data business. Furthermore, digitalisation of manufacturing networks has enhanced and enabled the change in roles as well as transparency in networks. Adoption of technologies also indicate evolutions regarding business models and, on the other hand, business models typically cause challenges or requirements to the technologies. As an example, CE business models pose requirements to digital platforms in terms of transparency in the value chain or to application interfaces to enable industrial symbiosis. In particular, Circular Economy business models will be analysed including network approaches integrating both upstream and downstream dimensions towards CE within the overall product life cycle (closed-loop supply chain, remanufacturing, recycling, and other activities. When possible, examples of transformation from manufacturing driven business towards innovation driven service business will be highlighted.

[3] A business model describes the rationale of how an organization creates, delivers, and captures value, in economic, social, cultural or other contexts. Business model can be seen as an integrating element between strategy and operations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.2 Reference documents on added value and business models.

CE has the potential to revolutionize many industries as companies begin to develop their business models around the ideas of extending product life cycles, expanding from products to services, and focusing on renewability and resource efficiency, or closing the loop. The use of data and IT has the potential to change the way value is created and to enable better resource efficiency for business. Many CE solutions are supported or even enabled by data and digital platforms. They ensure the availability, reliability, and transparency of the solutions to the relevant actors and stakeholders. Therefore, the traditional presentation of two CE circles (biological and technical cycles) could be complemented with the third necessary cycle of the CE: the information cycle (see Figure 1, presented by Valkokari et al. 2019[4]).

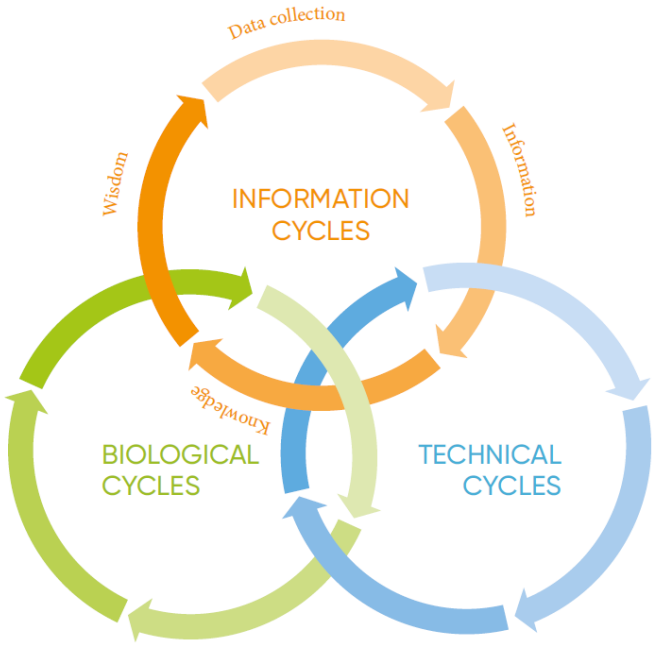


Figure 10: Information as a third dimension of CIRCULAR ECONOMY

A manufacturing company, in order to become more circular from typically quite an linear operation models of manufacturing networks, needs to first make strategic decision and consider renewal of its business model and modify its culture moving towards a sustainable attitude and understand the core of the CE principles. Embracing these principles require to modify internally the companies' business model, anyhow, there are several possible ways to change. Indeed, only once strategic agenda and the mind-set on the entire company (and its network) has been changed, it is possible to efficiently move towards the adoption of Circular Manufacturing strategies (such as closing-the-loop or remanufacturing). Furthermore, the change of their current business model quite often requires also change on position within value network or even broader change (or disruption) of network.

[4] *Valkokari, P et al. (2019). Advancing Circular Business.*

https://www.vtt.fi/sites/datatowisdom/PublishingImages/publications/FINAL%20Advancing%20circular%20business.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.3 Examples from projects (mapping of projects)

Industry 4.0 technologies contribute to sustainable operations management decisions and new business models through integrating value chains based on data collection and data sharing. Following this principle of sustainability-oriented management of manufacturing operation highlights the connection between digital manufacturing platforms and circular economy approaches.

In practical terms, this entails an integration of the more traditional understanding of efficiency management with a more comprehensive awareness of production operations impacts on the environment, giving way to the emergence of sustainable products, sustainable production processes, and sustainable logistics decisions.

From the perspective of efficiency management, the combination of technical enablers such as CPS, IoT, and smart factories introduces a shift from mass production to mass customisation, enhanced coordination between demand and supply, and the transformation of linear supply chains into digitally connected value networks. The search for added value by manufacturing firms aiming at closer customer contact, more stable revenue streams, and improved resource utilisation is also shifting their role from product seller into becoming solution and service providers.

The variety of business models therefore ranges from isolated use of data for differentiation (where the product is the primary source of value and product data is used strategically to improve both product and service offerings) to a gradual transition to combining data from multiple sources to create additional value. The latter ultimately leads to platform-based delivery networks where companies collaborate to leverage data opportunities to reduce costs and extend product-service offerings.

Our theoretical synthesis of the projects proposes an evolutionary identification of value generation conceptual components. The general view is that the components illustrate each project's focus by describing the dominant logic they apply both to capturing economic value and to create value to customers. This is a typological flexible view that outlines components in a value-oriented activity system that is made up of interdependent activities, where possible configurations build-up on each other and grow in complexity.

The positioning of projects in the matrix (Figure 11) reflects the intersection of two main dimensions: (1) the use of digital technologies to exploit and explore information on manufacturing processes and the performance of manufacturing equipment; and (2) the applied use of that information to strategically direct either the improvement of existing cycles or the creation of new cycles.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

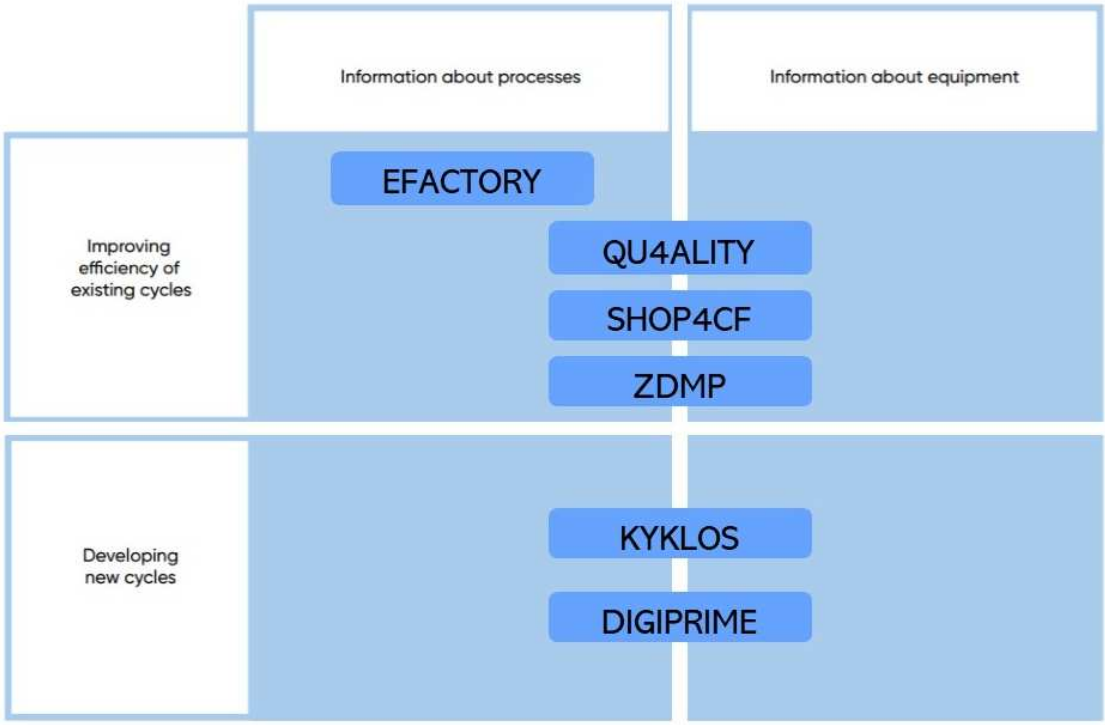


Figure 11: Mapping of the projects

At the level of the two top quadrants, value creation and delivery is determined by a focus on streamlining resources and capabilities, channels, partners and technology for the maximisation of efficiencies. At the level of the two bottom quadrants, value is mapped to different value circle actors (suppliers, partners, competitors, and customers) to attain a novel sustainable value proposition.

Crucially, across all projects the focus is on the optimisation of the value creation architecture in terms of key resources and activities. This entails the use of new enabling technologies increasing efficiency and improving performance at the levels of reducing costs, time and manufacturing failures. Value creation occurs through production, logistics management and quality control that become more efficient. Machine to machine interaction controls internal processes and connects them with suppliers. The delivery of value is on the individualisation and customisation of production.

In addition, common across projects, is the aim to enhance the delivery of value through better understanding of customers' needs and experiences, achieved through data analysis-based segmentation and improved self-service digital channels that aim to implement new revenue streams, generate time, and cost savings. This is particularly evident in the EFPF project.

Emphasis on platforms that collect information about the use of physical assets and make this information available for further processing are also a common feature of the projects. In particular, the emphasis is on the technical implementation of platforms that collect information about manufacturing processes and potentially about products throughout their entire lifecycle, so

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

manufacturing firms can exploit additional revenue sources through offering data-driven services and act on feedback to improve process and product (e.g. projects QU4LITY and ZDMP). However, there is also concern with the development of platform infrastructure that allows the deployment of human-centric industrial applications, combining in a complementary way machine capability such as high accuracy and precision, with human assets such as creativity and adaptability (project SHOP4CF).

Finally, a set of projects takes a differentiated look at new value creation models where data and services become products in themselves, composing new value circles through new channels, new markets and customers. Thus, the project KYKLOS looks at product servitisation strategy through the proposal of maintenance services, and product recycling/ reuse. Project DIGIPRIME, on the other hand, supports the future systematic creation of cross-sectorial circular value-chains for the remanufacturing and re-use of high added-value components.

On a second level of analysis, Figure 12 below further develops the conceptualisation of the integration of digital manufacturing platforms and CE business models. This is premised on the transformation of the way in which resources are utilised, i.e. the goal is closed production systems where resources are reused and kept in a production/ consumption loop that maximises the efficient use of resources through product-life extension, redistribution/reuse, remanufacturing, and recycling. Again, possible configurations determine a company's positioning along what might be considered an evolutionary pathway with increasing levels of complexity, supported by a close integration of the biological, technical and data cycles introduced in 2.2.

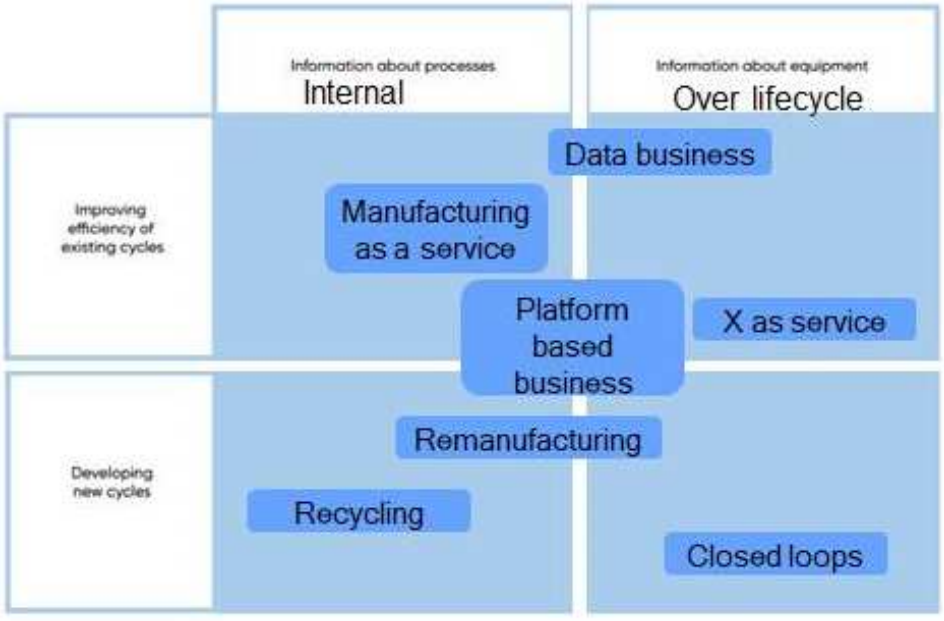


Figure 12: Mapping of business models

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Data business concerns the adaptation of design and product decisions based on the active use of planning, monitoring and control data (e.g. in the form of sensors and apps), in a manner that reduces resource consumption to improve manufacturing productivity.

'Manufacturing as a service' and 'X as a service' trigger the shift from resource- and order-orientation towards service- and requirements-orientation. This is possible because of platform-based business that enables parties to connect and share information related to supply and demand. In addition, based on parameters of resource production and consumption, firms can monitor and control the performance of operations, intervene in the process and assess in real time the performance of machines, in order to plan adequate maintenance.

The use of similar sensor technology for performance monitoring is also fundamental for 'Remanufacturing', where the goal is failure detection without the need to completely disassemble the product or components for effective repair; as well as for 'Recycling', where the tracking, recycling and management of manufacturing materials and waste are optimised. In both cases, the production and logistics of sustainable operations management are adaptable and based on the data provided by the resources of cyber-physical systems.

Finally, 'Closed Loops' represents the broadest perspective on circular economy, with greater emphasis on significant extension of energy and materials circularity and a comprehensive use of data. The latter is used to inform not only production, but also on product use (i.e. through products embedded with information on components, materials, disassembly and recycling) and post-consumption logistics to enable manufacturers to more easily reuse, remanufacture, or recycle components of the product and its packaging.

2.3.1 EFPF- European Connected Factory Platform for Agile Manufacturing

The EFPF project has established a federated digital platform to interlink manufacturing platforms, smart factory toolsets and Industry 4.0 concepts through an interoperable data spine (Figure 13). This is enabling an ecosystem of small smart factory platforms to compete and cooperate to deliver customer value. An integrated EFPF Platform and Marketplace interlinks digital manufacturing platforms, smart factory tools and Industry 4.0 concepts. Unified access and single-sign-on is provided to interoperable tools and services. Cross-domain embedded pilot cases demonstrate how the integrated marketplace framework connects with external marketplaces in the EFPF ecosystem using API interfaces. This allows the filtered listing of products from external marketplaces. An agent-based marketplace performs marketplace negotiations in online bidding processes, therefore automating existing manual procedures. In terms of governance, the European Factory Foundation was established as a legally independent body that maintains, manages and grows the EFPF digital platform and federated ecosystem, with an emphasis on growing business opportunities for members and maximise trade, connectivity, communication and interoperability across the ecosystem.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

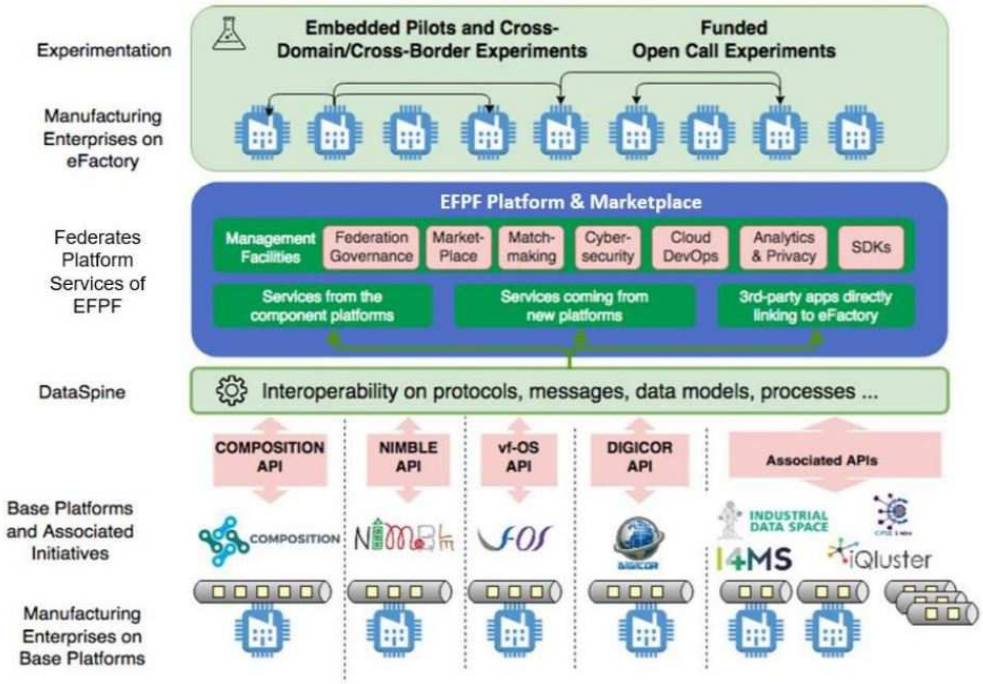


Figure 13: EFPF architecture

The federated marketplace infrastructure presented in figure above set up by the project allows multiple marketplaces to be connected. This provides a unified interface to multiple marketplaces, from where it is possible to search for different products listed on different marketplaces, and complete transactions. A back-end business mechanism allows the economic interactions between different marketplaces, so if a transaction is made through the marketplace, a commission is taken. The platform provides federated search mechanisms, so a manufacturing firm can search for a product on four connected marketplaces. This is a brokerage business model, as the platform allows connectivity between different types of products, different types of systems, platforms and protocols. The platform's data spine enables connectivity and interoperability between different existing systems and platforms, all of which with their own business models and their own user communities. Not being focused on developing the tools and services that other platforms would define as their value proposition, EFPF is focused on developing a brokerage model that enables connectivity between different kinds of existing systems, where the value is in enabling different systems to communicate, and different user communities to use the functionalities and services from different platforms.

An example can be found in data management platforms focused on zero-defect manufacturing, which are implemented within a shop floor environment, where manufacturers can see that the production system is relying on tools or services originating in a supply chain. In order to ensure consistency and quality in products, it is necessary that the supply chain is aware of quality constraints put in place for the product, and that there is compliance with regulations and certifications. EFPF has developed an end-to-end supply chain management solution that ensures compliance and transparency, as well as visibility of activities that are taking place across supplier

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

network. Manufacturers can connect their quality system with the supply chain management system and connect suppliers with their supply chain management system to make sure that the products that on the shop floor are compliant and developed in completeness with ability and transparency, following specified protocols. So being part of a federation, that solution should be accessible to the DMP users because it becomes searchable on the marketplace.

2.3.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality

QU4LITY provides factories and manufacturing equipment vendors a one stop-shop platform for a comprehensive assessment of autonomous quality processes and digital continuity enablers focused on the deployment of zero-defect manufacturing. QU4LITY relies on an ecosystem of orchestrated open platforms that span all phases of product and lifecycle to leverage advanced autonomous decision and control loops— i.e. multi-stage deep process analytics, digital twin orchestration and simulation-based control, embedded intelligence and real-time control, as well as augmented human-centred decision support capabilities. Drawing on fourteen pilot lines, the ecosystem demonstrates a standardised and certifiable, data-driven zero-defect manufacturing product and service model, which effectively operates a shift from current production quality methods into the disruptive concept of autonomous quality. This enables manufactures and solution providers to develop, validate, deploy and adopt cognitive collaborative quality assurance solutions throughout an entire supply chain, ultimately leading to cost and resource-efficient goods that are responsive to market and customer needs.

Q4ALITY's platform business model is premised on the concept of a one-shop-stop marketplace for autonomous zero-defect manufacturing solutions, providing a single-entry point to the project's intellectual property, and allowing users to explore, access, test and market services and solutions, as well as to access a portfolio of potential clients and partners. Alongside network building and the facilitation of collaboration of matchmaking, the interoperability of solutions and their compatibility with recognised standards are at the core of the platform's value proposition. A concrete example of the platform's impact on the project's pilot business models is the integration of novel analytical conformity inline inspections systems within the production line of (industrial ceramics manufacturer). Q4LITY is enabling the implementation of in-line automation components that are capable of automatically removing defective produce from production lines and introducing recycling/ re-introduced raw materials into the production line. In practical terms, this means that this novel in-line automation component is not only capable of early of early product defect detection and warning, but also of self-readjusting for corrective action, therefore effectively increasing the overall production effectiveness through facilitating process adjustment decisions.

2.3.3 ZDMP – Zero Defect Manufacturing Platform

ZDMP is developing a digital platform for connected smart factories to enable excellence in manufacturing through zero-defect processes and zero-defect products. The project connects end users' systems (e.g. shop-floor and Enterprise Resource Planning systems) to enhance product and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

production quality assurance through data acquisition into a ready-built, open, reference platform, which ultimately simplifies the development of zero defect applications to deliver enhanced business value comparatively to do-it-yourself platforms. ZDMP has a value-chain focus that ensures the quality of a product through deploying modelling, detection, inspection and predictive techniques. Starting with the automotive, electronics, machine tools and construction sectors, the initial ecosystem will be extended through open calls that will allow SMEs and start-ups to produce, pilot and adapt technical solutions through the platform.

Aiming to service the whole manufacturing community irrespective of specific sectors, the project is concerned with making applications from technology components – software and hardware - which are able to improve the processing of products and improve quality. The components are of a generic nature and encompass messaging, data transfer and analytics related to process or product quality. There is a focus on specific zero-defect software components and inspection algorithms for process optimisation, the core principle being that other actors can take and build them into applications, which are then sold on the project's marketplace. The solutions developed through the project in terms of components will enable applications to be built faster, especially originating in small-size software companies, which provide services to manufacturing companies in a quicker way that is often developed in conjunction with existing customers and then placed on the marketplace. The effect of a more accelerated development of tools and components achieved through the project is that it contributes to an overall more cost-effective solution acquisition through the reduction of development and ownership costs. Post-project business sustainability will be assured by the constitution of IPFS, a company managing the project's IPR and operating as a marketplace. Taking commissions on applications sold, the marketplace will provide an environment where developers can acquire components, build new applications and put them back on the marketplace.

2.3.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences.

KYKLOS4.0 is focused on the development of an ecosystem that autonomously creates the configurations, methodologies, production techniques, autonomous decision-making processes and actions at all levels and stages of the manufacturing value chain. This addresses the interrelated goals of increased energy efficiency, decreased use of raw materials through second use of materials such as manufacturing process waste, customer-centricity and on-demand manufacturing. Through cross-sector pilots, the project adopts a life cycle management approach to devise and enable a set of product strategies for reconfigurable and reusable products, using a set of set of intelligent tools for real time analytics and prediction, as well as recommendation systems. Within the KYKLOS4.0 ecosystem (Figure 14), the customised open production system framework includes a set of production – service simulation models that enable responses to: product specifications, produce to order or make to stock requirements, product usage based on customer-profiling, product servitisation strategy through the proposal of maintenance services, and product recycling/ reuse.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

A concrete example of the synergies between manufacturing as a service and product as a service business models is explored in the pilot currently developing a new methodology and approach to design, produce and deliver the next generation of customisable wheelchairs integrating a system with postural device. The pilot is developing a fully automatized process where users can configure the chairs through web modelling tools according to individual specifications, where unique components of the wheelchair are 3D printed; and where augmented reality manuals are available to users. In complement to this, blockchain certification of the wheelchair components ensures product standards and quality, and predictive maintenance is employed to identify repair needs and prioritise replaceable/ reusable components.

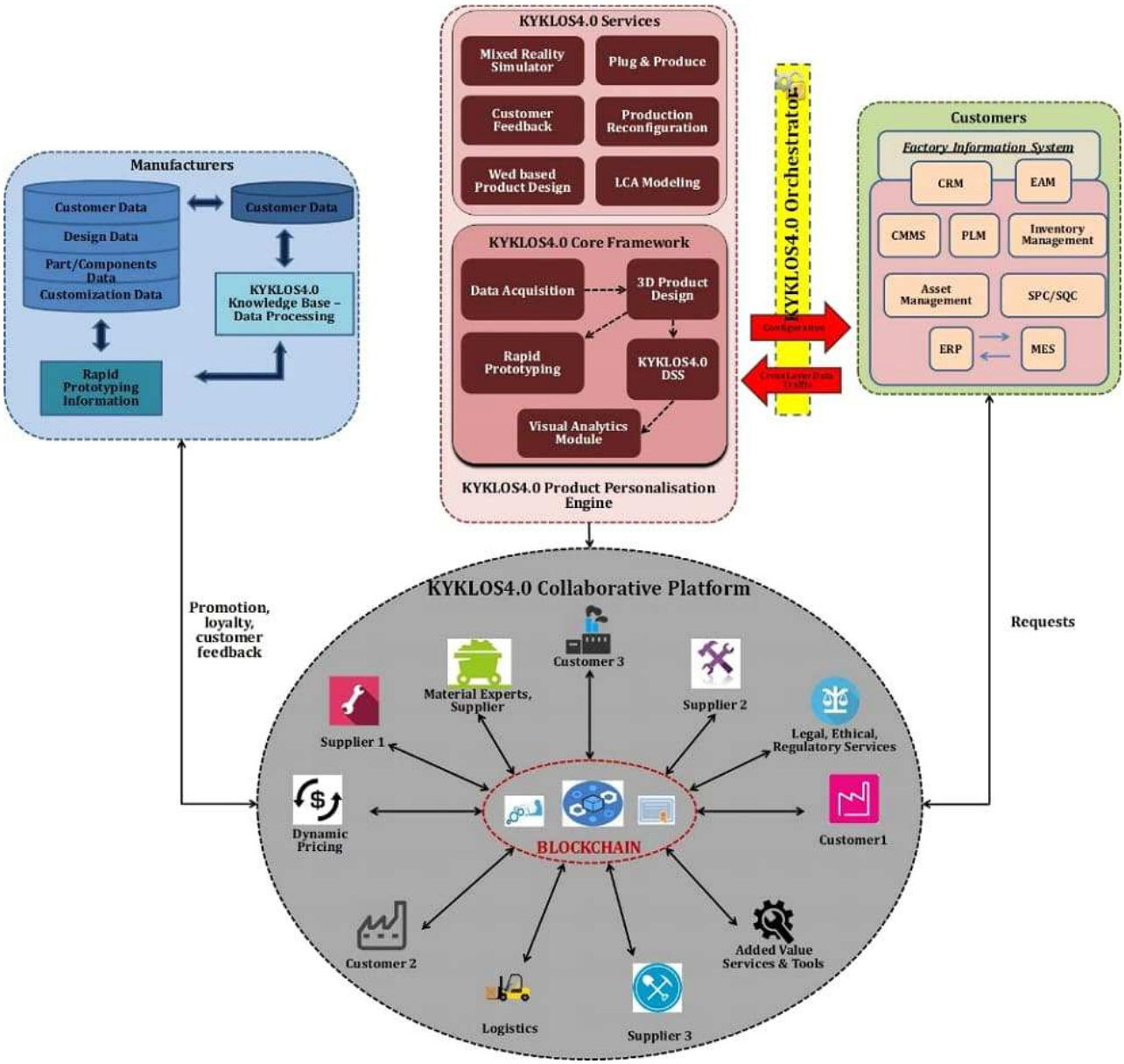


Figure 14: KYKLOS4.0 collaborative architecture

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

2.3.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks.

DigiPrime is focused on the development of a circular economy digital platform that enables the creation of circular business models based on the data-enhanced recovery and reuse of functions and materials <https://www.digiprime.eu/the-digiprime-concept-and-objectives/> .

A federated model of digital platforms for cross-sector business in the circular economy will be validated through cross-sectoral pilots and use cases in multiple industries including automotive, renewable energy, electronics, textile, and construction. The platform will help overcome current information asymmetry among value-chain stakeholders, thus contributing to unlock new circular business models based on the data-enhanced recovery and re-use of functions and materials from high value-added post-use products across manufacturing sectors. Through deploying a multi-node federation structure that is replicable on different, existing and prospective sectorial platform instances, DigiPrime supports the future systematic creation of cross-sectorial circular value-chains for the remanufacturing and re-use of high added-value components (i.e. batteries, composite and techno-polymer parts, textile components, and mechatronics / electronics).

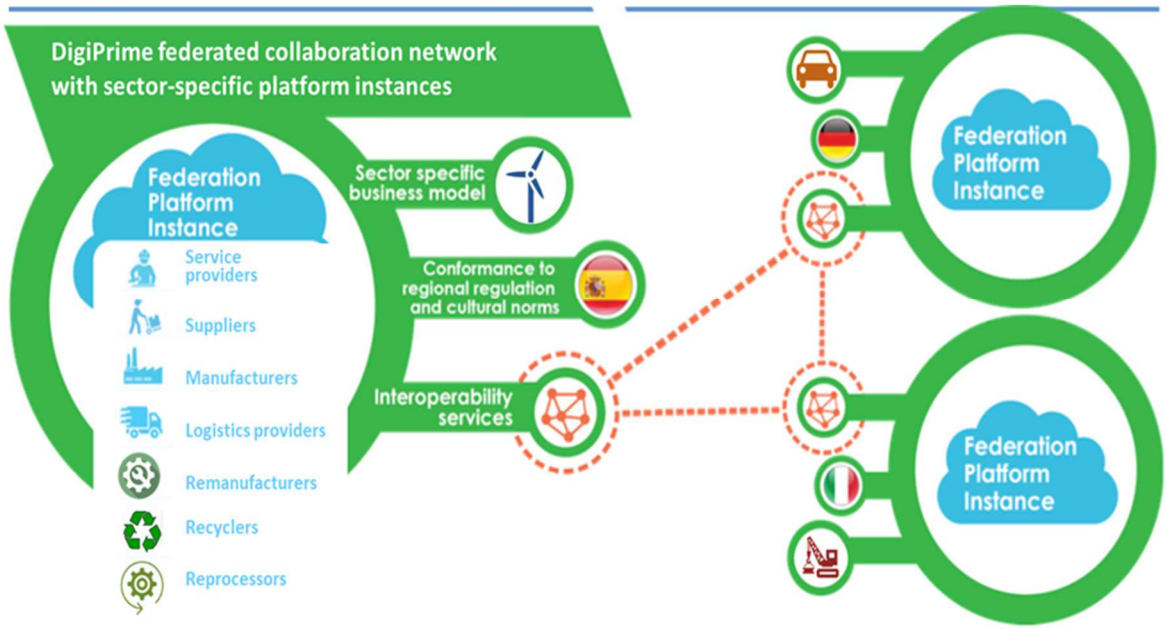


Figure 15: DigiPrime collaboration network

DigiPrime develops a multi-sided platform pursuing the goal that all relevant actors of circular economy scenarios - i.e. Products and materials manufacturers, de-manufacturers, re-manufacturers, material recyclers, Consultancy, Research and Innovation centres and ICT providers are placed in a common space thereby facilitating contact between two or more sides that would otherwise be unlikely to interact. The platform facilitates transactions (data and services) among those actors by actually reducing transaction costs: that's the real value DigiPrime business model

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

relies on. In fact, the platform provides a convenient way of matching the different sides of an interaction (e.g. search or recommendation function), a virtual space to interact, a code of conduct, instruments that increase transparency and trust (i.e. comprehensive information, feedbacks, Material flow monitoring and aggregated system-oriented KPIs, Barriers Identification and legislation support, Circular Innovation Hubs integration, De-and remanufacturing oriented product information formalization, Reverse Logistics and value-chain integration, Demand and supply forecasting, Circular production planning and control, Material characterization and certification), methods of secure transaction, etc. to which both sides agree.

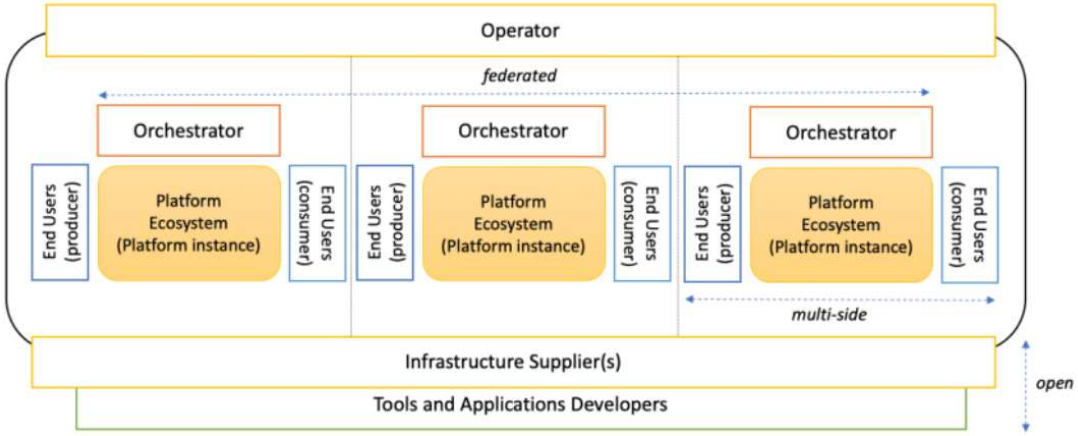


Figure 16: DIGIPRIME federated view

Moreover, the concept and availability of federated agile business collaboration platforms for the circular economy is at the core of the DigiPrime vision. The proposed federated platform model will lead to disruption and business benefits in all the above areas of circular economy impact. Unlike platform monopolies, federated platforms offer diversity and demand-led development in a wide range of industry sectors, yet they all adopt a common architecture, standards and core technologies to facilitate interoperability and economies of scale.

In their simplest shape, existing online platforms do not intervene in the transaction (still guaranteeing its correct execution), except by asking for a fee from one or multiple sides of the transaction in order to make profit. Those kind of platforms do not take control over the object of the transaction, nor on the transaction price. Considering preliminary investigations performed, the heterogeneous variety of requirements DigiPrime wants to address requires a more complex approach. For this reason, our platform needs to adopt a hybrid business model, choosing to act as a platform operator mediating between different market participants in one area of activity and as something like a distributor in another. Hybrid value creation is defined as the innovation strategy of generating additional value by innovatively combining products, data and services. To support such a vision, we currently foreseen a model where a permissioned network of actors can be created on top of the platform. To be in the network each actor will pay a minimal annual fee. Then each actor might earn incomes by selling products, data and services on the platform and/or need to pay additional fees once consuming/acquiring products, data and services.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

To further define the business model of the DigiPrime platform, the project has started to define key elements of the Platform Design ToolKit (https://platformdesigntoolkit.com/), a tool inspired initially by the business model canvas, but extended with a set of tools especially thought for Platforms with several actors and with a distributed value generation. In the following only the Ecosystem mapping canvas and the final Business Canvas are reported for page limits; the overall canvas will be used as first reference for the business model generation and a key guideline for implementations, so to have always a clear vision shared among all the consortium partners.

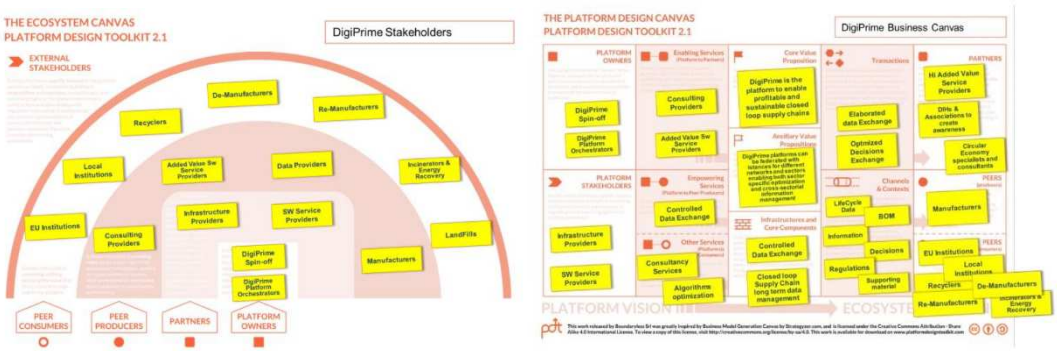


Figure 17: DIGIPRIME CANVAS

2.3.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories

The SHOP4CF project is developing an open architecture platform encompassing technologies based on RAMI 4.0 and FIWARE Technologies to support human workforce in manufacturing activities, and providing basic implementation as a free, open-source solution. The project operates through the implementation pilots combining large-scale industrial leaders and smaller pilots selected through competitive calls. The focus of the human-oriented technological platform in on supporting human workers in the production activities of the manufacturing industry, with an emphasis on technological solutions that improve well-being and working conditions, automates repetitive tasks and increases workforce productivity. Operating as a one-stop-shop marketplace for developers and users and based on the unification of interfaces for easy integration and cross-industry application, the platform makes available a set of augmented / virtual reality tools including virtual planning of safety behaviour, augmented reality projection of assembly instructions, and digital twins of production lines.

From a business model perspective, SHOP4CF builds upon the RAMP marketplace to extend current functionalities with twenty additional technology components and tools – currently under development - to validate the impact of digitised processes and operate as a check list to assist in safety assessment of manufacturing digitisation. As a point in case, the introduction of automated guided vehicles in the shop floor prompts the need to perform safety assessments, which the project addresses with the development of a checklist tool that will be publicly available. In complement to this, an online learning platform will assist SMEs with integration. Finally, in terms of sustainability

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

of the marketplace, the project aims to establish an association funded by membership, transaction and consultancy fees to manage the app store, connect technology providers with user requests and offer consultancy as a service.

3 Industrial agreement and Legal aspects

Exploring and identifying the different regulatory frameworks, legal aspects, GDPR aspects and free data flow constraints.

3.1 General observations on legal aspects.

3.1.1 Types of industrial relations

Industrial agreements are at the core of industrial organisation and innovation ventures. In any industrial activity, agreements are codified in contracts. Such contracts are standardised into a number of clauses that ensure the provision and compensation of exchanges incurred between the parties in the agreement as well as provisions for failure to fulfil the contractual obligations agreed upon.

The form of the agreements and the formal contracts vary greatly considering the type of relationship between the parties and main features of the relationship (objectives, operational area involved, and the main mean of relational exchange that integrate the parties in the agreement). Figure 18: Type of agreements

gives an indication of the generic type of agreements. As will be seen bellow each of these agreements present particularities that must be considered in order to make explicit legal issues.

characteristics	Supply relationships	Agreements Joint-Ventures	Regional industrial systems
main objective	operational synergies	technological/ functional synergies	strategic synergy
main area involved	operating core 	support staff 	strategic apex 
main integration vehicle	material flow	expertise flow, skills exchange	associative and consortial bonds

Figure 18: Type of agreements[5]

3.1.2 Challenges of I4.0 for data protection

Issues of data protection can be divided into three areas: the first one refers to the safety against disruption of the operations; the second refers to the protection of personal data; and the third to the

[5] Nassimbeni, G. (1998). Network structures and co-ordination mechanisms: a taxonomy. International journal of operations & production management. 18, 6.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

protection of non-personal data at the different operational levels of the data pyramid.[6] The former is related to the risks that arise from the interconnectedness of the elements of the factory among each other and to the Internet of Things. When all the supply chain is aided by an advanced IT system that usually is situated on a cloud, this makes the whole production process exposed to the threats of hacking and sabotage. The protection of personal data is a tricky topic in the Smart Factory, because very often operators in these environments think that the only informational risks are those related to production, sales and supply-chain related data.

Personnel data: I4.0 requires an increasing level of integration of data from different sources, including data from not only workers, but also from different providers and sources. This enforces Private by design (PbD) requirements, due to both company security rules and regulatory requirements. A major aspect of the GDPR are the so-called legal grounds for lawfully processing personal data, one of which is consent. In several IoT applications where consent is used, it may even need to be explicit consent.[7] There are still some issues with personal data after the GDPR:

- data consistency and the use of different sources of information and/or different time periods or geographical positions;
- data storage: although properly scrambled, masked, or blurred, the related persons probably are not aware such pieces of information do exist related to them; and
- problems related to EU citizens when requesting products or services outside of the EU. The harder problem is the second one, mainly due to the absence of accountability, as a user never knows who gathers information about them and they cannot ask for access, erasure, or modification. Thus, there are two types of accountability:
    - Accountability regarding users; but also,
    - Accountability within the organization.

3.1.3 Context of industrial "contract" agreements in relation to data generation, storage, transfer and analytics

Following (CARSA, 2021) **"Industry Agreements"** are tools designed to address the barriers that hinder the development of industry data ecosystems to enable industry stakeholders to enjoy the full benefits of the data revolution. They target economic gains for all participants and the creation of new market opportunities, new ecosystems and standards. Industry agreements may encompass three types of solutions:

- Federated Digital Infrastructures – FDI (e.g., reference architecture and reference models);
- Common Vocabulary Standards – CVS (e.g., common ontology, taxonomy, semantics, etc);

[6] Automation pyramid to the automation network. The former is made of five levels. Starting from the top, there is the Enterprise Resource Planning (ERP), a tool which refers to a variety of management activities. Then the Manufacturing Execution System (MES) follows, that manages production from scheduling to maintenance operations, to resource allocation. The third and fourth level aims at process control, based on Supervisory Control and Data Acquisition (SCADA) and the physical controllers known as Programmable Logic Controllers (PLCs). The last level is the production level, where interactions of machines, equipment and sensors (non-personal data) interact with personnel (personal data). This last stage generates issues that fall into the realm of the GDPR.

[7] Sun, S., Zheng, X., Villalba-Díez, J., & Ordieres-Meré, J. (2020). Data handling in industry 4.0: Interoperability based on distributed ledger technology. *Sensors*, *20*(11), 3046.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- **Relational Contractual Agreements – RCA** (e.g., rules for accessing and storing data, limitations on aggregation, and the use and further sharing of data, beyond a typical discussion on data ownership).[8]

Much of the current work developed under the programme "Factories of the Future" under Horizon 2020 has been focusing on developing and reaching agreements on FDIs and CVS while leaving RCAs underdeveloped. The form and content of the contract agreement will be strongly affected by the functionalities of industrial data infrastructures (e.g. Industrial data spaces). In the following in section 3.2 an exploration of the policy and legal framework is explored with an analysis of its limitations to guide in detail industrial agreements and their legal implications. In section 3.3 the notion of general forms and content of legal contracts agreements are outlined.

3.2 Reference documents on legal aspects data protection and data flows.

3.2.1 European Data Strategy

The vision

The EU should create an attractive policy environment so that, by 2030, the EU's share of the data economy – data stored, processed and put to valuable use in Europe - at least corresponds to its economic weight, not by fiat but by choice. The aim is to create a single European data space – a genuine single market for data, open to data from across the world – where personal as well as non-personal data, including sensitive business data, are secure and businesses also have easy access to an almost infinite amount of high-quality industrial data, boosting growth and creating value, while minimising the human carbon and environmental footprint. It should be a space where EU law can be enforced effectively, and where all data-driven products and services comply with the relevant norms of the EU's single market. To this end, the EU should combine fit-for-purpose legislation and governance to ensure availability of data, with investments in standards, tools and infrastructures as well as competences for handling data. This favourable context, promoting incentives and choice, will lead to more data being stored and processed in the EU.

The challenges

- *Availability of data:* The value of data lies in its use and re-use. Currently there is not enough data available for innovative re-use, including for the development of artificial intelligence. The issues can be grouped according to who is the data holder and who is the data user, but also depend on the nature of data involved (i.e. personal data, non-personal data, or mixed data sets combining the two).
- *Imbalances in market power*: Beside the high concentration in the provision of cloud services and data infrastructures, there are also market imbalances in relation to access to and use of data, for example when it comes to access to data by SMEs.
- *Data interoperability and quality*: Data interoperability and quality, as well as their structure, authenticity and integrity are key for the exploitation of the data value, especially in the context of AI deployment.

[8] (Carsa (2021) Background document shared for expert validation workshop within the "Study on technological and economic analysis of industry agreements in current and future digital value chains". A study prepared for the European Commission DG for Communications Networks, Content & Technology

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- *Data governance*: There have been calls to further reinforce the governance of data use in society and the economy.[9] For these data spaces to become operational, organisational approaches and structures (both public and private) are needed that enable data-driven innovation based on the existing legal framework.
- *Data infrastructures and technologies*: The digital transformation of the EU economy depends on the availability and uptake of secure, energy-efficient, affordable and high-quality data processing capacities, such as those offered by cloud infrastructures and services, both in data centres and at the edge.
- *Empowering individuals to exercise their rights*[10]: Individuals value the high level of protection granted by the GDPR and ePrivacy legislation. However, they suffer from the absence of technical tools and standards that make the exercise of their rights simple and not overly burdensome.
- *Skills and data literacy*: Currently, big data and analytics are top of the list of critical skills shortages.
- *Cybersecurity*: In the area of cybersecurity, Europe has developed an already comprehensive framework to support Member States, businesses and citizens to tackle cybersecurity threats and attacks, and Europe will continue to develop and improve its mechanisms to protect its data and the services building on it. The safe and widespread use of data-fuelled products and services will also depend on the highest cybersecurity standards. The EU Cybersecurity Certification Framework and the EU Agency for Cybersecurity (ENISA)34 are expected to play an important role towards that endeavour.

The roadmap for EU Data Strategy implementation (5 key actions)

The vision and challenges are supported by a number of key actions organised around five pillars that give coherence to the EU Data Strategy.

1. Key actions supporting the *development of a cross-sectoral governance framework for data access and use:*
   - Propose a legislative framework for the governance of common European data spaces, Q4 2020
   - Adopt an implementing act on high-value data-sets, Q1 2021
   - Propose, as appropriate, a Data Act, 2021
   - Analysis of the importance of data in the digital economy (e.g. through the Observatory of the Online Platform Economy), and review of the existing policy framework in the context of the Digital Services Act package (Q4 2020).
2. Key actions to enable investments in data and strengthening Europe's capabilities and infrastructures for *hosting, processing and using data, interoperability*:
   - Invest in a High Impact project on European data spaces, encompassing data sharing architectures (including standards for data sharing, best practices, tools) and governance mechanisms, as well as the European federation of energy-efficient and trustworthy cloud infrastructures and related services, with a view to facilitating combined investments of €4-6

[9] 'Common European data spaces' is one of initiatives used as spearhead to generate a governance framework for industrial data. See https://ec.europa.eu/digital-single-market/en/news/report-european-commissions-workshops-commoneuropean-data-spaces.

[10] Same logic applies for companies

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

billion, of which the Commission could aim at investing €2 billion. First implementation phase foreseen for 2022;
- Sign Memoranda of Understanding with Member States on cloud federation, Q3 2020;
- Launch a European cloud services marketplace, integrating the full stack of cloud service offering, Q4 2022;
- Create an EU (self-)regulatory cloud rulebook, Q2 2022.

3. Key action to develop European digital competences by *empowering individuals, investing in skills and in SMEs:*
   - Explore enhancing the portability right for individuals under Article 20 of the GDPR giving them more control over who can access and use machine-generated data (possibly as part of the Data Act in 2021).
4. Key action to establish *Common European data spaces in strategic sectors and domains of public interest*.
   - Building in the experience of the European Open Science Cloud the Commission will support the establishment of nine data spaces (Manufacturing, green deal, mobility, health, financial, energy, agriculture, public administration and data science skills.
5. Key action to promote *international data flows*:
   - To this end, the Commission will create a European analytical framework for measuring data flows (Q4 2021). This should be a durable framework that provides the tools to conduct a continuous analysis of data flows and the economic development of the EU's data processing sector, including a robust methodology, economic valuation and data flows collection mechanisms.

3.2.2 European Data Governance (European Governance Act)

3.2.3 OECD Guidelines

The main result of the expert committee was the identification of eight fundamental principles that still today influence the discourse on privacy and data protection:

Collection limitation: This principle entails that data collection should be limited as possible and that, when personal or non-personal data are obtained, it happens by lawful and fair means, with the awareness and approval of the data subject.

- *Data quality*: This principle refers to the relevance of personal data for the purpose for which they are obtained and, relative to that purpose, to accuracy, completeness and veracity of the data.
- Purpose specification: This principle states that the data subject should be made aware of the purpose for which personal data are collected not later than the moment of the collection and that then the use of data should be limited to the fulfilment of the purpose. Every change in the subject should be specified too.
- *Use limitation*: Personal data should not be disclosed, made available or used for purposes other than those specified as according to the previous principle, unless required by the law or with the approval of the data subject.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- *Security safeguards*: There must be security safeguards that protect data against loss, unauthorised use, destruction, use, modification and disclosure.
- *Openness*: This principle refers to the fact that it should always be possible to know the nature and use of personal data, as well as the identity of data controller and his usual residence. In general, all developments, practices and policies relative to personal data have to be kept open.
- *Individual participation*: This principle lists all the ways in which an individual can be responsible for his own data. He has to be able to have confirmation from a data controller that the data controller has data relating to him. Then, data relative to an individual should be communicated to him in a timely manner, at an inexpensive charge, in a reasonable way and in an intelligible form. Moreover, the individual should be able to take action in case the previous rights are denied to him and finally, if the challenge is successful, data should be erased, updated or corrected.
- *Accountability*: The data controller has to comply with measures that ensure the previous rights and held accountable for compliance. As mentioned before, these guidelines were the first impressive step towards data regulation.

The reach of this document can be explained by three main aspects. First, they are technologically neutral, i.e. they are not limited to automated data or to any industry, as well as to no sector, whether private or public. Secondly, they are written in a language that makes them both non-binding, as it appears from the use of the verb should and of structures non-typical of treaties, and very easy to understand, with a simplicity that ended up being perfect for the kind of complex evolution of the subject. Moreover, the guidelines add the principle of accountability, which had never appeared in earlier works. Finally, the most important point is that the eight principles call Member States to action but leaving space for flexibility.

3.2.4 European Data Protection Directive[11]

The Directive 95/46/EC of the European Parliament and of the Council on the protection of individuals with regard to the processing of personal data and the free movement of such data constitutes the first appearance of the right to data protection in European secondary law. This new set of rules, promulgated in 1995, was fuelled by the increased use of data in many industries and fields, consequent to the spread of Information Communication Technologies in the 1970s. The content of the Directive is not particularly innovative, as it follows closely that of the OECD Guidelines. However, two main aspects are relevant in this case. First, the protection granted by the principles addresses the freedom of individuals and their privacy, especially relative to data processing. Secondly, it promotes the free flow of information in the internal market of data. By the time the Directive was promulgated, the European data protection framework was far from being harmonised. Consequently, the Directive was conceived as a tool that, by harmonising the data protection practices in Europe, could promote the existence of an internal market of data too.

[11] EU (1995) Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the Protection of Individuals with Regard to the Processing of Personal Data and on the Free Movement of Such Data [1995] OJ L 281/31. Brussels: European Commission

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

3.2.5 Article 16 of the Treaty on the Functioning of the European Union[12]

1. Everyone has the right to the protection of personal data concerning them.

2. The European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall lay down the rules relating to the protection of individuals with regard to the processing of personal data by Union institutions, bodies, offices and agencies, and by the Member States when carrying out activities which fall within the scope of Union law, and the rules relating to the free movement of such data. Compliance with these rules shall be subject to the control of independent authorities.

The rules adopted based on this Article shall be without prejudice to the specific rules laid down in Article 39 of the Treaty on European Union.

3.2.6 The General Data Protection Regulation[13]

In principal, the GDPR has its roots on the Data Protection Directive, which was adopted by the EU in 1995. The GDPR is characterized by an extended scope on data protection as it affects all individuals and organizations, regardless of their geographical location, that record data and process information related to European citizens. Furthermore, the GDPR considers 'personal data' in an extended context covering information and identifiers like Internet Protocol (IP) addresses and cookies. The former directives were vaguely accepting as personal information any information that could directly or indirectly link to specific individuals. Moreover, notifications about discovered data breaches is now mandatory within 72 h of the incident, with imposed penalties ranging from 2–4% of an organization's global annual turnover during the previous fiscal year[14]. For companies involved in intense data processing activities, the appointments of a data protection officer is being provisioned. GDPR requires that an impact assessment is performed to identify data security risks and mitigation strategies adopted by every organization.

The GDPR also foresees that individuals have the right to: (1) provide their consent to organizations for processing their data, and (2) access any stored information related to them.

The GDPR is expected to result in substantial fines while the need to comply with the imposed regulations was anticipated to significantly increase business cost. To accommodate the GDPR ramifications would require an increase in business budgets of about 10%. [15]

The ultimate goal of the GDPR is to reinstate trustiness with consumers through transparency and security. GDPR addresses issues of personal data: Hacking—Use of stolen credentials and use of backdoor or command-and-control servers; Social phishing; Malware like spyware/keylogger, command-and-control servers and export data; and Services classification vagueness. GDPR addresses these challenges by:

- harmonizing of data-protection rules;
- fostering transparency and reporting obligations and updating the legal basis for processing personal information;

[12] Article 16 of the Treaty on the Functioning of the European Union (TFEU)
[13] The General Data Protection Regulation (GDPR)

[14] Rodger A (2017) Ovum's mini-guide to GDPR. Ovum TMT Intelligence, London. https://ovum.informa.com/~/media/Informa-Shop-Window/TMT/Files/Brochure/Ovum-MiniGuide-to-GDPR-Sept-2017.pdf

[15] Sydekum R (2018) Can consumers bank on financial services being secure with GDPR? Comput Fraud Secur 6:11–13. https://doi.org/10.1016/S1361-3723(18)30054-X

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- allowing the switch of service providers in an easy and cost-effective manner;
- imposing the use of an advanced web application firewalls;
- detecting mobile app tampering;
- taking advantage of scalable multi-cloud advances;
- preventing malware from stealing credentials from victims' devices.

Concerning non-personal data in industrial applications, the GDPR is still in its infancy and CF2 waits to see further implications in different sectors.

3.2.7 European Cybersecurity Act

The EU Cybersecurity Certification Framework and the EU Agency for Cybersecurity (ENISA) are to give structure and enforce cybersecurity regulations in the single market. A European cybersecurity certification framework. The EU Cybersecurity Act introduces for the first time an EU-wide cybersecurity certification framework for ICT products, services and processes. Companies doing business in the EU will benefit from having to certify their ICT products, processes and services only once and see their certificates recognised across the European Union.

3.2.8 Cybersecurity: EU COM Briefing

Digitising Industry (Industry 4.0) and Cybersecurity: EU COM Briefing

The New General Data Protection Regulation – Privacy in the Industry 4.0

3.3 Industrial contract types

The form of the agreement between two or more industrial entities will depend on the type of relation and type exchange conducted between the parties participating in the industrial agreement (Figure 19). The most common forms of industrial contract agreements are displayed and outlined in this section further below.

The formalization of industrial contracts in the context of industrial digitalization is still in its infancy and there is little to no information as to the form and contents of the contract that ensure the protection of property, ensure delivery and quality of services, liabilities, etc. These issues will be outlined in the sections further below.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

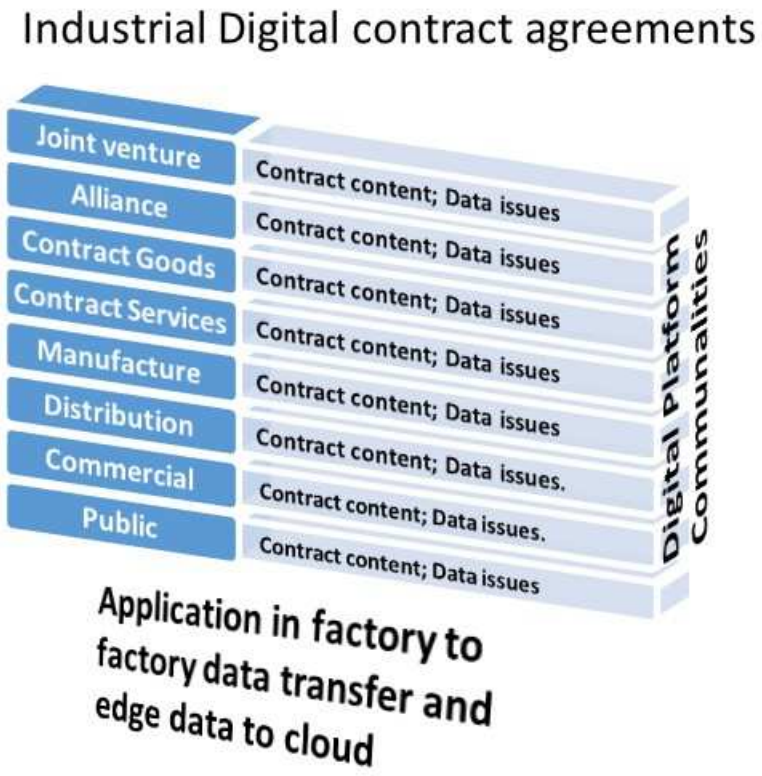


Figure 19: Industrial Digital Contract agreements

Factories of the future are developing in that context of industrial organisation landscape that is changing rapidly enabled by digital technologies. The notion of edge-to-cloud reflect advances that cover the collection of data connect several levels of the data pyramid. Connecting from the sensor level (in equipment, machinery and manufacturing or production cells) to PLCs to SCADA to Enterprise Resources Processing (ERP). Most of these operations are currently occurring within a single factory (or business), but is moving and striving to enable a more autonomous flow of data across different factories and business units. This level of sophistication in data gathering, storage, transfer and associated analytics is currently embodied in the concept of *digital platform* whereby the connecting rod for all levels of business manufacturing operations is the flow and analytics of data. This new paradigm generates a new landscape of contractual issues that to a large extent is to be defined.

Industrial agreements on data accumulation (storage) data flows, data analytics and exploitation by third parties of data must be formalised in a way that the parties involved in such agreements are protected. The type of contracts varies depending on the aim of the relationship between parties in the agreement. With the new wave of servicitation of industrial operations (like manufacturing) often industrial agreements can take the form of one the following most common forms of Industrial contract agreements are: Alliances, Corporate Joint Venture, Commercial Sale of Goods, Long-Term Supply of Goods, Supply of Services, Manufacture Agreement, Distribution of Goods, Commercial Agency. These are briefly defined below

- **Alliance**: A framework for an alliance or collaboration between parties.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- **Corporate Joint Venture** (short form): A framework for a joint venture between two parties to establish a jointly owned company.
- **Commercial Sale of Goods**: An agreement for the sale of manufactured goods between a seller and a buyer. It contains added specifications and explanations on issues such as lack of conformity and limitation of the sellers' liability.
- **Long-Term Supply of Goods**: An agreement for the long-term supply of manufactured goods between a supplier and a customer.
- **Manufacture Agreement**: An agreement under which the client wants the manufacturer to design, manufacture and deliver certain goods, which the client intends to integrate into its own final products or its services.
- **Distribution of Goods**: An agreement for the distribution of manufactured goods, between a supplier and a distributor, whether or not the supplier is the manufacturer of the goods.
- **Commercial Agency**: An agreement under which a commercial agent negotiates the sale or purchase of goods on behalf of another person (the principal).
- **Supply of Services**: An agreement under which a service provider provides certain services to a client.

Each Model Contract indicates has a number of basic elements that should be should considered when entering into an agreement in order to identify and make explicit existing and potential legal issues. Although there are a large number of communalities between different forms of contracts, the differences between them require attention according to the goals of the agreement. Such differences have legal implications of benefits, responsibilities and liabilities. Table 3.1 below shows the most common components of a contract agreement for each of the industrial relations listed above. Here is important to highlight these particularities are not defined in sufficient detail in current legal instruments that provide guidelines for data protections (of citizens and companies).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Table 3.1 Digital industrial agreements generic taxonomy content

Alliance	Joint Venture	Supply of Goods	Supply of Services	Manufacture Agreement	Distribution of Goods	Commercial Agency
Objectives and key principles	Interpretation Business of JVC	Supply of the Goods	Supply of the service – Qualifications of the Supplier	Manufacture and supply of the Goods	Appointment of the Distributor	Scope of appointment
	Establishment of JVC: Conditions precedent	*Procedure for ordering*	*Procedure for ordering*		*Procedure for ordering the Goods*	*Obligations of the Principal and the Agent*
Management Committee	Directors and Management	Delivering the Goods			*Supply of the Goods*	Minimum orders
Joint Projects	Additional contributions of the Parties	*Price of the Goods*	*Payment of fees*	*Payment of price*	*Price of the Goods*	Agent's commission – right to commission
Contributions of the Parties	Dividend policy,Transfer of Shares	*Payment*	*Late payment and interest*	*Late payment and interest*	*Payment*	*Method of calculating commission and payment*
	Capital and further finance	Quality of the goods	Quality of the service	Quality of the goods	Quality of the service	Advertising, fairs and exhibitions
Data: transfers, storage, analytics	*Data: transfers, storage, analytics*	*Data: reliability, accuracy, periodicity, velocity*	*Storage: access, security, reliability, capacity, upload and retrieval speed*	*Data: transfers, storage, analytics*	*Data: transfers, storage, analytics*	*Data: transfers, storage, analytics*
Alliance costs	Costs	*Warranties relating to the Goods* General warranties	*Warranties and*	*Warranties relating to the Goods*	*Warranties relating to the Goods* General warranties	*Restriction of territory*
Lack of conformity (with agreed standards)	*Lack of conformity (with agreed standards)*	*Lack of conformity (with agreed standards)*	*Lack of conformity (with agreed standards)*	*Lack of conformity (with agreed standards)*	*Lack of conformity (with agreed standards)*	*Lack of conformity (with agreed standards)*
Intellectual Property	*Intellectual Property*	*Transfer of property*		*Intellectual property and trademarks*	*Intellectual Property*	*Trademarks and property rights*
Secondments and personnel (security and privacy)	Secondments and personnel (security and privacy)	Non-performance of the Buyer's obligation to pay the price at the agreed time		Cooperation of the Parties for improvements and modifications	Support and training	
Preferred supplier/distrib utor	General meetings	Non-performance of the Seller's obligation to deliver the Goods at the agreed time			Distribution of the Goods	Financial responsibility (Option)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

	Reserved Matters	*Documents and manuals*	*Documents and manuals*	*Documents and manuals*	*Documents and manuals*	*Documents and manuals*
Confidentiality	Confidentiality	*Confidentiality*	*Confidentiality*	*Confidentiality*	*Confidentiality*	*Confidentiality*
Restrictions on the Parties	Restrictions on the Parties	Effects of contract avoidance in general				Exclusivity, non-competition
Duration and termination	*Establishment of JVC: Closing Deadlock or termination*	*Duration, termination and consequences of termination*	*Term, termination and consequences of termination*	*Duration and termination Consequences of termination*	*Duration and termination Consequences of termination*	*Term, termination and consequences of termination*
Change of circumstances (hardship)	*Change of circumstances (hardship)*	*Change of circumstances (hardship)*	*Change of circumstances (hardship)*	*Change of circumstances (hardship)*	*Change of circumstances (hardship)*	*Change of circumstances (hardship)*
Force majeure	*Force majeure*	*Force majeure*	*Force majeure*	*Force majeure*	*Force majeure*	*Force majeure*
Liability	Supremacy of this contract	*Liability* Restitution	*liability*	*liability*	*Liability*	*Indemnity or compensation on termination*
Entire Agreement	*Entire agreement/variations*	*Entire agreement*	*Entire agreement*	*Entire agreement*	*Entire agreement*	*Entire agreement*
Notices	*Notices*	*Notices and writing*	*Notices*	*Notices*	*Notices and writing*	*Notices*
No partnership or agency	*No partnership or agency*	*No partnership or agency*	*No partnership or agency*	*No partnership or agency*	*No partnership or agency*	*No partnership*
Assignment and subcontracting	*Assignment and subcontracting*	*Assignment and subcontracting*	*Assignment and subcontracting*	*Assignment and subcontracting*	*Assignment and subcontracting*	
Effect of invalid or unenforceable provisions	*Effect of invalid or unenforceable provisions*	*Effect of invalid or unenforceable Articles*	*Effect of invalid or unenforceable provisions*	*Effect of invalid or unenforceable provisions*	*Effect of invalid or unenforceable Articles*	*Effect of invalid or unenforceable provisions*
Authorizations		*Authorizations*	*Authorizations*	*Authorizations*	*Authorizations*	*Authorizations*
Dispute resolution procedure	*Dispute resolution procedure*	*Dispute resolution procedure*	*Dispute resolution procedure*	*Dispute resolution procedure*	*Dispute resolution procedure*	*Dispute resolution procedure*
Language of agreement	*Language of agreement*	*Language of contract*	*Language of contract*	*Language of contract*	*Language of contract*	*Language of contract*
Applicable law	*Applicable law*	*Applicable law*	*Applicable law*	*Applicable law*	*Applicable law*	*Applicable law*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

3.3.1 Digital industrial agreement common elements

Table 3.1 in previous page indicates a large number of item clauses to the considered when conducting an industrial digital contract agreement. The variation across forms of industrial agreements as displayed in Table 3.1 is apparently low but there will be significant differences in most clauses depending on aims of the relation, the specification of the type of digital goods (data, infrastructures, storage facilities, etc.) or services (data curation, analytics, storage, etc.). The full outlining of the legal implications of digital industrial agreements still very much on its infancy. The list of clauses below is not exhaustive but must serve as examples and guidelines to identify variation and a more nuanced analysis of rights, responsibilities and liabilities. These rights, responsibilities and liabilities might not be otherwise identified when considering entering an industrial business relationship involving digital goods and services supporting or underpinned by the follow of industrial personal and non-personal data.

3.3.1.1 Definition of the supply of the goods (or service) (this can be considered Clause 1)

This article must define the goods or service subject to the agreement. This one of the most important clauses in the agreement. This clause defines functions, interfaces, and technologies to realise digital products and services. Such definition will help to identify and make explicit the different regulatory frameworks and legal aspects that are relevant to secure industrial data flows free of constraints. In addition, it will help define responsibilities and liabilities.

3.3.1.2 Delivering the Goods

The agreement must define the place of delivery, date or period of delivery, carrier (logistics or telecom network provider), third parties involved.

3.3.1.3 Price of the Goods

This clause must indicate the total price, price per unit of measurement, currency and the method for determining the price.

3.3.1.4 Payment

The payment clause must specify (latest) time for payment and whether this is done in advance, delivery of goods (or services). The Buyer must arrange for an irrevocable documentary credit in favour of the Seller to be issued by a bank, subject to the Uniform Customs and Practice for Documentary Credits published by the International Chamber of Commerce (ICC). The issue must be notified at least 14 days before the agreed date for delivery, or before the beginning of the agreed delivery period specified (see 3.3.1.2).

3.3.1.5 Data: reliability, accuracy, periodicity, velocity

The provision of goods (or services) should define the characteristics of the data and data flows in relation to their volume, reliability, accuracy, periodicity and velocity of data transfers. The agreement should specify the needs of the buyers and what the supplier can fulfill considering the intrinsic characteristics of data flows (required and offered).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

3.3.1.6 Warranties relating to the Goods (or services) and liabilities

The Supplier warrants to the Client that the service will be provided as is customary for the provision of similar services on the Client's market. The goods (or services) will be provided in accordance with the specification agreed in clause one, and on the delivery time *[At the intervals and within the times]* expressly agreed in clause addressing deliveries. *Third party supplier*: Where the Supplier supplies in connection with the provision of the service any goods supplied by a third party, the Supplier does not give any warranty, guarantee or other term as to their quality, fitness for purpose or otherwise, but shall, where possible, assign to the Client the benefit of any warranty, guarantee or indemnity given by the person supplying the goods to the Supplier. *Goods or services client specifications*: The Supplier shall have no liability to the Client for any loss, damage, costs, expenses or other claims for compensation arising from any material or instructions supplied by the Client which are incomplete, incorrect, inaccurate, illegible, out of sequence or in the wrong form, or arising from their late arrival or non-arrival, or any other fault of the Client, provided the Supplier has duly notified the Client within agreed time of receipt of such material or instructions.

3.3.1.7 Lack of conformity (with agreed standards)

Lack of conformity refers to the non-compliance with the characteristics of the goods (or services) agreed to deliver. This includes amounts, quality, quantity, standards, functionalities, support and training, duration of supply, and any other features described in clause one.

3.3.1.8 Intellectual property and transfer of property

Transfer of Property: Following the definition of the goods and services to be provided to the Buyer (done in clause one), the Seller must deliver to the Buyer the Goods free from any right or claim of a third person.

3.3.1.9 Documents and manuals

Documents and manuals refer to the Seller duty to make available to the Buyer (or representative specified by the Buyer) the following documents: Commercial invoice, transport or transfer, packing list documents (specify any detailed requirements); Insurance documents; Certificate of origin (to be defined for data transfers as first or second party originating the data); Certificate of inspection; Handbooks and manuals for operation, maintenance and repair of the goods supplied. The documentation should be made available according to the specified delivery of goods and services.

3.3.1.10 Confidentiality

This clause refers to all reasonable efforts that each party in the agreement shall use to keep confidential all commercial and technical information that it may acquire in relation to the customers, business or affairs of the other party. No party shall use or disclose any such information except with prior consent of the other party. This restriction shall not apply to any information: which is or becomes publicly available through no default of that party; is already in that party's possession without any obligation of confidentiality; to the extent that it is required to be disclosed by applicable law or by the rules of any recognized regulatory body. Each party shall use all reasonable efforts to ensure that its employees, agents and any affiliates observe these confidentiality obligations. No announcement in connection with the Alliance shall be made by either party without the prior approval of the other party (such approval not to be unreasonably withheld or delayed) except as may be required by law or by any stock exchange or by any governmental authority. Bridging the confidentiality clause will apply the clause on liabilities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

3.3.1.11 Force majeure

"Force majeure" refers to war, emergency, accident, fire, earthquake, flood, storm, industrial strike or other impediment which the affected party proves was beyond its control and that it could not reasonably be expected to have taken the impediment into account at the time of the conclusion of this contract or to have avoided or overcome it or its consequences. A party in an industrial agreement affected by force majeure shall not be deemed to be in breach of this the agreement, or otherwise be liable to the other, by reason of any delay in performance, or the non-performance, of any of its obligations under the contract to the extent that the delay or non-performance is due to any force majeure of which it has notified the other party.

3.3.1.12 Liability

Strongly related to clause one, for example in relation to quality of data, data, security breaches, delivery, data analytics misuse or misrepresentation, loss of stored data, access or retrieval of data, etc. *Liability Clause*: Except in respect of death or personal injury caused by the Supplier's negligence, the Supplier shall not be liable to the Customer by reason of any representation (unless fraudulent), or any implied warranty, condition or other Term, for any loss of profit or any indirect, special or consequential loss or damage (whether caused by the negligence of the Supplier, its servants or agents or otherwise) in relation to the supply of the Goods (or any failure to supply them) or their resale by the Customer, or otherwise arising out of or in connection with the agreement.

3.3.1.13 Dispute resolution procedure

For any dispute, controversy or claim arising out of or relating to the goods or services under agreement, including its conclusion, interpretation, performance, breach, termination or invalidity, the parties dispute shall be finally settled under agreed rules of arbitration. Such rules must specify the arbitration institution and number of arbitrators appointed, the place of arbitration and language shall specified in the agreement.

3.3.1.14 Applicable law

In the context of industry agreements developing workable functionalities and data flows often will involve entities from different jurisdictions and hence subject to different regulators. The agreement must specify the national or international law that the agreement will follow for its implementation.

3.3.2 Strategic alliances and Joint Venture common features (applicable to research ventures)

Industrial agreements under the form of alliances and joint ventures hold similar features but each alliance or collaboration agreement is different. A contract agreement must consider the following issues depending on the purpose of the Alliance or joint venture. Provisions that are not relevant to the particular agreement should not be considered. Provisions that could be included are:

- The formation of a Management Committee on which the Parties involved are represented.
- Share of costs and risks implicit in the alliance or joint venture
- Definition of areas of responsibility to contribute towards the success of the Alliance. In some cases responsibilities will be expressed in general terms – and not involve formal legal commitment. In other cases, specific legally binding commitment and liabilities will be appropriate.
- Definition of what knowhow and technical development will be shared by each party (e.g. where Intellectual Property), more detailed license or other contracts might be necessary.
- Duration of the Alliance and setting conditions for renewal requiring mutual agreement.
- Definition of dividend shares if there is a clear imputation of (potential) profits.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

3.4 Examples from projects (mapping of projects)

In most of the ICT-07 projects, Industrial agreements and legal aspects are still at a very embryony level, considering most of them are only 1 year old. So, this chapter will be further analysed on D.1.4.

3.4.1 EFPF- European Connected Factory Platform for Agile Manufacturing

This chapter will be further analysed on D.1.4.

3.4.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality

This chapter will be further analysed on D.1.4.

3.4.3 ZDMP – Zero Defect Manufacturing Platform

This chapter will be further analysed on D.1.4.

3.4.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences.

This chapter will be further analysed on D.1.4.

3.4.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks.

In this moment, DIGIPRIME is focusing on legal aspects on two sectors: plastics and batteries. (the rest of the subsectors -textile, mechatronics…- will be analysed further along the project).

Regarding plastic, DIGIPRIME is taking into account the following legislation:

1. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the reduction of the impact of certain plastic products on the environment. 2018/0172 (COD)
2. Directive 1994/62/EEC of the European Parliament and of the Council of 20 December 1994 on
3. packaging and packaging waste
4. DIRECTIVE 2000/53/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 September2000 on end-of life vehicles
5. DIRECTIVE 2005/64/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 October 2005 on the type-approval of motor vehicles with regard to their reusability, recyclability and recoverability and amending Council Directive 70/156/EEC
6. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A European Strategy for Plastics in a Circular Economy

Regarding the battery sector, the Batteries Directive (2006/EC/66) is the only piece of EU legislation that is entirely dedicated to batteries. Its provisions address the lifecycle of batteries, i.e. design, placing on the market, end-of-life, collection, treatment and the recycling of spent batteries. It defines objectives, sets

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

targets7 and outputs, identifies measures to meet them and establishes additional provisions to enable and complete these key requirements.

The commission has released the Regulation Proposal and the Impact Assessment Report (3 docs)

•COM(2020) 798/3: Proposal for a Regulation
•COM(2020) 798/3: Annexes 1 to 14
•SWD(2020)335 final Part 1: Impact Assessment (main report)
•SWD(2020)335 final Part 2: Impact Assessment (Annexes 1 to 8)
•SWD(2020)335 final Part 3: Impact Assessment (Annex 9)

Many of the environmental problems linked to batteries are due to an insufficient functioning of the EU internal market, explained by, e.g.
•Absence of a complete set of rules for batteries placed on the market,
•Uneven implementation of obligations,
•Existence of barriers to the functioning of recycling markets.
So,
•The proposal contains a complete set of rules for batteries placed on the market, and removes barriers to harmonised product requirements and effective functioning of recycling markets.
•Building a sustainable, competitive and innovative battery value chain in Europe requires complete legal certainty to the economic operators to make the required investments.
•Centre of gravity: internal market; other objectives ancillary.

The adoption of the proposal also opened a new phase of feedback that can be provided to the Commission. until 1st March 2021 through the following link: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12399-Modernising-the-EU-s-batteries-legislation

The feedback provided will be summarised by the European Commission and presented to the European Parliament and Council with the aim of feeding into the legislative debate.

DigiPrime is working on the Feedback on the Proposal for a Regulation of the European Parliament and of the Council concerning batteries and waste batteries, repealing Directive 2006/66/EC and amending Regulation (EU) No 2019/1020 translating DigiPrime key concerns on Pilot 1: reuse, repurposing, remanufacturing, battery passport, EPR and labelling into provisions

3.4.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories

This chapter will be further analysed on D.1.4.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

4 Standards

From the group of cross-cutting factors identified as key enablers for increased digitalisation and connectivity introduced in Figure 1, **'Standards and Standardisation'** operates within a unique triad. At a foundational level, the digital 'Tools and Technology' that forms each level of the automation pyramid must be implemented, the presence of 'Standards and Standardisation' bodies for that technology is a measure of its maturity, which in turn helps enable and ensure the 'Interoperability' of the solutions or strategies being deployed. However, while these CCFs are often interdependent, they remain separate. Technologies can be interoperable without codified open standards. Likewise, technologies may be standardised yet not interoperable. Additionally, open standards for interoperability may be drafted for technologies that have not yet reached a level of maturity for mass-distribution. These interrelationships are visualised in the Venn diagram below (see Figure 20).

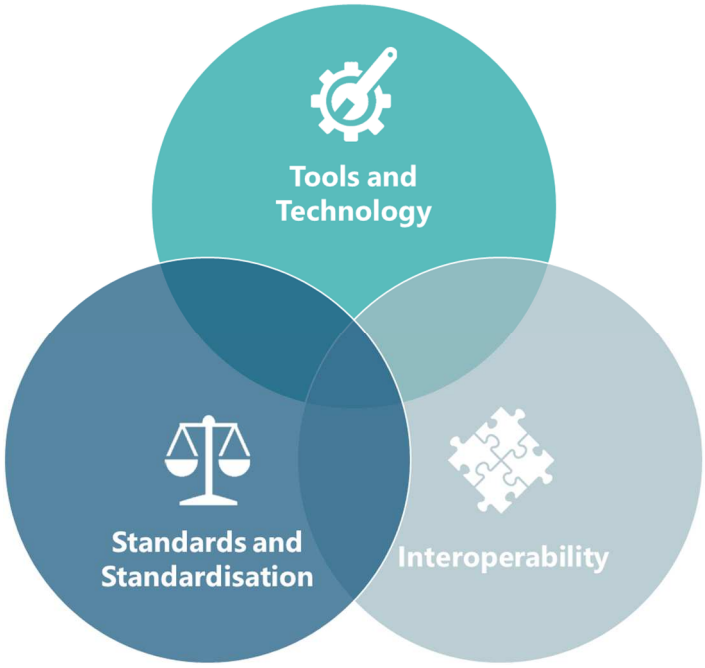


Figure 20: Venn diagram of technology, standards and interoperability.

The presence of standards and accepted standardisation bodies are a key enabler and CCF to facilitate the broad implementation of innovative tools and processes across an entire industry. The Connected Factories project (both CF1 and CF2) provides support for the standardisation of projects across regional, national and international boundaries. This support primarily takes the form of a wiki that was introduced in CF1. The wiki provides useful information to aid and inform new projects being initiated, and also serves as a vehicle to collect information. In this way the wiki can both support and evolve with manufacturing as a whole as it engages with the envisioned transformation.

4.1 General observations on standardization.

Standardization is the driving force of innovation and sustainable technological development. Standards practically guide the work of the CF2 project developers and help to channel the needs and expectations of the stakeholders. Particularly, technical experts of the projects accumulate information that is valuable for drafting of future standards and, thus, express their future expectations in the standardisation work.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

The last few years have seen lively debates about which areas of standardization are the most important in the digital transformation. This question will not yet find a clear answer for the moment and will definitely need further elaboration from the standardization community. As adopted by IEC Strategic Group 12, Digital transformation is "the profound transformation of business and organizational activities, processes, competencies and models to fully leverage the changes and opportunities of a mix of digital technologies and their accelerating impact across society in a strategic and prioritized way, with present and future shifts in mind".

4.2 Reference documents on standards

The following standards (currently addressed by the projects) have been identified as the most important, see Table 3[16].

Table 3: Key standards identified in CF2.

ID[17]	Title	Link
IEC 61158 series	Industrial communication networks - Fieldbus specifications	Link
ISO 23952:2020	Quality information framework (QIF) — An integrated model for manufacturing quality information	Link
ANSI/MTC1.4-2018	MTConnect	Link
Apache Kafka	Apache Kafka	Link
Camera Link	Camera Link	Link
DCAT	Data Catalog Vocabulary (DCAT) - Version 2	Link
GigE Vision	GigE Vision	Link
HTTP/REST standards	(standards collection)	Link
IEC 61499 series	Function blocks	Link
IEC 62443 series	Security for industrial automation and control systems	Link
IEC 62541 series	OPC unified architecture – Part 1: Overview and concepts	Link
IEC 63278-1 ED1*	Asset administration shell for industrial applications – Part 1: Administration shell structure	Link
IEC PAS 63088:2017	Smart manufacturing – Reference architecture model industry 4.0 (RAMI 4.0)	Link
IEC TS 62832-1:2016	Industrial-process measurement, control and automation - Digital factory framework - Part 1: General principles	Link
IEEE 1589-2020	IEEE Standard for Augmented Reality Learning Experience Model	Link
IEEE 802.11 Standards	IEEE 802.11 Standards	Link
IEEE 802.15.4-2020	IEEE Standard for Low-Rate Wireless Networks	Link
IEEE 802.1AS-2020	IEEE Standard for Local and Metropolitan Area Networks--Timing and Synchronization for Time-Sensitive Applications	Link

[16] The complete listing is currently under development (see the report on WG1 Standardization *Task 1.2* in 4.3) and will be migrated to the wiki according to the updated taxonomy.

[17] * under development

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

IIRA:2019	The Industrial Internet of ThingsVolume G1: Reference Architecture Version 1.9	Link
ISO 23247 series*	Automation systems and integration — Digital Twin framework for manufacturing	Link
ISO 23952:2020	Automation systems and integration — Quality information framework (QIF) — An integrated model for manufacturing quality information	Link
ISO 9000 GLOSSARY	Glossary – Guidance on selected words used in the ISO 9000 family of standards	Link
ISO 9001ISO 9001:2015	Quality management systems — Requirements	Link
ISO(IEC CD 22123-2*	Information technology — Cloud computing — Part 2: Concepts	Link
ISO/IEC 15408 series	Information technology – Security techniques – Evaluation criteria for IT security	Link
ISO/IEC 17788:2014	Information technology – Cloud computing – Overview and vocabulary	Link
ISO/IEC 18045:2008	Information technology — Security techniques — Methodology for IT security evaluation	Link
ISO/IEC 19464:2014	Information technology – Advanced Message Queuing Protocol (AMQP)	Link
ISO/IEC 20546:2019	Information technology - Big data - Overview and vocabulary	Link
ISO/IEC 20922:2016	Information technology – Message Queuing Telemetry Transport (MQTT) v3.1.1	Link
ISO/IEC 20924:2018	Information technology — Internet of Things (IoT) — Vocabulary	Link
ISO/IEC 21778:2017	Information technology – The JSON data interchange syntax	Link
ISO/IEC 21823-1:2019	Internet of things (IoT) — Interoperability for IoT systems — Part 1: Framework	Link
ISO/IEC 21823-2:2019	Internet of things (IoT) — Interoperability for IoT systems — Part 2: Transport interoperability	Link
ISO/IEC 21823-3 *	Internet of things (IoT) — Interoperability for IoT systems — Part 3: Semantic interoperability	Link
ISO/IEC 22123-1*	Information technology — Cloud computing — Part 1: Terminology	Link
ISO/IEC 22989*	Artificial Intelligence Concepts and Terminology	Link
ISO/IEC 23053*	Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)	Link
ISO/IEC 2382:2015	Information technology — Vocabulary	Link
ISO/IEC 27000:2018	Information technology – Security techniques – Information security management systems – Overview and vocabulary	Link
ISO/IEC 27001:2013	Information technology – Security techniques – Information security management systems – Requirements	Link
ISO/IEC 27002:2013	Information technology – Security techniques – Code of practice for information security controls	Link
ISO/IEC 30166:2020	Internet of things (IoT) — Industrial IoT	Link
ISO/IEC DIS 19944-1*	Cloud computing – Cloud services and devices: data flow, data categories and data use — Part 1: Fundamentals	Link
ISO/IEC NP 24392*	Information technology -- Security techniques --Security reference model for Industrial Internet Platform (IIP)	Link
ISO/IEC TR 22417:2017	Information technology — Internet of things (IoT) use cases	Link
ISO/IEC TR 24030*	Artificial Intelligence (AI) — Use cases	Link
ISO/IEC TR 30164:2020	Internet of things (IoT) – Edge Computing	Link
ISO/IEC TS 27100	Information technology -- Cybersecurity -- Overview and concepts	Link

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

ISO/IEC/IEEE 42010:2011	Systems and software engineering — Architecture description	Link
ISO/IEC30141:2018	Internet of Things (IoT) — Reference Architecture	Link
MIMOSA	MIMOSA	Link
ODRL	ODRL Information Model 2.2	Link
OPC 40501-1	*OPC 40501-1 UA for Machine Tools V1.00.0 (Companion Specification)*	Link
PPMP	Production Performance Management Protocol Specification	Link
ROS	Robot Operating System (ROS)	Link

To access the complete listing please visit the wiki at: https://portal.effra.eu/wiki.

4.3 DMP Cluster WG1 Standardization

4.3.1 Goals

The DMP (Digital Manufacturing Platform) cluster is a project cluster that was established with the aim of promoting cooperation between the projects of "DT-ICT-07-2018-2019: Digital Manufacturing Platforms for Connected Smart Factories". It also includes upcoming projects focusing on AI and CSA, which were funded under the 2019 call.

Across the four main pillars: (1) Platform Building; (2) Large Scale Piloting; (3) Ecosystem Building; and (4) Standardization, the cluster strategy builds on various collaborative topics, which discover common interests, i.e. potential synergies, among all cluster participants. The key topics include joint activities regarding standardization, research, dissemination of events, performance management and KPIs, market analysis and business models, pilots and open calls.

Standardization is a key topic of the cluster. The DMP Working Group 1 *Standardization* is focusing on common standardization work with the goal to exchange on standardization results of the projects and push common standardization activities in order to reach a wider spectrum in a joint work. Thus, the key aim of the WG1 is to organize the cluster framework in such a way that the projects will be able to cooperate freely in developing common strategies for interoperability and the development of/contribution to current standards including ZDM technologies. In particular, the impact of ConnectedFactories2 can be summarized as follows:

- coordination of joint activities in the field of standardization among the member projects to increase the overall impact in standardization;
- facilitation of the exchange of best practices and experiences among the projects to promote the rapid development of standards and their application in large-scale pilots;
- coordination of the joint dissemination activities with the standardization focus to promote joint results.

4.3.2 Tasks

The coordination and support of ConnectedFactories2 applies to the following key tasks of the WG1:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- **TC1.0: Common standardization strategy (Ambassador: O.MEYER, FHG, CF2)**

Main goals:	The main goal of this task is to analyse the overall goals of the cluster with regard to standardization and settle a common standardization strategy.
Outputs:	The output of the task includes the common strategy of the WG1 and a list of relevant tasks.
Current status:	*Ongoing*
Notable results:	One of the notable activities of the TC1.0 is the collection of status updates on the accomplished standardization activities from all members. During this activity, each project presents the results and experiences from the latest standardization outcomes. The regular exchange between the projects is intended to establish a common understanding and assistance with regard to standardization activities and progress between the projects.

- **TC1.1: Link to EC activities (Ambassador: C.GRUNEWALD, DIN, ZDMP)**

Main goals:	The main goal is to establish a link to EC activities and collect updates on relevant roadmap activities at the European level (e.g.
Outputs:	The key output of this task includes short reports about the relevant EC activities and news.
Current status:	*Finished*
Notable results:	Participation at the event “Boosting Innovation through standards - Your gateway to the market” (13 November 2019, Brussels, Belgium)).

- **TC1.2: Common standards (Ambassador: O.MEYER, FHG, QU4LITY)**

Main goals:	The main goal is to identify common standards used by projects and analyse, classify, and migrate these to the wiki in accordance to the updated framework taxonomy.
Outputs:	The output of this task includes a list of common standards and a classification roadmap according the taxonomy.
Current status:	*Recursive (6-month-periods)*
Notable results:	To accomplish the task, a detailed analysis of more than 200 potential standards took place (see an example in Figure 21). The first draft version of the common standards matrix was successfully finalized and distributed for comments among the WG1 members. Initially, three projects (EFPF, ZDMP and QU4LITY) contributed their results. The selection of the projects is determined by the progress in the standardization activities of each project.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 873086.

In the mid and long-term, it is expected that the remaining projects will enter their results into the matrix. During the joint meetings, it was decided that the matrix should be reviewed at regular intervals (6-month periods) and updated if necessary. The results will serve as input for the wiki taxonomy in terms of standards and standardization activities. Other relevant results will be processed and made available on the EFFRA portal.

								RAMI4.0 transfer to EFFRA/WIKI						Factors							EFPF			ZDMP			QU4LITY		
Committee	ID	under development	Title	Link	Date of Publication	Publisher	License	Asset Layer	Integration Layer	Communication Layer	Information Layer	Functional Layer	Business Layer	(tbd)	Human	Security & safety	Interoperability &	Quality	RA	AI	EFPF "in usage"	EFPF RA	EFPF Details	ZDMP "in usage"	ZDMP RA	ZDMP Details	QU4LITY "in usage"	QU4LITY RA	QU4LITY Details
DIN German Institute for	EN 61069 series		Industrial-process	Link	-	_	Private									x	x								---	---		Distributed Trustworthiness	Cyber Security in Industrial Environment
ANSI	B11.0 - 2020		Safety of Machinery	Link	2020	ANSI	Private									x									---	---		Digital models and Vocabularies	Description of industri plants and components
ANSI	B11.Tr10—2020	x	Functional Safety of Artificial	Link	-	ANSI	Private									x				x					---	---		Control Service	Control Service; desig and integration of safet
IEC/TC 65 Industrial-process	IEC 62443 series		Security for industrial	Link	-	ANSI, IEC,	Private									x					x		Two partners	x	Secure installation,	Information Security		Digital models and Vocabularies	e@Class: Supports the digital
CEN/TC 459/SC 3 Structural steels	EN 10219-1:2006		Cold Formed Welded structural	Link	2006	CEN	Private																		none	none		Digital models and Vocabularies	Information security management systems
CEN/TC 459/SC 10 Steel tubes and iron	EN 10305-3:2016		Steel Tubes for precision	Link	2016	CEN	Private																		none	none		Control Service	PLC,HMI (Part 3: PLCOpen XML)
CEN/TC 459/SC 10 Steel tubes and iron	EN 10305-5:2016		Steel tubes for precision	Link	2016	CEN	Private																		none	none		Digital models and Vocabularies	CDD, Definition of the properties and associat
CEN/TC 319 Maintenance	EN 13306:2018		Maintenance – Maintenance	Link	2018	CEN	Private											x						x	Prediction and optimisation	Maintenance		Collaboration, Business and	SIS design: Specification, design
CEN/TC 319 Maintenance	EN 16646:2014		Maintenance – Maintenance	Link	2014	CEN	Private											x						x	none	Maintenance		Factory Network/ Field and Proximity	Profiles for industrial communication networ

Figure 21: Common standards mapping matrix (sample)

- ❑ **TC1.3: Common feedback and recommendations (Ambassador: M.LORENZ, Austrian Standards, EFPF)**

Main goals: The main goal of this task is to collect and analyse the common feedback and recommendations for standardization in the projects and, based on the results, compose recommendations for actions for the relevant standardization bodies and organisations.

Outputs: The key output of this task is a list of normative recommendations for actions.

Current status: *In preparation, Recursive (6-month-periods)*

Notable results: Due to the fact, that the analysis of major (standardization) results in a project is commonly planned towards the end of a project, it was decided to align the task activities with the planned timelines of contributors. To accomplish the task, a working group of three projects, i.e. QU4LITY, ZDMP, and EFPF, was established to set up the first strategic steps of the task and then discuss these at the joint regular meeting. Initially, the task foresees to contribute to a list of recommendations and update these recursively in 6-month-periods.

- ❑ **T1.4: Joint CWA proposals and guidelines (Ambassador: C.GRUNEWALD, DIN, ZDMP)**

Main goals: The main goal of this task is to identify and coordinate the joint CWA activities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Outputs: The main output of this task is the joint strategy of WG1 with regard to CWA proposals (incl. joint discussions, collecting of inputs, regular updates, etc.)

Current status: *Ongoing*

Notable results: The main results of the task can be summarized as follows:

- the WG1 projects show high motivation and participation in the CWAs;
- the first dissemination activities show high acceptance of responsible TCs;
- the following CWAs and guidelines are currently coordinated by WG1, see Figure 22.

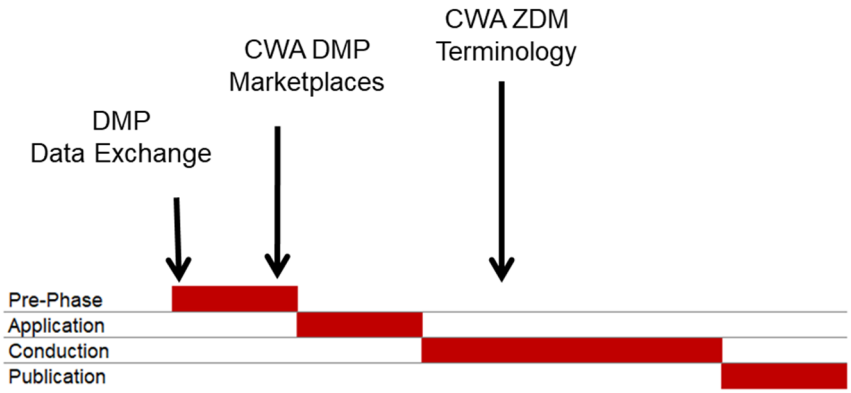


Figure 22: Current progress of the CWAs and standardization guidelines

❑ **T1.5: Joint standardization events (Ambassador: O.MEYER, FHG, CF2)**

Main goals: The main goal of this task is the coordination and support of joint standardization events for WG1 members.

Outputs: The key output of the task is a report on standardization events related to WG1 activities.

Current status: *Ongoing*

Notable results: The following events with regard to standardization activities of WG1 as well as the dissemination of the specific standardization results of the projects were coordinated in the task:

- Cybersecurity workshop organised by ConnectedFactories 2 on the 20th of January 2020
- ConnectedFactories Webinar - Standards for digital manufacturing organised in association with the ConnectedFactories CSA on the 20th of October 2020.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- **T1.6: Joint dissemination work (Ambassador: O.MEYER, FHG, CF2)**

Main goals:	The main goal of this task is the coordination and support of joint dissemination activities (joint work with the DMP Cluster WG Dissemination).
Outputs:	The key output of the task is a set of disseminations including the key results of the WG1 activities.
Current status:	In preparation
Notable results:	First discussion and coordination of the joint dissemination topics took place n the regular joint meetings. The common strategy still needs to be aligned with the DMP Cluster WG Dissemination.

4.3.3 Meetings

Since the launch of the DMP Cluster several WG1 meetings and workshops took place (see Table 4). According to the latest resolutions of the WG1, the meetings are to be held regularly at three-month intervals. Intermediate meetings with regard to any internal work of the tasks are admissible at any time.

The coordination and organisation of the meetings is the responsibility of the ConnectedFactories2 Task 1.3 lead. The convenor of the WG1 is O. MEYER (Fraunhofer IPA).

Table 4: Relevant CSA activities in the DMP Cluster.

DMP Cluster / Plenary	
Date	Activities
19-09-25, 20-03-12, 20-05-13, 20-06-04, 20-12-02 - 20-12-03, *[18]21-02-26	Presentation / WG1 report on current status and results
DMP Cluster / Leads	
Date	Activities
20-09-16,*21-01-28	Discussion / WG1 report on current status and results
20-09-25, 20-11-20	Discussion / Alignment between DMP Cluster and ConnectedFactories2 activities; WG1 / CF2 Task 1.3 alignment

[18] planned

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

DMP Cluster / WG1 Standardization

Date	Activities
20-01-23	Agenda ➢ General update on actions (O. MEYER, CF2) ➢ Discussion points ❑ T1.0 General strategy ❑ T1.1 "Boosting Innovation through standards - Your gateway to the market"
20-05-12	Agenda ➢ General update on actions (O. MEYER, CF2) ❑ Standardization activities (ZDMP, Qu4LITY, EFPF) ➢ Discussion points ❑ CWA preparation
20-05-18	Agenda ➢ General update on actions (O. MEYER, CF2) ➢ Presentation of the CWA drafts (Ch. GRUNEWALD, ZDMP) ➢ CWA Discussion points ❑ Titles, members and participants, timeframe ❑ Targeted committees ❑ "Scope narrowing" (project contribution), etc.
20-06-23	Agenda ➢ (16 - 17 CEST) General update on actions (MEYER, CF2) ❑ Standardization in KYKLOS4.0 (BENGTSSON, KYKLOS4.0) ❑ Standardization in QU4LITY (MEYER, QU4LITY) ❑ Standardization activities/RAMI 4.0 (NAZARENKO, UNINOVA) ❑ Update of the projects' activities ➢ (17 – 18 CEST) CWA preparation (GRUNEWALD, ZDMP) ❑ Task 1.4 CWAs
20-09-14	Agenda ➢ (16 - 17 CEST) General update on actions (MEYER, CF2) ❑ Projects' status update (ALL) ❑ Task 1.6: Joint papers update (cooperation with WG3 "Joint research activities")

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

	❑ Task 1.2: Common standards (MEYER, NAZARENKO, Report) ❑ Task 1.5 Webinar preparation ➢ (17 – 18 CEST) T1.4 - CWA preparation (GRUNEWALD, ZDMP) ❑ Task 1.4 CWAs
20-12-09	Agenda ➢ (16 - 17 CEST) General update on actions (MEYER, CF2) ❑ Projects' status update (*ALL*) ❑ Update digiPRIME (*SOLDATOS*) ❑ Update KYKLOS 4.0 (*BENGTSSON*) ➢ Tasks: ❑ Task 1.2 Common standards (*MEYER*) ❑ Task 1.3 Collection of gaps and recommendations (*MEYER*) ❑ Task 1.6 & T1.5: Events and joint dissemination activities (*MEYER*) ➢ (17 – 18 CEST) T1.4 - CWA preparation (GRUNEWALD, ZDMP) ❑ Task 1.4 Joint CWA proposals
21-02-17	Agenda ➢ (16 - 17 CEST) General update on actions (MEYER, CF2) ❑ Projects' status update (*ALL*) ➢ Tasks: ❑ Task 1.2 Common standards (*MEYER*) ❑ Task 1.3 Collection of gaps and recommendations (*MEYER*) ❑ Task 1.6 & T1.5: Events and joint dissemination activities (*MEYER*) ➢ (17 – 18 CEST) T1.4 - CWA preparation (GRUNEWALD, ZDMP) ❑ Task 1.4 Joint CWA proposals

4.4 Examples from projects (mapping of projects)

4.4.1 EFPF- European Connected Factory Platform for Agile Manufacturing

This subchapter summarizes the key mapping results with regard to EFPF project. The projects' activities in standardization are coordinated in the WP11: Dissemination, Collaboration and Standardisation, Task 11.3 (Regulatory Alignment, Compliance and Standardisation Strategies). The work includes periodical reporting that is provided by EFPF partners as guidance in standardisation activities:

- D11.11: Standardisation Plan - Vs: 1.0 – Status: Published

4.4.1.1 Goals

EFPF focuses on the alignment of all project activities and goals with the current regulations as well as on-going standardisation activities EFPF wants to ensure compliance with the General Data Protection Regulation (GDPR) of the EFPF platform.

Within EFPF, standardisation activities are derived by the experts within the consortium to provide two-way communication between EFPF RTD activities and ongoing standardisation activities. The project promotes

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

the use of "Standardisation guidelines for IST research projects interfacing with ICT standards organisations" by the Cooperation Platform for Research and Standards (COPRAS[19]).

4.4.1.2 Focus objectives

Based on the nature of technical activities (i.e. implementation of a federated digital manufacturing platform that interlinks multiple platforms, tools and services through a standardised interoperable Data Spine), the following focus objectives of EFPF are considered relevant to the ongoing standardisation and regulation activities as depicted in Figure 23.



Figure 23: EFPF - Standardization focus objectives (Source: EFPF, D11.11, Vs.1.0, p.9)

Moreover, the consortium carries out important interactions with the national and European regulation and standardisation bodies on smart factory automation, data processing and analytics in order to facilitate the sharing of data and standardisation processes.

4.4.1.3 Standardization activities

EFPF recognizes an urgent need for the convergence of different tools/solutions towards a networked, interoperable federation. This is due to the common problem of increasingly overlapping standards and the challenge of finding suitable standards for specific platform solutions. The approach taken in the EFPF is to closely monitor ongoing developments in various standardization initiatives and, through expert support, to align RTD activities with ongoing standardization activities. The main goal here is to adopt existing standards and, where possible, contribute to the development of standards. Based on this approach, a standardization plan was developed to better plan the project's standardization activities on a strategic and tactical level.

A data gathering exercise was organised within the project to raise partner awareness about relevant standards and to collect partner input on EFPF related standards. As the result, EFPF identified more than 40 standards references that were classified and listed in the D11.11. The outcomes are transferred in **¡Error! No se encuentra el origen de la referencia.** of this document.

In addition to CWA proposals that are coordinated in TC1.4, EFPF launched a EN-CENELEC Workshop on European Connected Factory Platform for Agile Manufacturing Interoperability (EFPFInterOp). The invitation was spread among the WG1 members. The motivation of EFPF for creating the CEN-CENELEC Workshop is to have a standardized interoperability framework enabling an open market infrastructure for European manufacturing, interlinking digital manufacturing platforms, smart factory tools and Industry 4.0 concepts to realise and support a connected and smart ecosystem of the future[20]:

[19] https://www.w3.org/2004/copras/docu/D15.html

[20] https://www.cencenelec.eu/news/workshops/Pages/WS-2020-011.aspx

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

4.4.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality

This subchapter summarizes the key mapping results with regard to QU4LITY project. The projects' activities in standardization are coordinated in the QU4LITY Task 9.2 Standardization and Clustering. The work includes periodical reporting, i.e.:

- [M15] Deliverable 9.5 - Contributions to SDOs, Associations and Clusters (Draft Report) – Status: submitted
- [M39] Deliverable 9.6 - Contributions to SDOs, Associations and Clusters (Final Version) – Status: to be prepared

4.4.2.1 Goals

The main goals and outputs with regard to standardization can be summarized as follows:

- reporting on the overall standardization strategy of the project and to specify the common standardization landscape;
- reporting on various standardization activities (also including monitored activities) based on the activities and contributions of the project consortium at international, national, and European level;
- reporting on the project's clustering activities regarding standardization, listing the recent standardization work and cluster roadmap activities;
- providing an overview of the related network events pursuing a specific standardisation purpose and contains a detailed description of the work carried out in the project
- providing a detailed overview and summary of the work done, including some useful information on limitations and lessons learned, and future work.

4.4.2.2 Focus objectives

The project identifies the following focus areas to be addressed in its standardization activities, see Figure 24

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

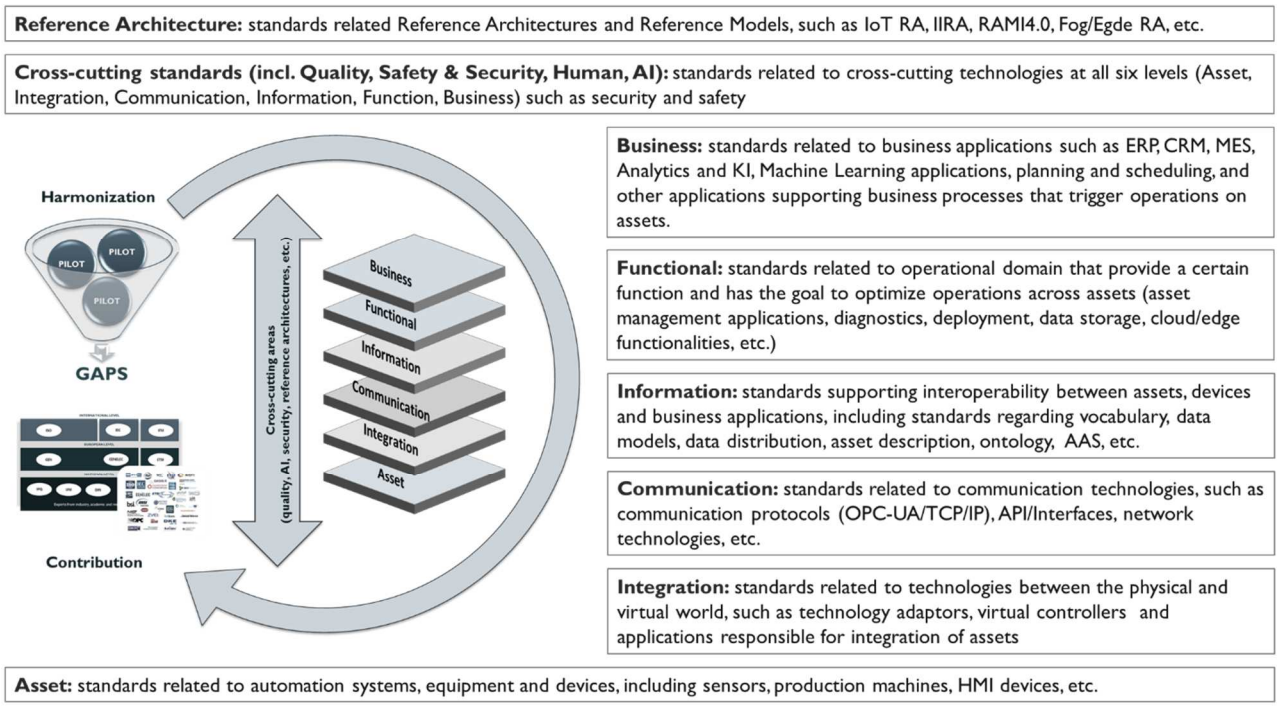


Figure 24: Standardization areas identified across RAMI 4.0 layers (Source: QU4LITY, D9.5, p.13)

4.4.2.3 Standardization activities

The current report on standardization activities of the project indicates that QU4LITY experts participated in more than 80 activities. Among these:

- more than 30 general assembly / plenary meetings (one to two-day meetings) of the various SDOs/SSOs at national, international and European level;
- ca. 40 remote working sessions and workshops in various standardization working groups and consortia at national, international and European level;
- 5 external events with dissemination of standardization results at European and international level;
- 4 large internal working sessions and (not counted) short regular editorial online conferences.

QU4LITY standardization experts are constantly involved in the key concepts of the project and provide pilots and service developers with standards-specific reviews and recommendations as well as helpful references with regard to standards and their use. QU4LITY experts share standardization results at internal meetings/workshops' on a regular basis. Such meetings aim to improve technology developments and standardization awareness of the partners to various standardization activities with regard to Cybersecurity, Artificial Intelligence, Interoperability and Administration Asset Shell, Zero Defect Manufacturing Terms and Definitions, New Market Technologies and Trends, Industrial IoT and Use Cases, and other.

The QU4LITY experts are promoting the standardization results at the EU digital manufacturing community, clusters and associations (such as OPEN DEI, EFFRA, ForeSee Cluster, DMP Cluster, etc.).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

4.4.3 ZDMP – Zero Defect Manufacturing Platform

This subchapter summarises the key mapping results concerning the ZDMP project. The projects' activities in standardisation are coordinated in "WP4: Technical Challenge: Requirements, Specifications, and Standardisation." The work includes periodic reporting outlined in the following deliverables:

- D4.6a: Standardisation Plan and Status Report – Vs 1.0.6 – Status: Published
- D4.6b: Standardisation Plan and Status Report – Vs 2.0.6 – Status: Informal Pre-Version Submitted to EU for Comment

These deliverables provide a regimented plan towards meeting the established standardisation goals against the current standardisation landscape in the field of zero-defect manufacturing.

4.4.3.1 Goals

The ZDMP open ecosystem is dependent upon a standardised interface to ensure an open and transparent environment. The project established three standardisation goals, as shown in **Figure 11**, to ensure that this takes place:

- Interaction – To engage with the relevant standards groups and standardising bodies for information exchange.
- Input – To actively contribute to the standardisation process(es) to exploit the project results.
- Compliance – To monitor the use of standards and standardisation within the project to foster compliant results.

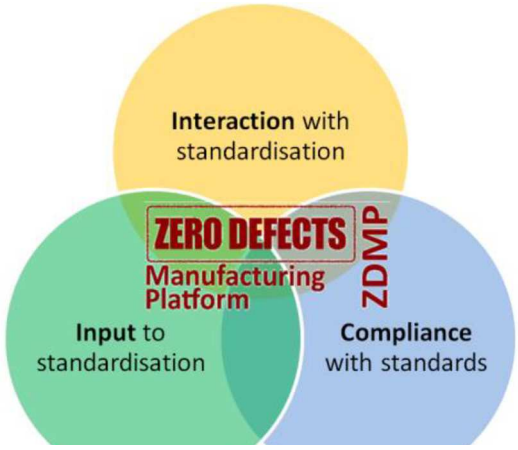


Figure 25. ZDMP standardization goals (Source: ZDMP, D4.6a, Fig. 1)

4.4.3.2 Focus objectives

The overall project has several main objectives, but standards and standardisation plays a key role in supporting three: extensibility, interoperability and openness. This is further defined in the ZDMP project objective to which the deliverable is attached:

- O4.6: To define and provide standardisation input and engagement

4.4.3.3 Standardization activities

The standardisation activities for ZDMP have taken the following form to date:

Horizon Scanning – The current standardisation landscape (as it would most impact the project) first had to be defined. This resulted in horizon scanning activities where the most important standards, standardised tools, and standardising bodies and/or committees were identified.

Standards Identification – Existing standards were then evaluated across a regional, national, European and International stage. They were subsequently broken down into several categories of particular relevance to the project: general, zero defects, smart manufacturing, cloud and platforms, and predictive maintenance.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Engagement – The various relevant standardising groups or bodies then had to be engaged with. This process was eased by different project partners who were already members of various standardisation-focused consortia.

Process Evaluation – It was then important to understand the process for participating in the creation or amendment of current standards within these standardisation bodies. The primary path towards this for many of the most relevant standards was determined to be via a European Committee for Standardisation (CEN) workshop and the generation of a CEN Workshop Agreement (CWA).

Workshops – CEN workshops are considered cornerstones for communicating standardisation needs and developing standardisation proposals, both within the ZDMP project and in cooperation with others. The primary aim of these workshops is to identify potentials in standardisation and identify any needs for activities within the project. First, a ZDMP project level workshop was held. As an output of this activity, a series of CEN workshops have been planned to discuss specific standardisation topics: Terminology, App Requirements and Data Exchange Guidance.

4.4.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences.

This subchapter summarizes the key mapping results with regard to KYKLOS 4.0 project. The projects' activities are at the early stage. Currently, there is no reporting documentation available at the portal.

4.4.4.1 Goals

KYKLOS 4.0 is developing an Advanced Circular and Agile Manufacturing Ecosystem based on rapid configurable manufacturing processes and individualized consumer preferences. The related standardization activities are described in WP4: Product on Demand Framework Integrate in the task "PLM repository based on ISO 10303 – Enable collection of heterogeneously formatted data". Jotne's PLM repository is the central repository for standards based access to lifecycle engineering data.

4.4.4.2 Focus objectives

Based on the project goals KYKLOS 4.0 aims to provide a set of product-service simulation models. The main interest of KYKLOS 4.0 is, therefore, related to the work of ISO TC 184/SC, especially ISO 10303 standard for Industrial Data. In particular, the following aspects are of great interest:

- product specifications, standards and regulatory compliance,
- product design & materials, the suppliers, the manufacturing strategy (produce to order or make to stock), the product usage (profiles of customers), and the product servitisation (type of maintenance services proposed), and eventually product recycling/reuse and
- security requirements.

4.4.4.3 Standardization activities

KYKLOS .0 wants to facilitate the acceptance and utilization of the developed solutions by the market in alignment with standardization. On the one hand, the projects aims to ensure capability and interoperability with existing solutions on the market through standards. On the other hand, it wants to use the "standardization system" as a powerful tool to disseminate the project results and start interaction with the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

market stakeholders. Following considerations with regard to standardization activities were provided to CF2 by the KYKLOS 4.0 experts:

- Through using international standard formats for the data storage the PLM Module will be key to KYKLOS 4.0 enabling consumer products manufacturers to integrate products and components that have been independently designed, produced and used, in addition to the manufacturing system itself.
- Using ISO 10303 standards for data exchange, sharing and archiving the PLM module will provide a central repository for all applications in the project, at the same time allowing any legacy system to be connected in commercialization's of the project results.
- Further, the project will significantly contribute to the standardization efforts in Industrial Data systems taking place in ISO TC 184/SC4 and its counterparts in CEN/CENELEC to work as a transfer channel of new industrial participation opportunities.
- At the same time, the standards will promote innovations, ensure quality of products, enhanced visibility, increase safety and environmental protections

4.4.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks.

DigiPrime is an interdisciplinary project that develops and validates a digital platform for the Circular Economy, with emphasis on the management of the circular chain, including cross-sector interactions. The project's standardization approach is also interdisciplinary and aims at covering standards and policies in multiple areas including:

1) **Standards relating to the project's Digital platform**: The project adopts standards-based approaches for the development of its Digital platform. Specifically, standards associated with Industrial Internet of Things (IIoT) applications (e.g., the Industrial Internet Reference Architecture, RAMI 4.0) are considered, in conjunction with standards and guidelines for the development of data spaces (e.g., design guidelines from the Industrial Data Spaces Associations (IDSA)). Most of these standards focus on the architectural aspects of the platform. Nevertheless, the project also develops and use standards-based components such as Lifecycle Assessment components based on MIMOSA standards and ISO55000 standards for asset management. Likewise, the data models of the platform adhere to standards and related guidelines (e.g., of the Industrial Ontology Foundry (IOF)).

2) **Standards relating to the project's Circular Economy aspects**: The applications, services and pilots that are developed and deployed over the platform adhere to circular economy standards and guidelines, such as guidelines from the European Batteries Alliance (EBA) regarding the Recyling of batteries, composite standards for the certification of recovered materials, as well as materials efficiency aspects (e.g., IEC TC21 on Secondary cells and batteries, IEC TC69 on Electric Road Vehicles).

3) **Regional/National Level Policy Making**: DigiPrime has an active role in circular policy making at regional level based on the consortium's liaisons with regional clusters and Digital Innovation Hub

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

(DIH). The project will provide relevant policy making guidelines for the circular economy, while developing a tool for supporting policy makers in identifying and resolving legal barriers to circular innovation at regional level.

4.4.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories

This subchapter summarizes the key mapping results with regard to SHOP4CF project. The projects' activities in standardization are coordinated in the SHOP4CF T7.1 Pre-regulatory aspects of human-robot collaboration within work package 7, Standardization, legal and ethical aspects. The work includes periodical reporting, i.e.:

- [M40] Deliverable 7.1 D7.1 : Contributions to standardization bodies
  - This is a public report about all activities within the project which contribute to standards. This includes a description of the activities taken to get SMEs involved in the standardization process, such as polling, training/information workshops and any feedback collected from SMEs that is intended to influence standardization bodies. It also includes description of the activities taken by the consortium to contribute to standardization processes, including any best-practice publications and or suggestions regarding current gaps in standardization and safety regulations.
  - Status: to be prepared

4.4.6.1 Goals

The main goals and outputs with regard to standardization can be summarized as follows:

- This task focuses on the issues regarding pre-regulatory aspects of human-robot collaboration. This includes identification of all relevant stakeholders and the accompanying use-cases. Then we will cross-reference the goals with current standards to identify gaps. The best practice guidelines will be based on experimental data gathered by the user-experience experts in the project, as well as according to the current standardization and regulatory situation.
- The project will result in a document clearly defining rules of engagement for different situations where humans come in contact with collaborative robots, specifically including adults in industrial settings, as well as children or the general public in industrial, civil (e.g. on the street) and domestic (e.g. in the home) settings. These rules of engagement include both expected robot behaviours as well as specific instances of how humans can intervene in normal robot operation (e.g. cause the robot to slow down, replan and change its trajectory, stop the robot, or have the robot initiate communication with the human with the goal of reducing any unintended process interruptions.
- The project will liaison with the DMP Cluster to also participate in standardization activities initiated through that organization and that match with SHOP4CF project profile. Currently this involved working on the WG1 Standardization in the DMP Cluster, as well as concrete participation in the CEN-CWA on the topic "Digital Manufacturing Platform – Marketplace requirements"

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

5 Interoperability

The DOW defines this task as:"focused on defining the best practices in interoperability,

- and **looking for new forms of cooperation amongst companies and sectors,**
- addressing **enhanced transparency** across manufacturing cells, production lines, factories and even between different manufacturing companies
- suggesting **actions to address the cooperation** challenges.

Interoperability amongst manufacturing companies rely on several aspects that will be analysed. These aspects include material, resources and product **traceability** as well as questions and improvements related to **quality control or logistic improvements**. And **technical constraints on** Transparency and interoperability. Leaving legal or business models aspects to be analysed in T1.1 or T.1.2

This task is closely related with the Hyperconnected Factories pathway (developed under ConnectedFactories 1) but also with Lot-size-1 and sustainable-value-networks in the current and future ICT 07 projects.

In order to address all this interoperability views, it is necessary to define a taxonomy that permits the clusterization of the different aspects.

5.1 General observations on interoperability

Europe has a good position and could win the "second half" of the digital match against global competitors (Commissioner Oettinger, 2015). In these considerations the important role of platforms and B2B-platforms are receiving more attention among policy makers and businesses (1). A first wave of commercial platforms is launched to the market (e.g. GE Predix, Siemens Mindsphere). **Commission and member states are investing in** developments of platforms and **interoperability.**

Vision of the Plattform I4.0: Interoperability is a huge thing in Germany this year. The key word here would be "Ecosystems", especially to the new for Industrie 4.0 till 2030 (Figure 26.



Figure 26: 2030 vision for I4.0 (Source: Plattform 4.0)

On the 5th and 6th February 2018, before this CF2 CSA, EFFRA hosted a dissemination event on digital platforms in manufacturing in association with the ConnectedFactories Coordination and Support Action. A specific session addressed standardisation and interoperability aspects of the FoF 2016-11 projects (this call

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

topic is associated with that ConnectedFactories CSA). More information and presentations from the respective sessions can be downloaded here: https://www.connectedfactories.eu/events/5-6-february-2018-connectedfactories-dissemination-event.

In the following sections, we have analysed different projects according to RAMI and IIRA concluding they would be a complementary way to define and map initiatives.

5.1.1 INTEROPERABILITY at RAMI 4.0 Vertical layers

INTEROPERABILITY can be defined in many ways and from many perspectives:

- Interoperability is create a knowledge representation of an agent/asset in modular production.
- Interoperability is the seamless movement of data along different levels of knowledge.

Looking for a new way to define interoperability, it is important to look at the RAMI 4.0[21] in first place (Figure 27):

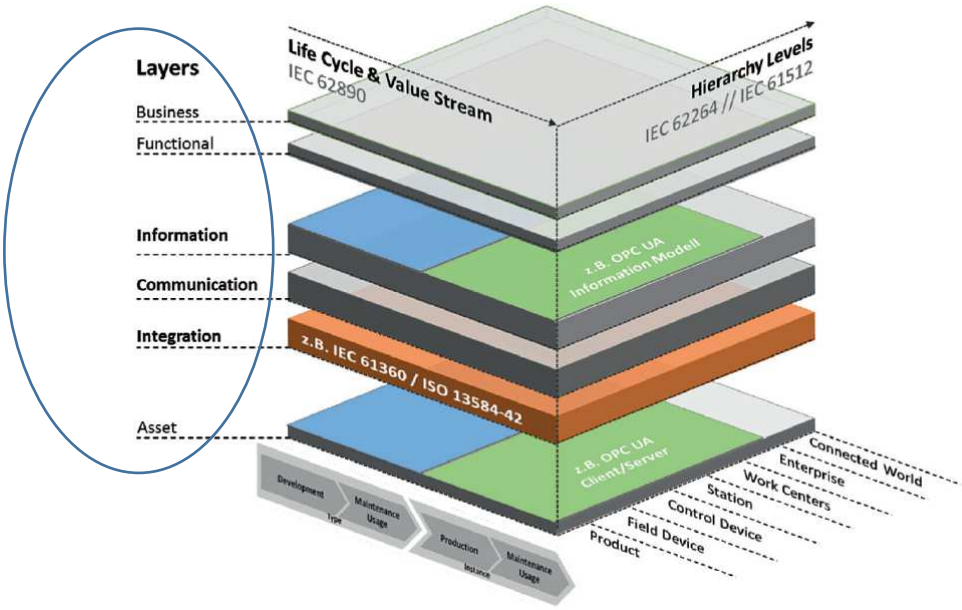


Figure 27: Interoperability layers in RAMI 4.0

RAMI 4.0 provides 6 vertical layers

- Business
- Functional
- Information
- Communication
- Integration
- Asset

[21] Reference architecture model industry 4.0 (RAMI 4.0)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

However, **there are many ways to look at the interoperability, so the following appoach tries to link them with RAMI 4.0 and use its architecture from now on.**

The first exaple shows how to describe each of RAMI 4.0 vertical layers with the help of MIDIH (Figure 28).

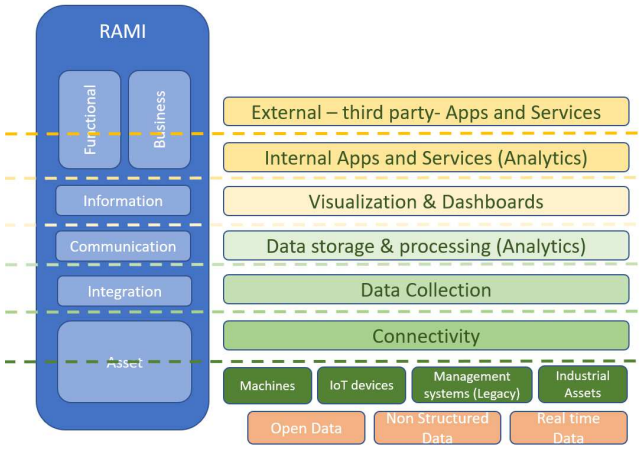


Figure 28: Interoperability comparison: MIDIH and RAMI 4.0

MIDIH RA provides similar RA with Functional layers and capabilities. In this case, the data sources (ASSETS in RAMI 4.0) are IOT devices, machines, legacy systems, industrial assets.. Other aspects to take into account are:

- open data;
- real time data;
- non structured data (streaming).

The MIDIH approach is shown in Figure 29.

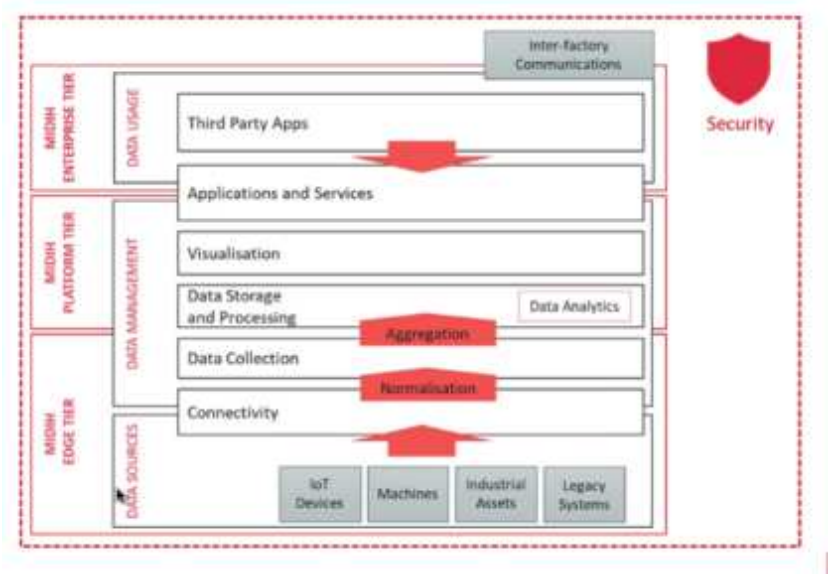


Figure 29: MIDH approach

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

But there are other ways to address interoperability, for example, through distinguishing three aspects:

1. DATA GENERATION: Data is generated on an ASSET, and INTEGRATED filtering the data (usually on the EDGE).
2. DATA MANAGEMENT: Then it is COMMUNICATED through the INFORMATION layers, transforming in structured data. This is usually the FOG at PLATFORM level.
3. DATA USAGE: And then is analyzed either for improving FUNCTIONAL aspects (performance, quality, productivity….) or BUSINESS aspects. This is the CLOUD. See the picture below:

In the following Figure 30, this different approach and RAMI 4.0 are mapped.

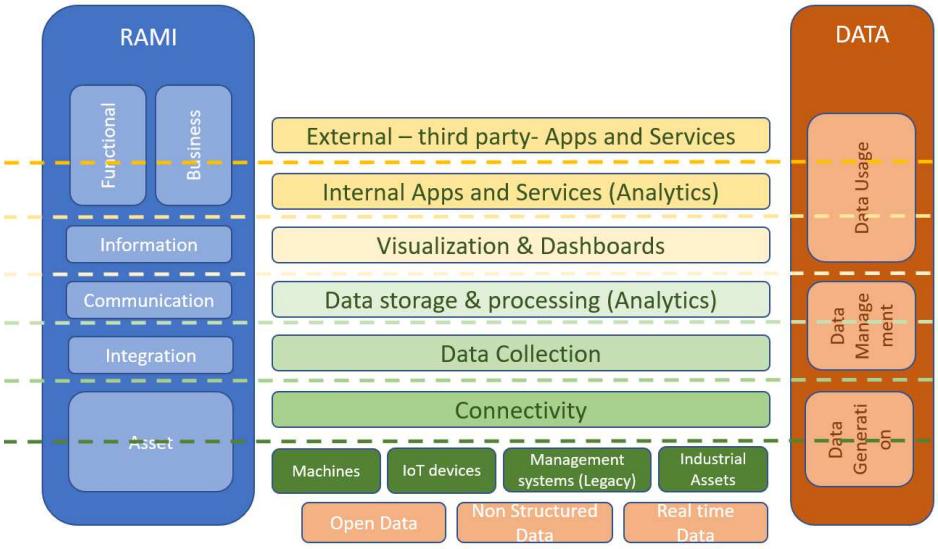


Figure 30: Data mapped in RAMI 4.0

In MIDIH, data sources along with connectivity, normalization, data collection and aggregation are made at EDGE level. It is also called DATA IN MOTION. Data storage and processing (analytics) are made at PLATFORM level (FOG). Also called DATA AT REST. While applications, services and third party apps are at enterprise level. See Figure 31 below.

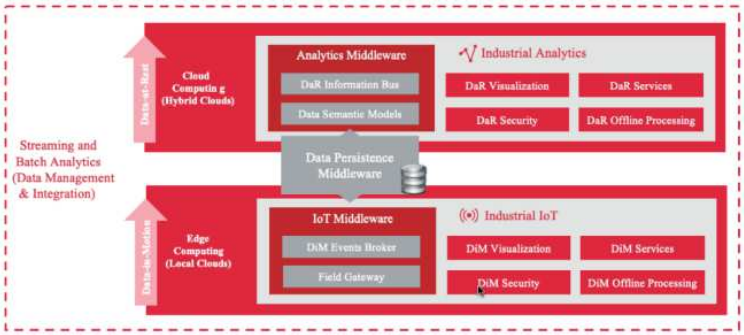


Figure 31: MIDIH data approach

The following shows the mapping results of both approaches (Figure 32):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

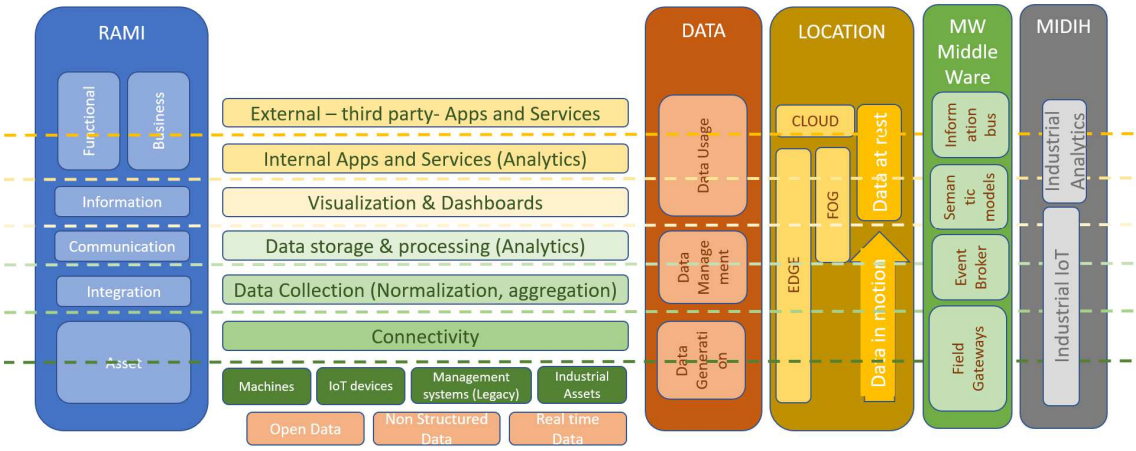


Figure 32: MIDIH data approach mapped in RAMI 4.0

At last, another way to look at interoperability (DIMOFAC, AAS, and EIF – see Figure 33) is:

- Technical interoperability: ability to exchange data (ISO/OSI);
- Syntactic interoperability: Description of the data with all its type attributes in uniform formats (OPC UA);
- Semantic interoperability: ability to interpret the exchanged data in such a way that intended actions can be recognized and triggered;
- Organizational interoperability: ability to act in non-technical processes.

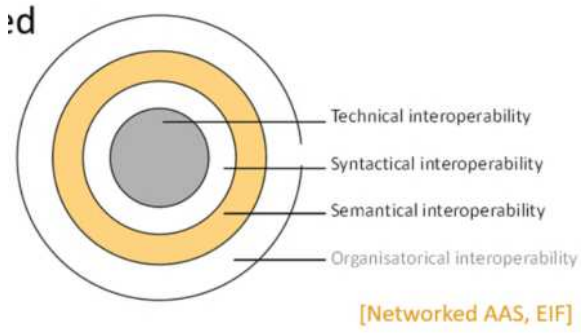


Figure 33: AAS approach to interoperability

After mapping of this definition into the RAMI 4.0, the following result is displayed (Figure 34):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

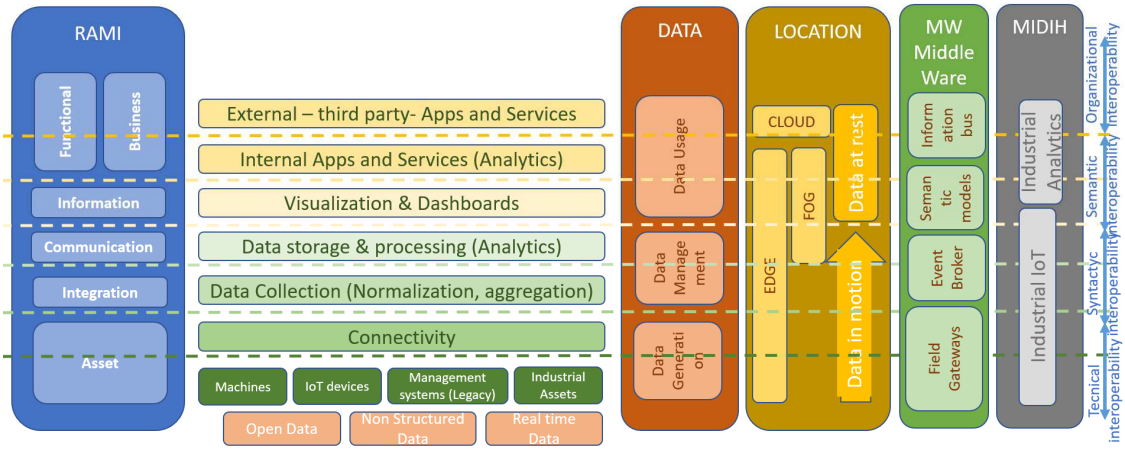


Figure 34: AAS approach mapped in RAMI 4.0

As a preliminary conclusion of this chapter, we could say that RAMI permits the mapping of the different interoperability approaches of different projects and initiatives.

5.1.2 Interoperability at RAMI 4.0 Horizontal Hierarchy levels

It is also possible to look at INTEROPERABILITY from the Horizontal perspective of RAMI 4.0 (Figure 35). In this way, it is possible to address not only a vertical flow, but also interconnecting with other devices, controls, stations, enterprise.

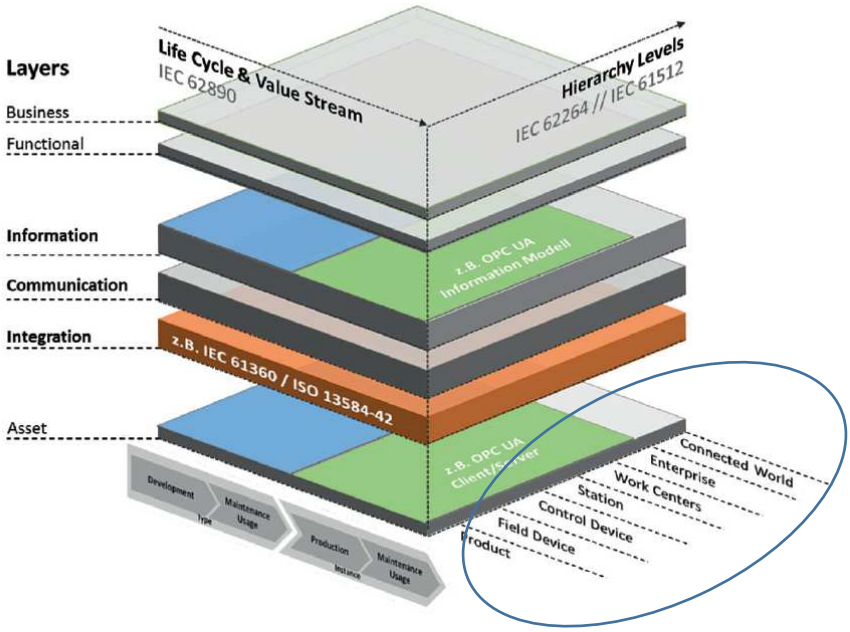


Figure 35: RAMI 4.0 horizontal layers - Hierarchy levels in RAMI 4.0

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

1. **Product:** Interoperability amongst products at use phase. RAMI 4.0 is much focused on the manufacturing than on use. Industrial products (where RAMI 4.0 applies) appear in multiple industries (where IIRA applies) so they must interoperate.
2. **Field device**: Interoperability amongst field devices (sensors, actuators…)
3. **Control device**: Interoperability amongst control devices (PLCs, PCs, AI based control tools…)
4. **Station**: Interoperability amongst stations (production cells, robots and machines, machines and humans…)
5. **Work centre**: Interoperability amongst work centres (production lines within a factory, departments within a plant…)
6. **Enterprise**: Interoperability amongst enterprises (different factories of a company)
7. **Connected world**: Interoperability amongst field devices (different companies, companies of the supply chain, customers-suppliers…)

In the following Figure 36 a sketch of the different levels is presented:

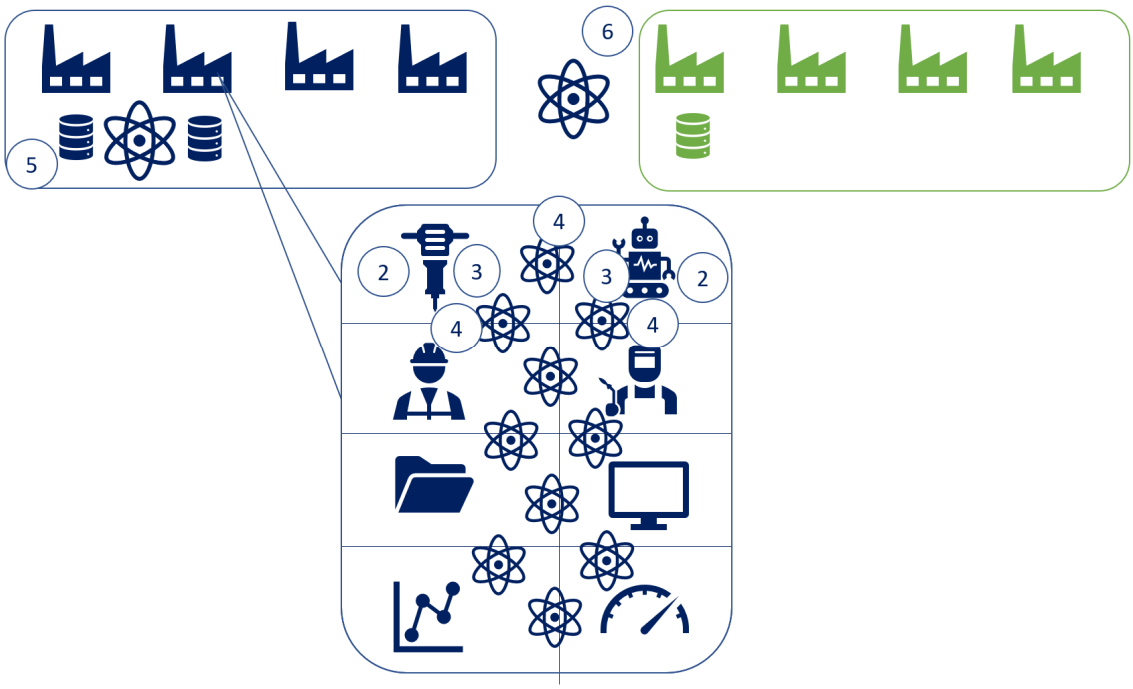


Figure 36: Sketch of different levels

The following Figure 37 highlights the relation amongst companies according to the vertical layer of RAMI. Exchanging data not only at high level (enterprise) but also amongst their machines, stations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

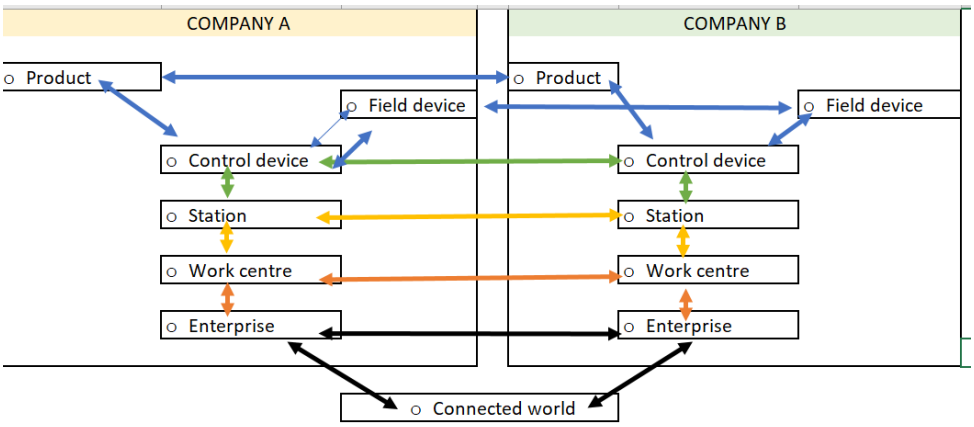


Figure 37: Horizontal interoperability

This interoperability concept was already addressed in the HYPERCONNECTED FACTORY pathway.

5.1.3 Interoperability in IIRA: Layered databus and architectural pattern

Industrial Internet consortium provides a similar reference architecture (IIRA) based on a data driven approach. The mapping of IIRA and RAMI 4.0 shows the following results Figure 38

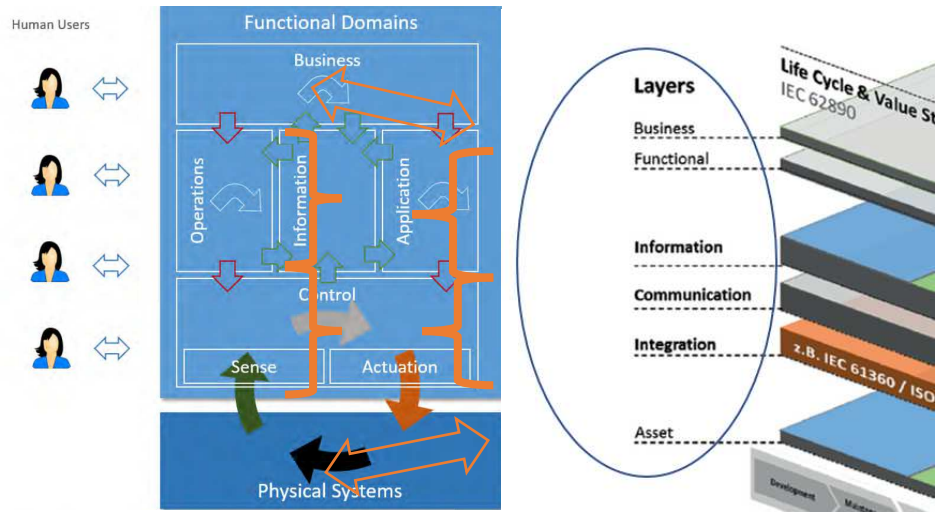


Figure 38: IIRA-RAMI 4.0 relationship

The three tier mapping defined by IIC, can also easily match it with RAMI 4.0 and the previous sketch (Figure 39)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

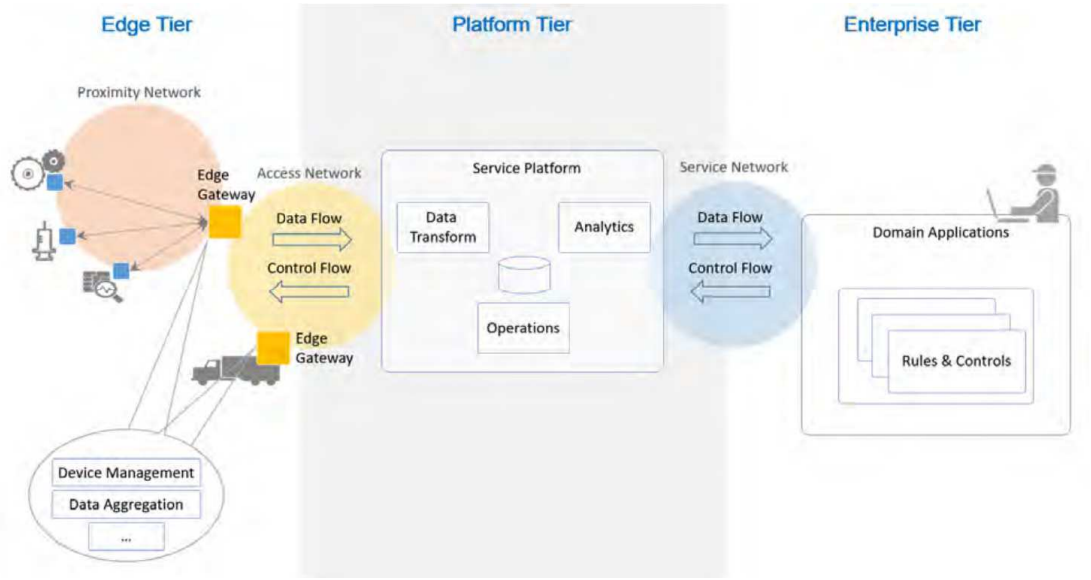


Figure 39: Three Tier IIoT system architecture

The rotation of the image allows its fitting in the previous sketch (Figure 40**¡Error! No se encuentra el origen de la referencia.**):

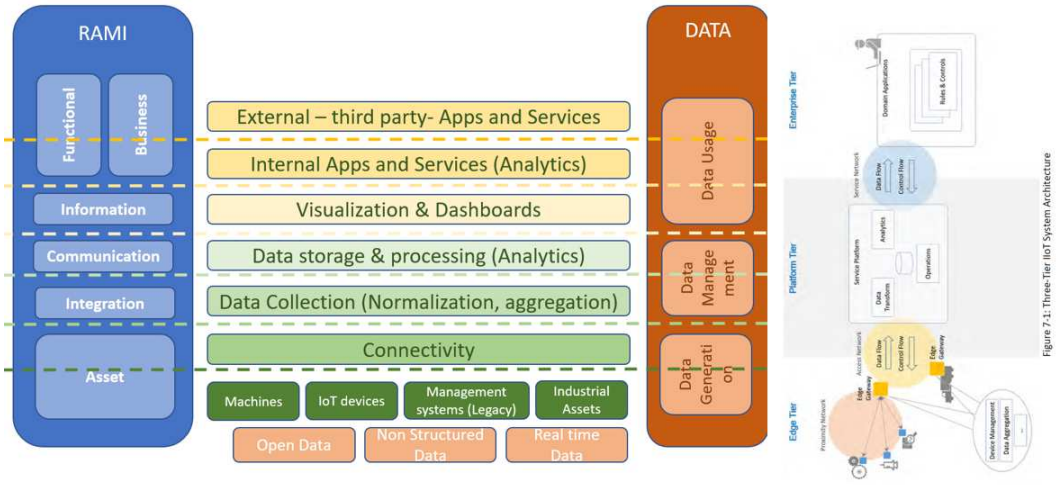


Figure 40: RAMI 4.0 and the the 3Tier IIoT

Furthermore, it allows its matching even clearer in the **¡Error! No se encuentra el origen de la referencia.** Figure 41 and matching it with the sketch as shown in Figure 42

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

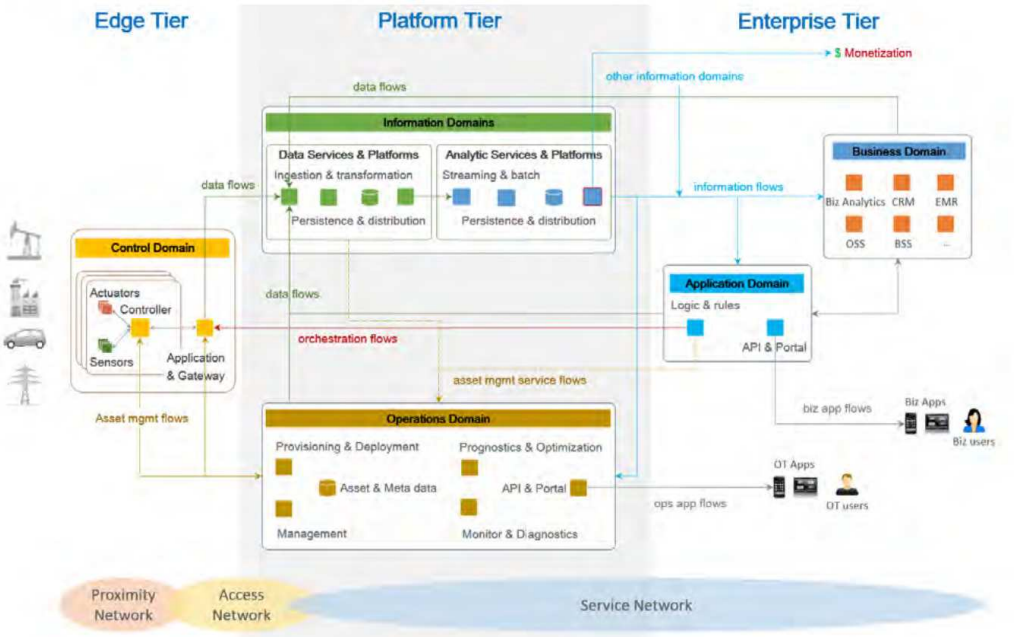


Figure 41: Three-tier architecture and the functional domain mapping.

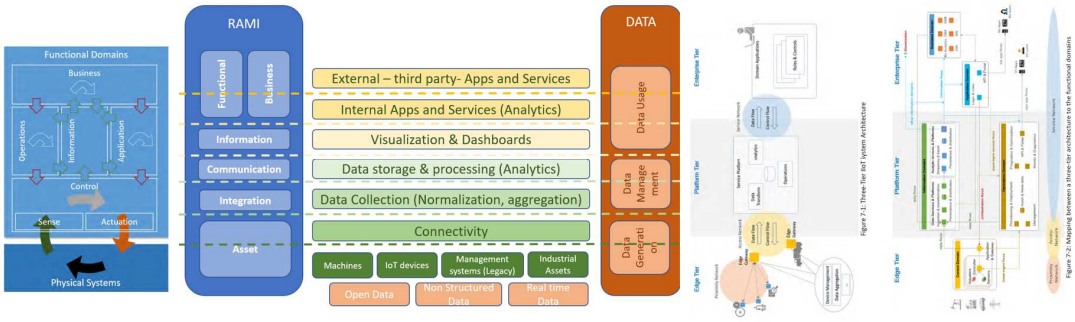


Figure 42: IIRA mapping

Continuing the evaluation of IIC RA, a layered databus architecture could be analysed (Figure 43). The lower level (smart machines) is the real world: sensors, actuators, objects, devices machines. It could even be a CPPS (e.g. a car, a robot).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

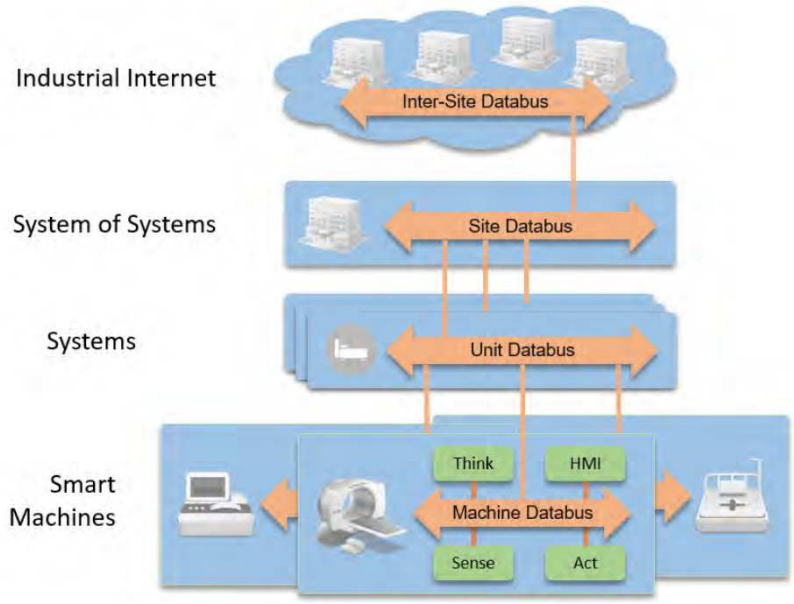


Figure 43 IIRA layered databus architecture

This architecture matches with the hierarchy layer in RAMI 4.0, as it is shown in the Figure 44 below.

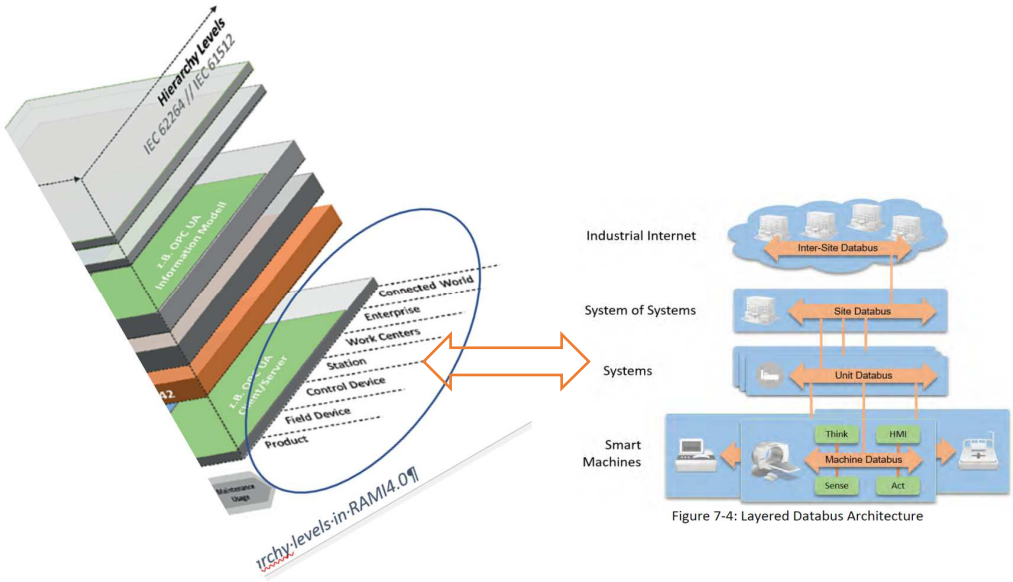


Figure 44: Mapping IIRA layered databus architecture in the RAMI 4.0 hierarchical layer

5.1.4 Interoperability approaches and goals mapped on RAMI 4.0

There are several **approaches to the interoperability topic** that need to be addressed when implementing interoperability:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

1. **Proprietary approach:** Decision of Interoperation of different commercial tools and platforms (against data protectionism). From a more technical point of view, **interoperability** is extremely relevant. This is not only since systems and tools will very likely come from **different vendors**, but also since many **legacy systems** have to be integrated.
2. **International approach:** Data exchange amongst borders.
3. **Sector approach**: Cross-sectorial reference architectures.
4. **Data resiliency approach:** to guarantee the integrity of common repositories. (Blockchain technology).
5. **Integration approach: A**mongst levels on the plant: Edge, fog, cloud.
6. **Semantic/information approach**: Modelling correlation between information sources. Like Open ontologies. Or AAS Asset administration shell.
7. **Data sovereignty approach:** to guarantee the trust amongst participants on data transactions (Industrial Data Space Association).
8. **Digital Twin & Digital Factory:** exchanging data between real and virtual assets?
9. **R**eal time communication.

The approached can be matched in the Horizontal layer of RAMI 4.0 as depicted in Table 5.

RAMI 4.0 vertical layer **Interoperability approach**	**Asset**	**Integration**	**Communication**	**Information**	**Functional**	**Business**
Proprietary					**x**	**x**
International					**x**	**x**
Data resiliency				**x**		
Sector approach					**x**	**x**
Integration		**x**	**x**			
Semantic				**x**		
Data sovereignty				**x**	**x**	**x**
Digital twin			**x**	**x**	**x**	
Real time comm	**x**	**x**	**x**			

Table 5: Interoperability approaches

At the same time, interoperability can be implemented considering different company goals (see Table 6):

1. **Quality goals:** improvements on quality control.
2. **Productivity goals:** improvements on productivity control.
3. **Maintenance goals**: improvements on maintenance control.
4. **Traceability goals** for material, resources and products.
5. **Production visibility goal:** M2M & HMI in factory environment: evaluation of human machine interfacing HMI.
6. **Cooperation approach** new forms of cooperation amongst companies and sectors either at supply chain or value chain.
7. **Logistic approach:** improvements on logistics control.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

RAMI 4.0 horizontal layer **Interoperability Goals**	Product	Field device	Control Devide	Station	Work Centre	Enterprise	Connected World
Quality		x	x	x			
Productivity				x	x	x	
Maintenance			x	x	x	x	
Traceability			x	x	x	x	x
Production visibility				x	x	x	
Cooperation (supply side)						x	x
Cooperation (value side)						x	x
Logistics						x	x

Table 6: Interoperability goals

5.1.5 Interoperability requirements

Several requirements need to be taken into account when addressing interoperability, as e.g.:

- Safety when addressing the interoperability amongst human and machines/ robots.
- Privacy when addressing interoperability amongst different companies.
- Reliability when data are required for very accurate decisions (i.e. at machine level).

Some of these requirements are already mapped in the IIRA, calling them “system characteristics” (Figure 45).

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 873086.

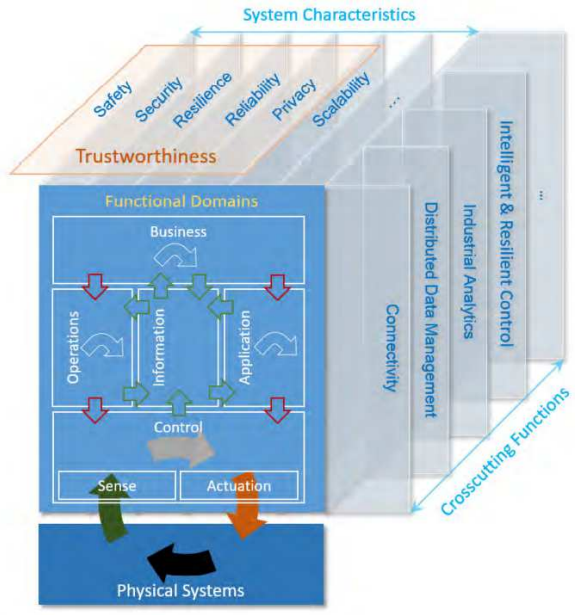


Figure 45: IIRA system characteristics

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

5.2 Reference documents on interoperability.

The following Table 7 shows the main reference documents on interoperability. The list is not exhaustive but highlights only some current work in the area.

Document title	Short description	Link
Progress report 2019. Shaping Industrie 4.0. Autonomous, interoperable and sustainable.	Publication of the Plattform Industrie 4.0: This report reflects the past developments, but also proposes future scenarios along technological and non-technological lines. At the core of the 2030 vision of Industrie 4.0 are the three pillars "autonomy, interoperability and sustainability".	Link
German Standardization Roadmap Industrie 4.0.	The Standardization Roadmap for Industrie 4.0 is one of the pivotal communication media for Industrie 4.0. It enables the national and international exchange of information between standardization, industry, associations, research and politics. It is a guide showing the way for individuals and organizations active in various sectors of technology and presents the outcomes from current work and discussions, as well as an overview of standards and specifications relevant to Industrie 4.0. It sketches out the requirements placed on standardization and lays down effective measures for their successful implementation.	Link
Usage View of the Asset Administration Shell	Publication of the Plattform Industrie 4.0: This discussion paper highlights the applications and benefits of the administration shell	Link
Structure of the Administration Shell	Trilateral perspectives from France, Italy and Germany - Publication of the Plattform Industrie 4.0: The 4th industrial revolution is radically transforming our economies, as innovation and digitization call for a paradigm shift in industrial production and products. Therefore, integrating the digital revolution is the new road ahead for industry.	Link
Relationships between I4.0 Components – Composite Components and Smart Production	Continuation of the Development of the Reference Model for the I4.0 SG Models and Standards-Publication of the Plattform Industrie 4.0: The RAMI4.0 model can be used to describe any I4.0 asset. The I4.0 component allows you to create an information technology link, using the administration shell, between any asset and Industrie 4.0. This document aims to describe an information technology structure that can be used to interrelate various I4.0 components and then organise these components into composites for specific purposes.	Link
Details of the Asset Administration Shell - Part 1	The exchange of information between partners in the value chain of Industrie 4.0 (Version 3.0RC01): The publication states how companies can use the Asset Administration	Link

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

	Shell to compile and structure information. In this way, all information can be shared as a package (set of files) with partners at several levels of the value chain. It is not necessary to provide online access to this data from the very beginning.	
Examples of the Asset Administration Shell for Industrie 4.0 Components – Basic Part. Continuing Development of the Reference Model for Industrie 4.0 Components	The aim of the publication is to provide examples relating to the recently agreed "structure of the asset administration shell" and thus to strengthen a common understanding of the content. This applies in particular to the collaboration with VDI/VDE GMA FA 7.21 and the Ontology sub-working group of Plattform Industrie 4.0.	Link
Industrie 4.0 Communication Guideline Based on OPC UA	Guidance for German small and medium sized companies: An important basis for the successful introduction of Industrie 4.0 is the manufacturer-independent exchange of data in production. For this purpose, the open interface standard OPC UA is increasingly established.	Link
I4.0-Sprache (engl.: Industry 4.0 Language)	Vocabulary, message structure and semantic interaction protocols of the I4.0 language: The publication of the Plattform Industrie 4.0 promises a new level of organization and control of value chains. Networking to form an Internet of Things using data and services, as well as extensive cooperation between components of an Industrie 4.0 system, will create dynamic, self-organizing, self-optimizing, and cross-company value creation networks.	Link
Industrie 4.0 Plug-and-Produce for Adaptable Factories: Example Use Case Definition, Models, and Implementation	The document provides a use case specification, a conceptual model for its realization, as well as the high-level mapping to different technologies. It also provides the description of an example realization to make the concepts more tangible. Still, the description may not be detailed enough to illustrate all facets of the use case. The aim is to use only standards for the implementation of the scenario, so that a vendor-neutral Plug&Produce becomes possible. At the end the document discusses standards useful for the example implementation and provides a first evaluation.	Link
Position Paper Interoperability	The vision for Industrie 4.0: Interoperable communication between machines within networked digital ecosystems In the industrial world, new forms of cooperation have replaced rigid value chains. The borders between countries, industry sectors and companies are becoming increasingly blurred. Machines, products and plants are able to communicate autonomously in digital, globally networked ecosystems that are dynamic, self-optimising and composed of multiple decentralised stakeholders.	Link

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Which criteria do Industrie 4.0 products need to fulfill?	Publication of the Plattform Industrie 4.0: ZVEI and the working group 1 on reference architectures, standards and norms of Plattform Industrie 4.0 have developed general and universal criteria for Industrie 4.0 products. These criteria are described in this guideline.	Link
Submodel Templates of the Asset Administration Shell - ZVEI Digital Nameplate for industrial equipment (Version 1.0)	Publication of the Plattform Industrie 4.0: The Submodel template "Nameplate" for the Asset Administration Shell aims at interoperable provision of nameplate information of an asset by means of a standardised property structure. It targets equipment for process industry and factory automation.	Link
Details of the Asset Administration Shell - Part 2	Interoperability at Runtime – Exchanging Information via Application Programming Interfaces (Version 1.0RC01). This part extends Part 1 and defines how information provided in the Asset Administration Shell (AAS) (e.g. submodels or properties) can be accessed dynamically via Application Programming Interfaces (APIs).	Link
Industrial Internet Consortium and Plattform Industrie 4.0 Explore the Application of Digital Twin and Asset Administration Shell Concepts	The Industrial Internet Consortium® (IIC™) and Plattform Industrie 4.0 announced the publication of a new whitepaper that explores digital twin technology concepts and their practical application in an organization. The joint whitepaper, Digital Twin and Asset Administration Shell Concepts and Application, provides clear and concise definitions of digital twin technologies, standards, and use cases. It also describes how the Plattform Industrie 4.0 Asset Administration Shell, an implementation of a digital twin for industrial applications, enables cross-company-interoperability across the complete value stream.	Link
I4.0 x Industrial Internet: Practices and Findings	White Paper of the Sino-German Expert Group on Industrial Internet: The Industrial Internet is a key enabler to the digital transformation of manufacturing. Working at the industry and expert level, the Sino-German Company Working Group on Industrie 4.0 and Intelligent Manufacturing (AGU) Expert Group Industrial Internet (EG II) aims to foster mutual understanding on technological concepts and develop a joint conclusion and recommendations. As the result of the initial phase of the EG II, the 2019 edition of the White Paper presents the preliminary findings of the joint work of German and Chinese companies and experts, builds the foundation for future cooperation and specifies topics for the future work of the AGU EG II.	Link
Sino-German White Paper on Functional Safety for	The paper surveys and analyses existing standards, specifications and research to give an overview of safety for Industrie 4.0 and Intelligent Manufacturing.	Link

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Industrie 4.0 and Intelligent Manufacturing		
Guidance for the Construction and Promotion of Industrial Internet Platforms & Evaluation Method for Industrial Internet Platforms.	Policy Update of the Sino-German Industrie 4.0 Project, August 2018: This Policy Update focuses on the "Guidance for the Construction and Promotion of Industrial Internet Platforms" and the "Evaluation Method for Industrial Internet Platforms". Whilst the former introduces measures to standardise and optimise platform development, the latter outlines specific capability requirements for a unified assessment to guide the application and development.	Link
Interoperabilität hoch zwei für Simulationsmodelle (available in German)	In this presentation, the simulation and standardization experts of Plattform Industrie 4.0 explain what lies behind the simulation submodel and show how they develop and expand a solution step by step using use cases.	Link
Der digitale Zwilling in der Industrie 4.0 (engl: The digital twin in Industrie 4.0)	In this presentation, the standardization experts from Plattform Industrie 4.0 explain what lies behind the management shell concept and how it works in practice.	Link
Shaping Europe's digital future. Interoperability	POLICY: The Commission has adopted a list of standards and specifications for harmonised electronic communications networks to ensure that consumer choice is not restricted because of incompatibilities	Link
2030 Vision for Industrie 4.0. Shaping Digital Ecosystems Globally	A holistic approach to the shaping of digital ecosystems: In this 2030 Vision, the stakeholders of Plattform Industrie 4.0 present a holistic approach to the shaping of digital ecosystems. Working from the specific situation and established strengths of Germany's industrial base, their aim is to create a framework for a future data economy in line with the requirements of a social market economy: emphasising open ecosystems, diversity and plurality and supporting competition between all the stakeholders on the market. The Vision is primarily addressed to industry and commerce in Germany, but explicitly highlights the importance of openness and a willingness to work together with partners in Europe and around the world.	Link
Industrie 4.0 Service Architecture - Basic concepts for interoperability	This status report provides the foundation for a reference model of the Industrie 4.0 Service Architecture.	Link
A Review of Interoperability Standards for Industry 4.0.	The focus of this paper is to examine the progress that is being made in order to establish interoperability across a diverse set of systems and also to identify the challenges in establishing this level of interoperability. To achieve this a literature review of current Industry 4.0 technologies and	Link

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

	current interoperability standards was be undertaken, to identify and categorise potential frameworks capable of providing an Industry 4.0 global interoperability standard. (https://doi.org/10.1016/j.promfg.2020.01.083)	
Industry 4.0 Interoperability, Analytics, Security, and Case Studies	(Edited By G. Rajesh, X. Mercilin Raajini, Hien Dang; ISBN 9780367501129). The book provides an understanding of the drivers and enablers of Industry 4.0; includes real case studies of various applications for different fields; discusses technologies such as cyber physical systems (CPS), Internet of Things (IoT), cloud computing, machine learning, virtualization, decentralization, blockchain, fog computing, and many other related areas; covers design, implementation challenges, and interoperability; offers detailed knowledge on Industry 4.0 and its underlying technologies, research challenges, solutions, and case studies.	
The Industrial Internet of Things Volume G1: Reference Architecture	The document is refining and advancing the 'Industrial Internet Reference Architecture'	Link
Architecture Alignment and Interoperability	An Industrial Internet Consortium and Plattform Industrie 4.0 Joint Whitepaper IIC:WHT:IN3:V1.0:PB:20171205	Link

Table 7: Recent publications regarding interoperability

It is important to highlight the first document "Plattform Industrie 4.0 Germany. Progress report 2019". This report reflects the past developments, but also proposes future scenarios along technological and non-technological lines. At the core of the 2030 vision of Industrie 4.0 are the three pillars "autonomy, interoperability and sustainability".

5.3 Examples from projects (mapping of projects)

5.3.1 EFPF- European Connected Factory Platform for Agile Manufacturing

The following describes the interoperability approach of EFPF, as was presented in Dec 2020 DMP CLUSTER-CF2 workshop (Figure 46 and Figure 47):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

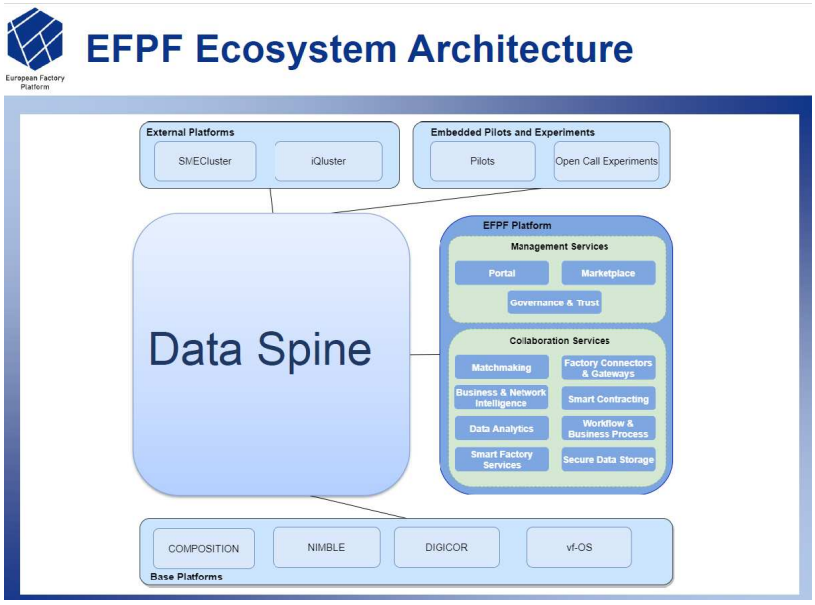


Figure 46: EFPF ecosystem architecture

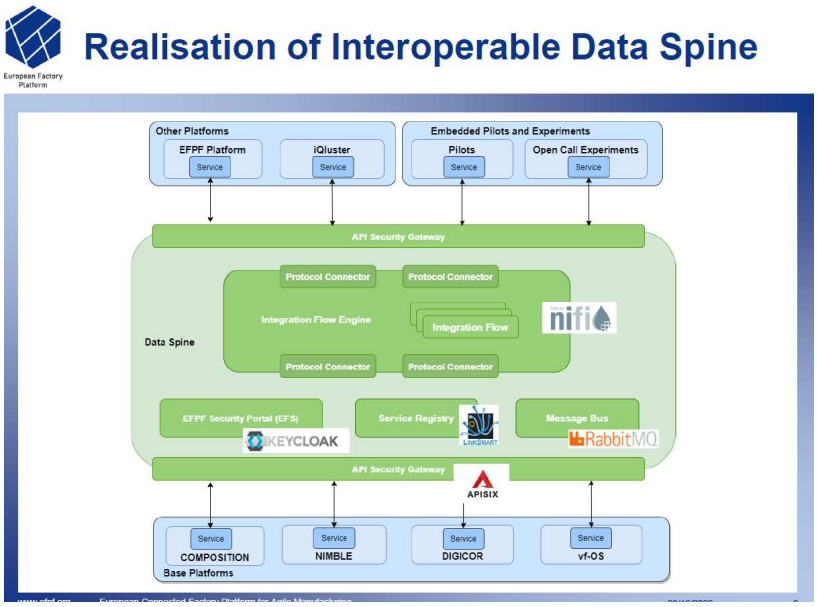


Figure 47: Interoperable Data SPine

- at Protocol level (Figure 48):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

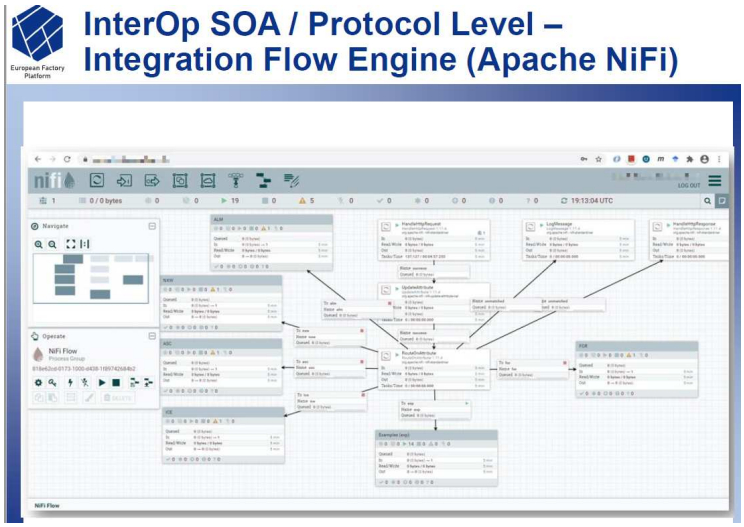


Figure 48: Interop SOA

- at data model level (Figure 49):

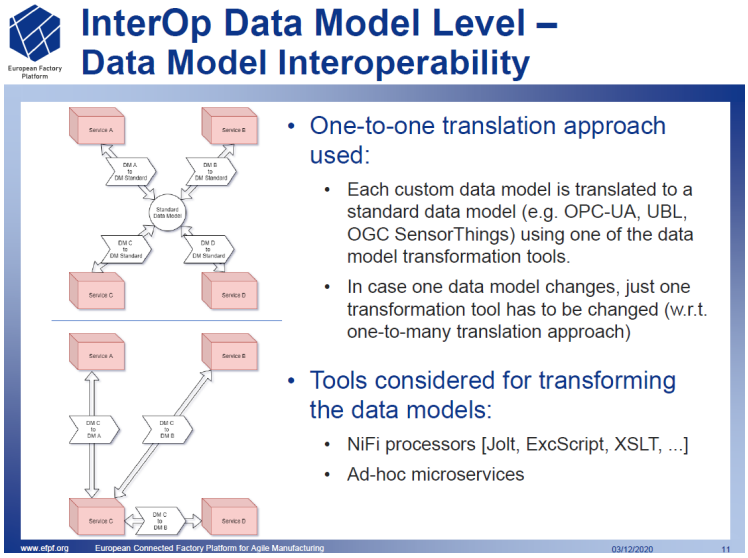


Figure 49: Interop Data model

- and giving as a result the following components interaction and implementation(Figure 50):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

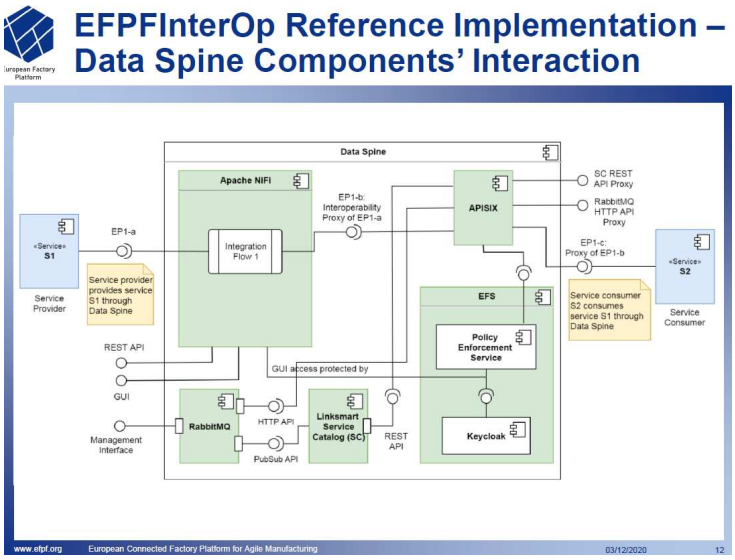


Figure 50: EFPF interoperability implementation

5.3.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality

QU4LITY approach to interoperability will be further analysed in the second half of CF2.

5.3.3 ZDMP – Zero Defect Manufacturing Platform

ZDMP approach to interoperability will be further analysed in the second half of CF2.

5.3.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences.

KYKLOS 4.0 is still in the initial phases of the project and the interoperability approach has not been properly defined yet. In the picture below, the general architecture is presented.

The interoperability approach will be analysed properly in the second half of CF2 (Figure 51)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

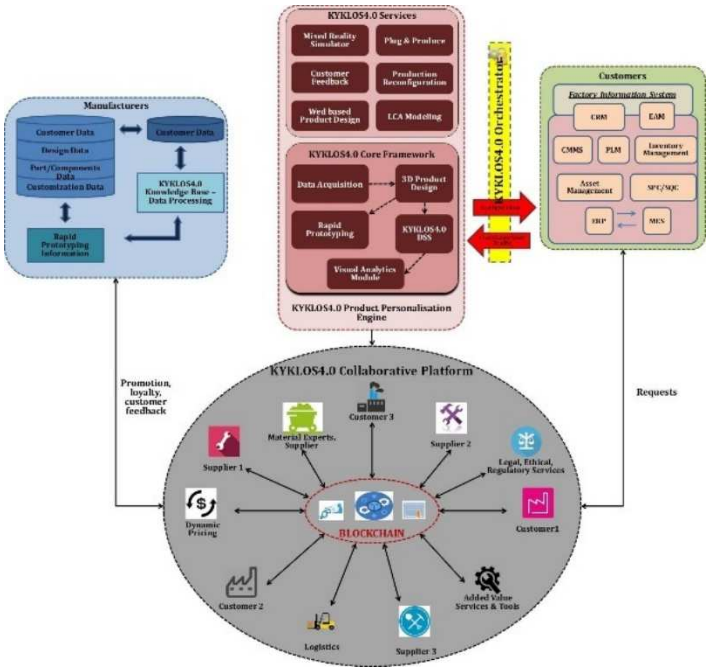


Figure 51: KYKLOS4.0 General Architecture

5.3.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks.

The following figures present DIGIPRIME approach to interoperability.

Figure 52 shows the relation amongst the company data and the services data through two types of data management, local and global.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

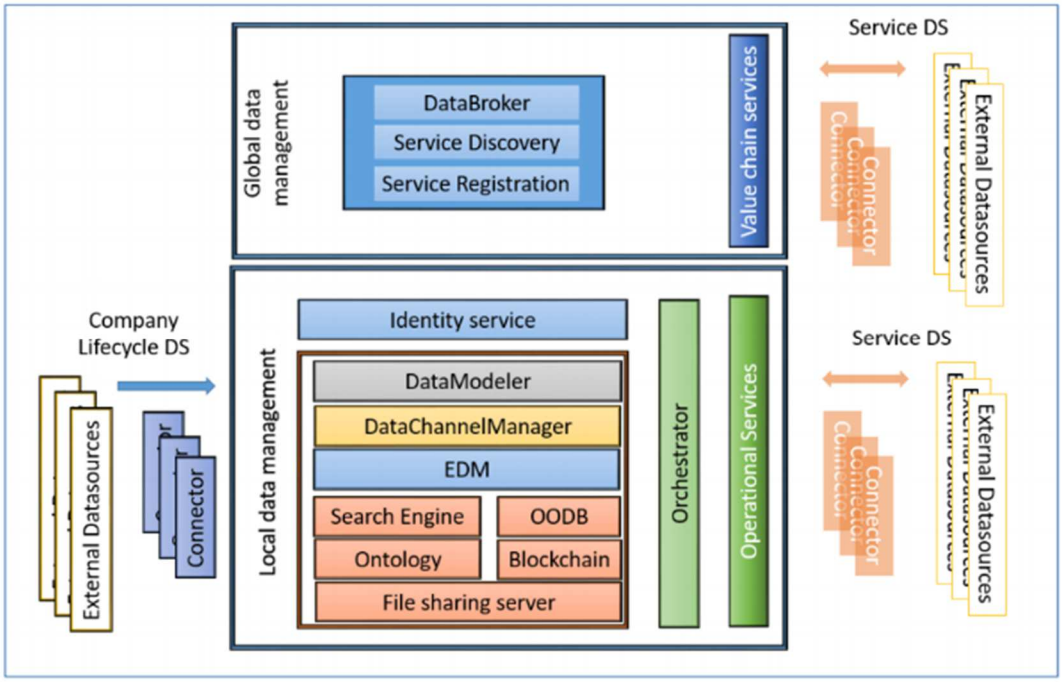


Figure 52: DIGIPRIME data management

Figure 53 presents the relation amongst the remanufacturing processes and the IT layers.

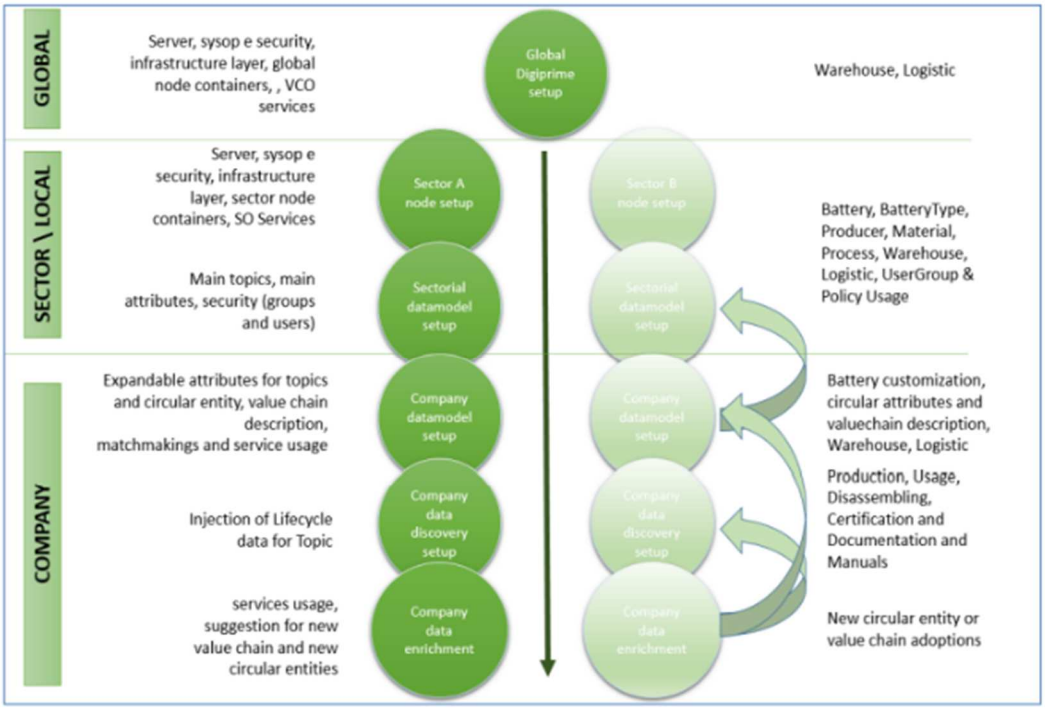


Figure 53 The DigiPrime Data Platform Infrastructure (left picture) and the lifecycle of the DigiPrime data model (right picture)

Figure 54 presents the key components in the interoperability architecture, and how services and data brokers are connected.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

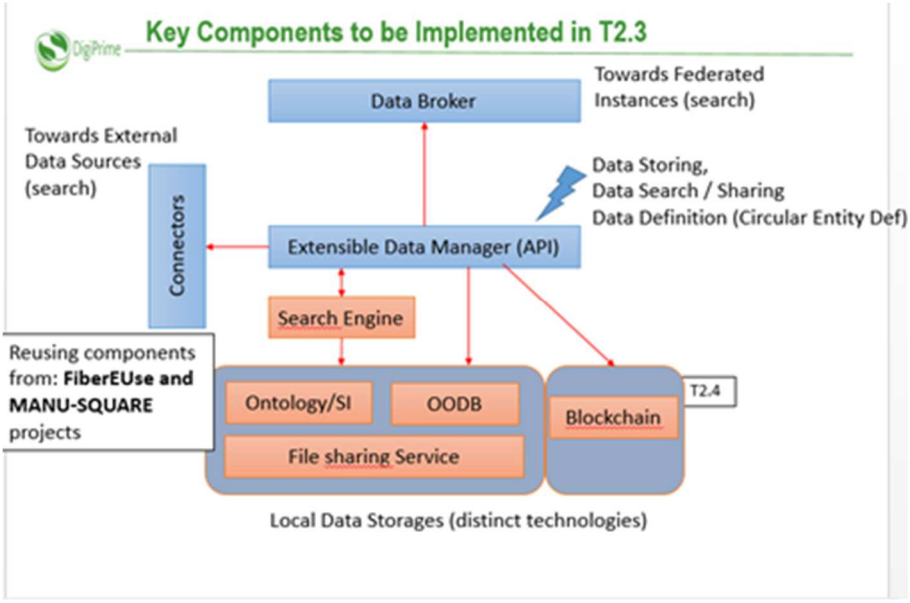


Figure 54: DIGIPRIME key IT components

This picture below (Figure 55) presents the semantic infrastructure overall approach.

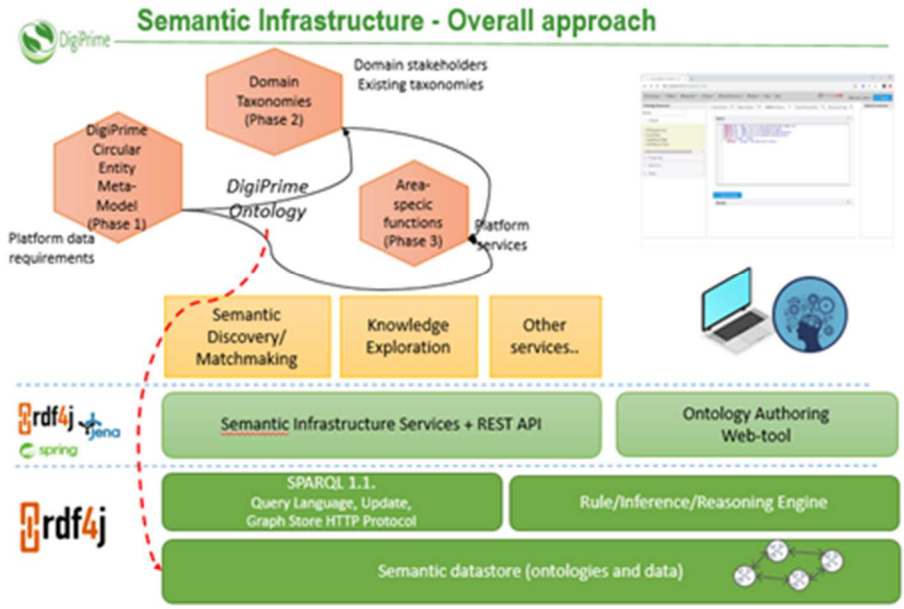


Figure 55: DIGIPRIME semantic infrastructure

At last, the final picture (Figure 56) presents the different applications and services, both operation and value chain services, on open and closed loop, along with the data buses and routing and incorporating security and ledger services.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

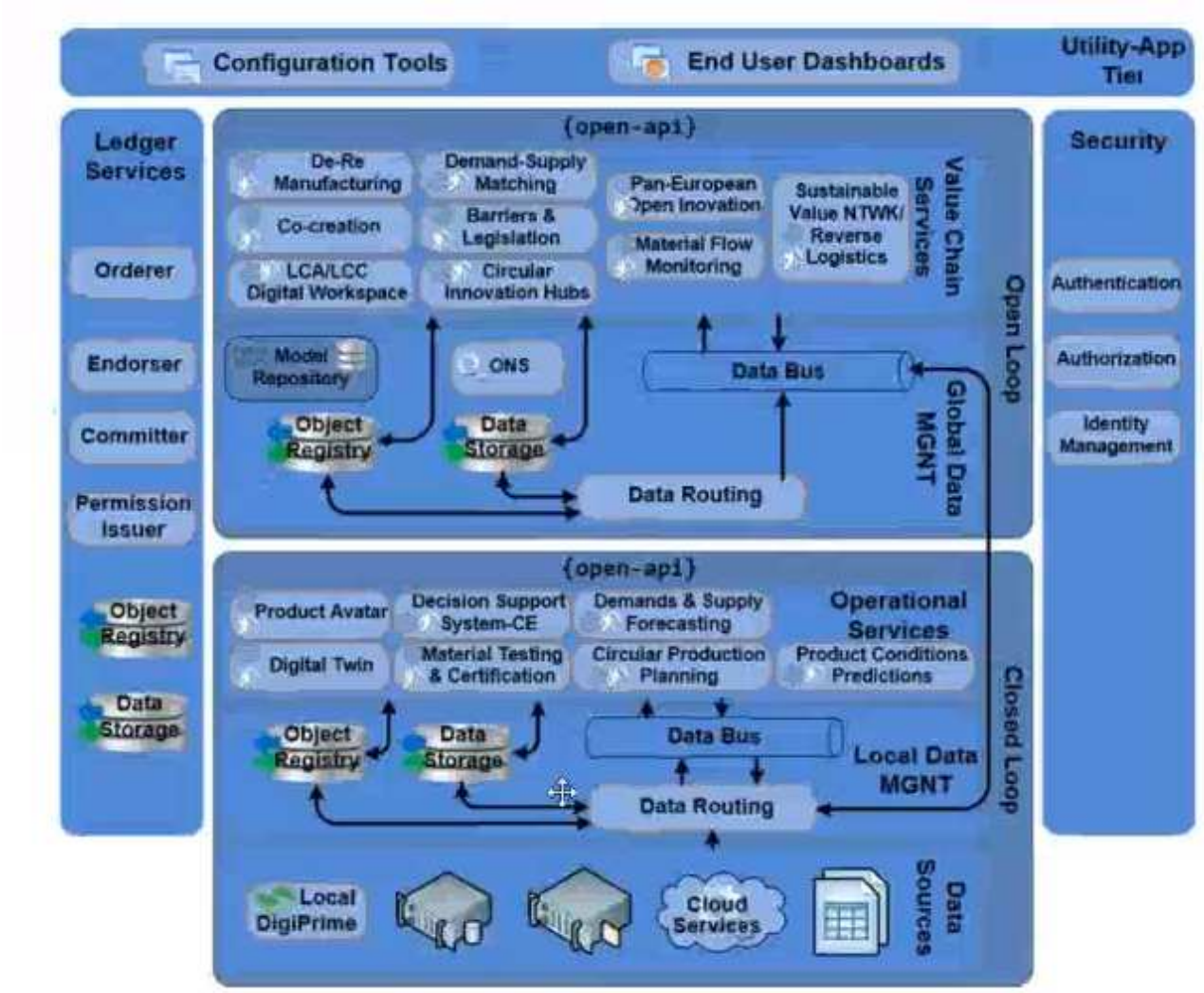


Figure 56: DIGIPRIME services interoperability schema

5.3.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories

ZDMP approach to interoperability will be further analysed in the second half of CF2.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

6 CyberSecurity

The role of this task is to ensure that CyberSecurity (CS) challenges are considered and addressed as needed along all the lines of the developments of the Digital Manufacturing Platforms, the Digital Manufacturing Pathways and overall digital manufacturing and Factory of the Future developments and this project.

6.1 General observations on cybersecurity

CyberSecurity is broad and complex domain of interacting technologies that cause individually and in combination vulnerabilities that could lead to adverse effects and could impact the whole manufacturing chain, the production company, the ecosystem it operates in, the environment, the economies to which it belongs and the society as a whole. CS evolves continuously alongside the developments of Information and Communication Technologies (ICT). In manufacturing, CS also considers legacy and cyberphysical systems. Both are evolving to (Industrial) Internet of Things (IIoT) and utilize both Edge- and Cloud based computing considerations and technologies such as distributed architectures, agile development, virtualization technologies, AI and big data.

CyberSecurity in Digital Manufacturing Platforms is being considered both from a Risk perspective, from architectural, systems, application and end point perspective trying to protect and preserve both the information flows from availability, integrity and confidentiality (CIA principle). CS in manufacturing should also preserve impact on the manufacturing itself, but mainly through the protection of the information and commands steering the automation and information and communication systems guiding, managing and controlling the production systems.

In 2020 and 2021, most harm on production companies was caused by ransomwares, an evolved form of malware that was distributed by email (through phishing attacks, malicious links leading to download and execute these malwares), targeted attacks, USB- and other portable memory, network and system intrusions and trusted supply chains (eg Solarwinds).

These observations suggest the ongoing need and requirement for a transversal approach to CyberSecurity, in the form of a further evolving Pathway, maximally based upon industry leading standard approaches with a view on future approaches whereby considerations of transparent supply chains, shared responsibilities and reliability based upon certified fundamental components and methodologies should be utilized.

6.2 Reference documents on cybersecurity

1. IEC62443 and derivatives
2. ISO27k series
3. NIST CyberSecurity standards and CyberSecurity for Manufacturing standards
4. CSA CAIQ and CSA Cloud Matrix

6.3 Examples from projects (mapping of projects)

Attemps have been undertaken to both provide and collect examples towards and from a diversity of projects working on CyberSecurity in manufacturing, and projects which are working on CyberSecurity having a spillover effect on CyberSecurity for manufacturing. This is an ongoing process, but is already happening.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

6.3.1 CS standards for projects to consider

As part of the focus of the Digital Manufacturing Platforms interactions, the CyberSecurity track and this task has been identifying and compiling different applicable standards which are being applied by manufacturers, technology providers and research projects working towards cybersecuring the environment and looking to apply existing methodologies, policies and technological standards which they can relate to. Some of the listed standards were presented to the projects and have been both selected and expanded by different project partners and their respective coordinators.

Not all projects under the Digital Manufacturing Platforms (DT-ICT-07-2018-2019) have already contributed to the following lists or overviews since a number of them are still in progress of development, however participating in the collaboration activities of the CF2 project.

1. International industrial CS standard developments : IEC62443, NIST, CSA, …
2. European industrial CS standard developments : CEN/CENELEC, RED, Machiner Directive, GDPR, ETSI IoT, CyberAct, ..
3. De-Facto standards : Industrial IoT CS Framework, Industry4.0, IDSA, Platform I4.0 WG Sicherheit, RAMI Security model developments, CSA Taking Control of IoT, OWASP, OPC – OPC/UA, SROS, …
4. Industry specific
    a. User orientation driven – Sector oriented (process industry / aerospace / energy) : Namur, WG 4.18 Automation Security, EEMUA, WIB,
    b. Technology orientation driven (IoT / cloud / OPC / Web application / …)
    c. Cybersecurity technology (TLS / HTTPS /
5. Non-industry-specific
    a. Standard organisation driven : NIST / ISO / IEC / CEN-CENELEC
    b. Regulated : NIS / GDPR / CIP
6. Governmental – regulated
    a. Sector Specific : nuclear, air traffic, health, telecom, …
    b. Country specific – Member State specific: Grundschutz, BSI, …
7. New approaches :
    a. Software Bill of Materials – SBOM,
    b. Reference Integrity Manifest – RIM, & RIMM,
8. Cybersecurity specific Vulnerability databases & Responsible Disclosure information sharing …

6.3.2 CS standards, standardisation participation – cross project analysis (part 2)

Standards can be important for organizations to save costs, be better aligned to facilitate cooperations and learn from best practices from others. Standards can also be a burden and a challenge to adhere to, trying to be compliant following methodologies which could be much heavier for smaller organisations with limited resources and expertise.

The CF2 project had the intention to first do stock-taking of available and relevant standards, to support the different projects in their choice, but equally asking the various projects which standards they have been considering for the execution of their developments. During the interactions, projects can learn from each

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

other's experiences and improve on the results being achieved from those developments. The first table indicates the assessment done by the CF2 project on the various CS standards the respective projects have considered, or are following with additions thanks to the contributions by the projects. This table will be further enhanced and completed, while the references will be added in the online Structured Wiki, with additional comments and considerations from the field

Connected Factories 2 CS & Privacy Standardization & Industry Standards															
CS Standard Analysis															
		DT-ICT-07-2018-2019							DT-ICT-08-2018-2019		ECSEL		DT-ICT-02-2018-2019		
		CF2	Kyklos 4	DigiPrime	Qu4lity	EFPF	SHOP4CF	ZDMP	SeCoIIA	COLLABS	Industry4.E	Productive4.0	DIH2	TRINITY	
IEC62443		X				X		X	X	X					
NIST		X				X		X	X	X					
	NIST SP800-82	X				X									
	NIST CSF	X				X									
NISTIR8183	CS for Manufacturing	X													
NISTIR 8259	CS for IoT Device Manufacturers	X													
CSA CAIQ		X													
CSA GDPR COC		X													
CSA ICS		X													
ISO13849						X									
ISO27	27000:2018	X				X									
	JTC1/SC27	X				X									
	27017:2015	X				X									
ISO33052:2016	PRM					X									
CIS-ICS		X													
ETSI IoT		X													
ETSI TS103 457	Trusted Cross-Domain					X									
CISA		X													
NIS		X							X	X					
STRIDE		X													
CVE		X							X	X					
ATT&CK		X							X						
Industrie4.0		X													
GDPR		X							X						
SBOM		X													
RIM		X													
ENISA	IS & P standards for SME	X				X									
	Procure Secure	X				X									
OPC	IEC/TR 62541-2:2016	X				X									
ISO/TC 262															
TLS		X													
HTTPS		X													
IDSA		X		X											

Table 8: Mapping of ICT-07 projects in CS standards

The different DMP-projects and other projects trying to secure automation and digital manufacturing activities apply similar standards. The Work in Progress (WIP) indicate how the projects have published and reported their use of various CyberSecurity standards. Analysis from the DMP Standardization workshop from October 20th 2020[22] shows that some projects are focusing more on specific aspects of CyberSecurity such as identification and authorization, but are not taking into account considerations such as device security, data transport, security monitoring, data protection, incident management and other cybersecurity perspectives that would allow for a more consistent holistic approach on CyberSecurity. Some projects (like SHOP4CF, SECOIIA, COLLABS, QU4LITY, …) apply first an enterprise risk assessment related approach and relate some of the challenges back to the underlying factories before identifying specific technology approaches and methodologies. For this they apply usually similar standard approaches such as the **NIST Cybersecurity Framework, IEC62443 and ISO 27k-series.**

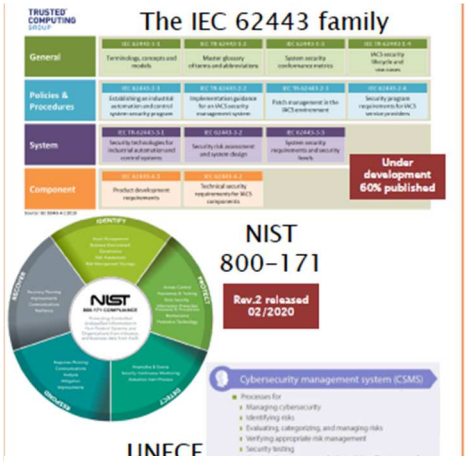


Figure 57 assessment of CyberSecurity standards being used by the COLLABS project, indicating the main use of NIST and IEC62443, adding the perspective from UNECE

[22] https://www.connectedfactories.eu/news/standards-digital-manufacturing-webinar-recordings-and-presentations-are-now-available

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Projects also refer to developing standards, indicating also that many current standards are not completely covering the requirements of digital manufacturing. Approaches refer to the Industrial Internet of Thing Consortium (IIC) and the CyberSecurity Framework (IISF)[23]. During the analysis and the subsequent workshops, additional CS standards and de facto standards were added to the list, whether to be considered only for specific verticals (SECOIIA and COLLABS on automotive) or general CS developments such as the ETSE 303645 for component design (SHOP4CF)-project.

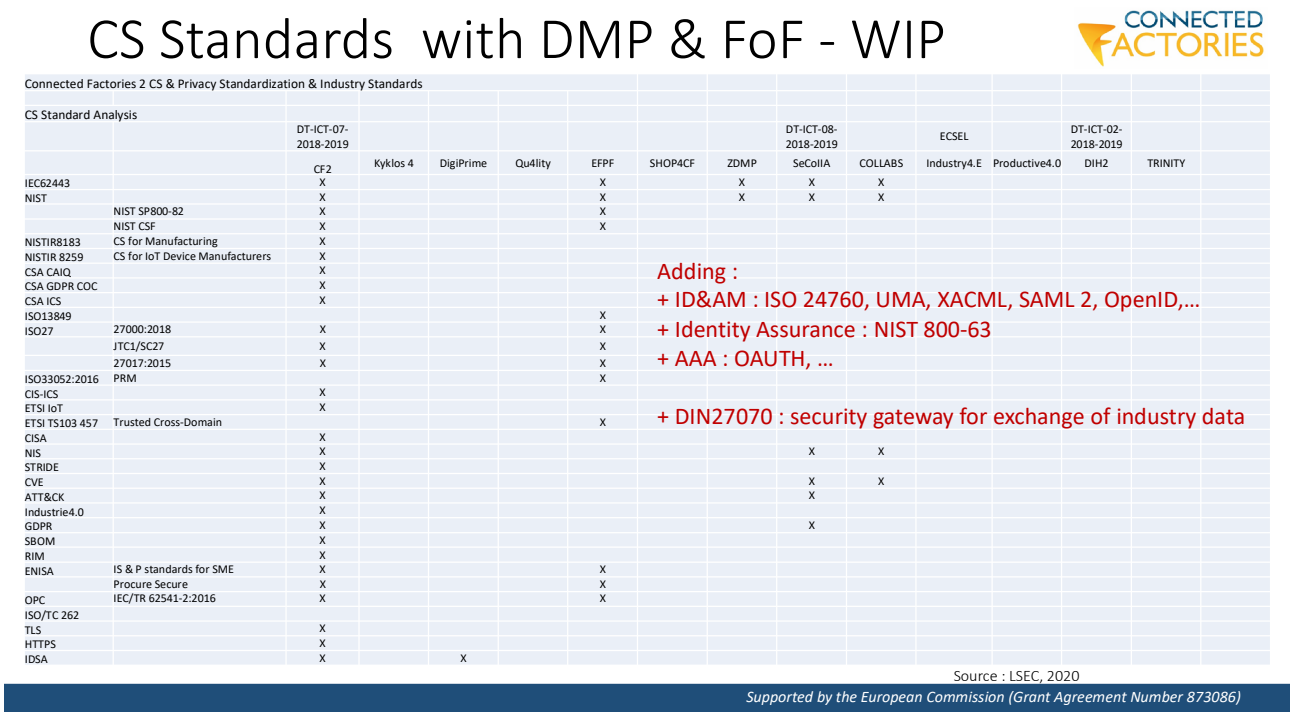


Table 9: New CS standards incorporated

During a series of activities by the CF2 project in collaboration with the DMP projects, additional discussions on the use of standards have been used. This resulted in the presentation of additional standards that were considered by the projects, or considerations from developing standard organizations which are relevant for the DMP and related manufacturing projects and which serve to support the developing CyberSecurity Pathway.

[23] https://www.iiconsortium.org/IISF.htm

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

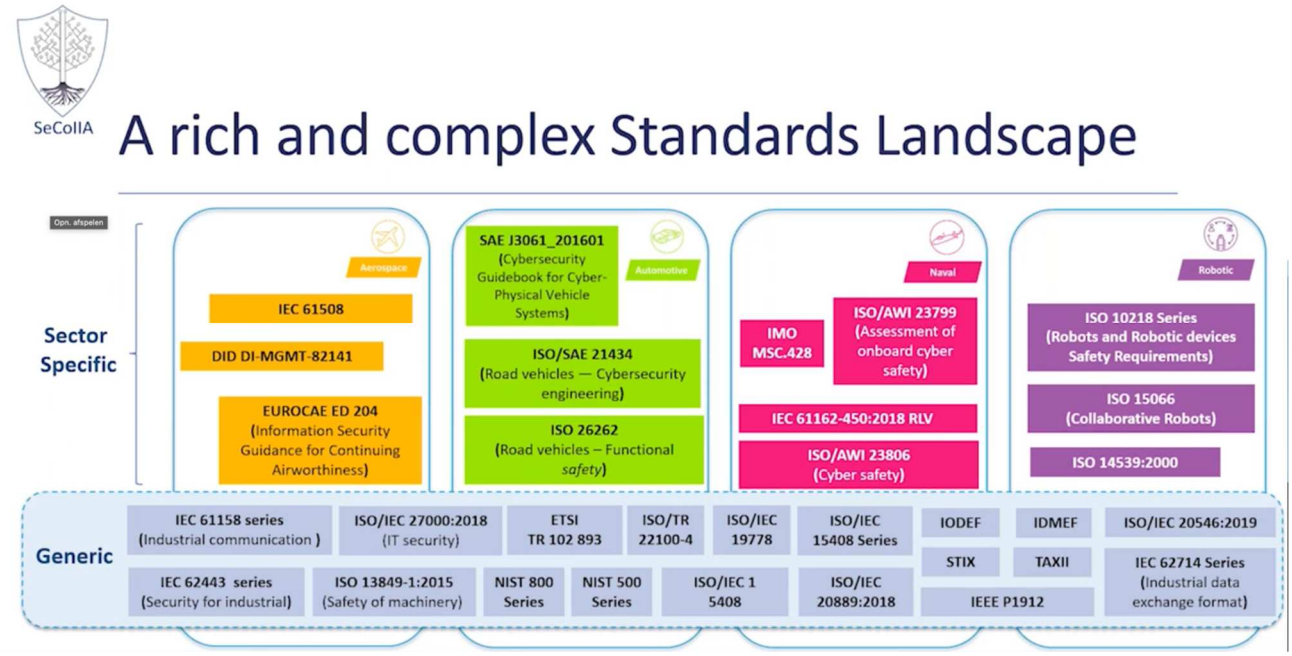


Figure 58 : assessment of security, safety and CyberSecurity standards investigated and applied in the SECOIIA-project, © SECOIIA project, 2021

This standards overview from the SECOIIA project indicates the importance of sector-specific CyberSecurity standards that need to be considered from the project to be able to serve its pilots. In addition, a number of traditional safety and security standards are also been considered that impact also the CyberSecurity approach. SECOIIA applied a transformation journey for standardization from the current state of the manufacturing environments, using an assessment to identify the need for alignment to the project objectives on the basis of a gap analysis.

For more information on the specific standards to be followed and the details of the standards, we refer to the structured Wiki and additional reference materials which will be added to the Structured Wiki as some of the additional standards are also to be considered by other DMP projects and related projects.

6.3.3 H2020-ICT-08-2019 : Security and resilience for collaborative manufacturing environments

Our listing and reference starts with the two projects which were selected under this program “Security and resilience for collaborative manufacturing environments”, as it indicates that the core focus of these projects is security, next to the manufacturing. In the two selected projects, the DMP serves the functioning of the manufacturing companies and their digital operations but mainly from the intention and the business intentions of the manufacturing companies, which are being supported by the security mechanisms.

6.3.3.1 SECOIIA : Secure Collaborative Intelligent Industrial Assets [24]

Also SECOIIA approaches manufacturing with different vertical industries (automotive, aerospace, robotics, maritime) and various manufacturing partners, with different levels of expectations and risk exposure levels.

[24] https://secoiia.eu/

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 873086.

With a mission of bringing higher levels of security and safety to the manufacturing industries while utilizing digitalization and collaboration in production and manufacturing techniques.

The security requirements of the SECOIIA project are in the first place driven by the specific use cases related to interconnectivity of factories belonging to the same group, to relations with suppliers providing maintenance and the considerations of the physical production of highly sensitive products and technologies. In addition specific safety and human-interaction with robots resulting from CyberSecurity are being considered. Finally it considers challenges for CyberSercurity from a product lifecycle management. At the same time it is considering the CyberSecurity of the systems from for instance ransomware. The project takes into consideration training and education of various persons / persona's in the factory.

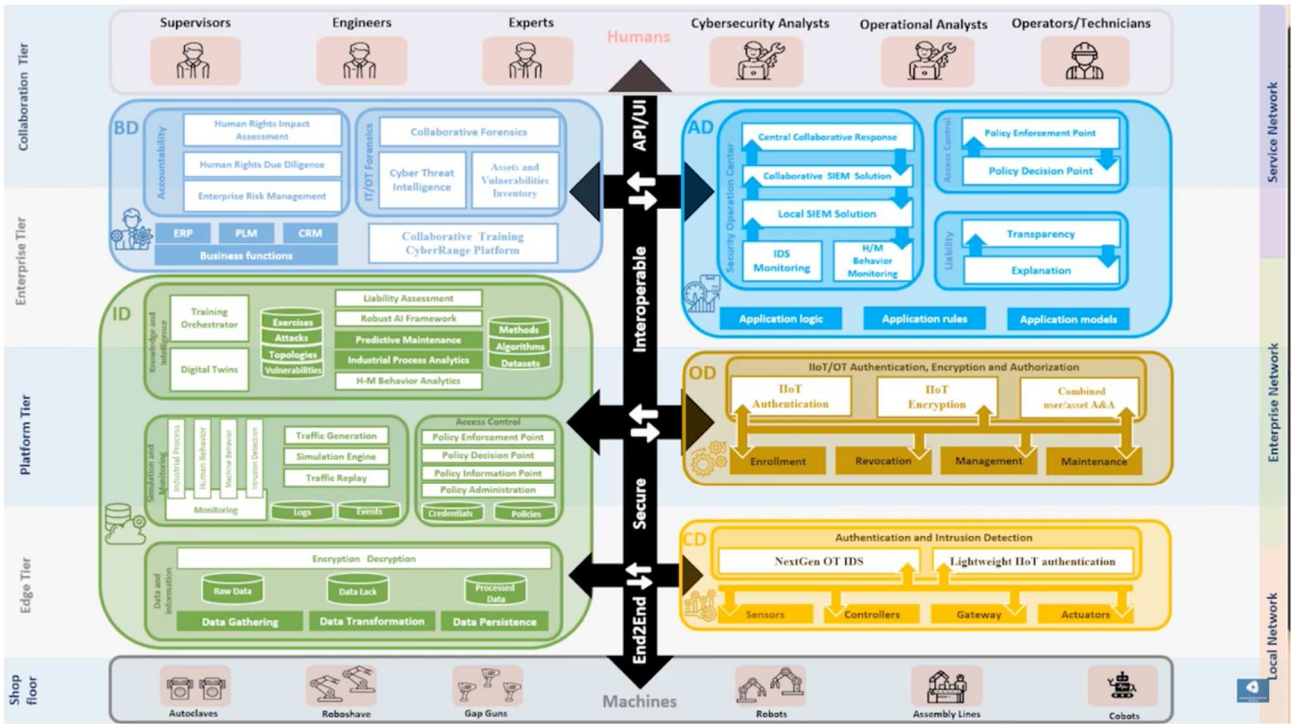


Figure 59 : overview of the current SECOIIA CyberSecurity approach in progress identifying a wide area of focus areas for CyberSecurity both from a functional – operational perspective, system perspective, persons/personas perspective and trying to apply various technology, process and skills-considerations. © SECOIIA project 2021



The SECOIIA project partners are aiming to produce CyberSecurity improvements on various levels, such as the identification and use of different CyberSecurity standards, considering the continuous evolutions and ongoing work on standardization. SECOIIA identifies the challenges related to the use of AI or Forensics which

Figure 60 : the CyberSecurity solutions approach by SECOIIA aiming to deliver impact on various interaction levels and for different identified entities which are involved in the manufacturing activities. © SECOIIA project 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

are currently not fully being covered by either standards or technologies and require specific additional attention.

Key learnings from this project are the scope and breadth of CyberSecurity in manufacturing environments, clearly indicating the complexity of CyberSecuring different activities, processes and entities and identifying challenges related to this and gaps that are already appearing (AI and forensics). The key use for projects under the DMP and other digital manufacturing environments or factories transforming towards digital relate to the enterprise and sectorial risk-based approach, the use of standards, the identification of a CyberSecurity-wide architecture on top of the current standard framework and particular technologies and methodologies towards continuous improvements, skills and education and analysis of intelligence coverage.

6.3.3.2 COLLABS : a COmprehensive cyber-intelligence framework for resilient collaborative manufacturing Systems[25]

The other project under the ICT-08-2019 program "Security and resilience for collaborative manufacturing environments" is COLLABS. Equally working with different production companies and manufacturing use cases, it considers also the factories from the inside with their transforming infrastructures evolving to digital and include challenges related to their supply chain relations.

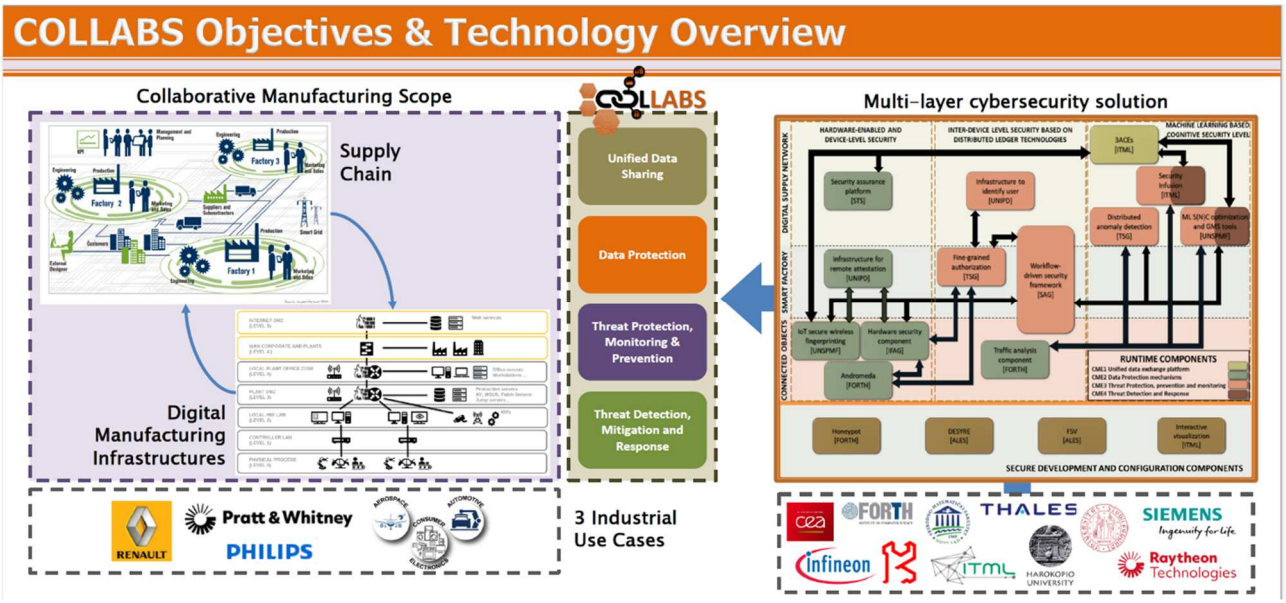


Figure 61 overview of the multi-layer CyberSecurity approach on the different business challenges derived from the different manufacturing environments © COLLABS project 2021

The ongoing work on the applied CyberSecurity architecture represents a similar approach, where both from the systemic level, the enterprise level and the manufacturing company in relation to its environment is being considered, and where the approach is to take a holistic perspective in trying to apply CyberSecurity on these different levels with specific approaches. For some of these approaches existing technologies will be applied,

[25] https://www.collabs-project.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

but COLLABS is aiming to derive a framework approach from this, in order to apply it into various factory environments.

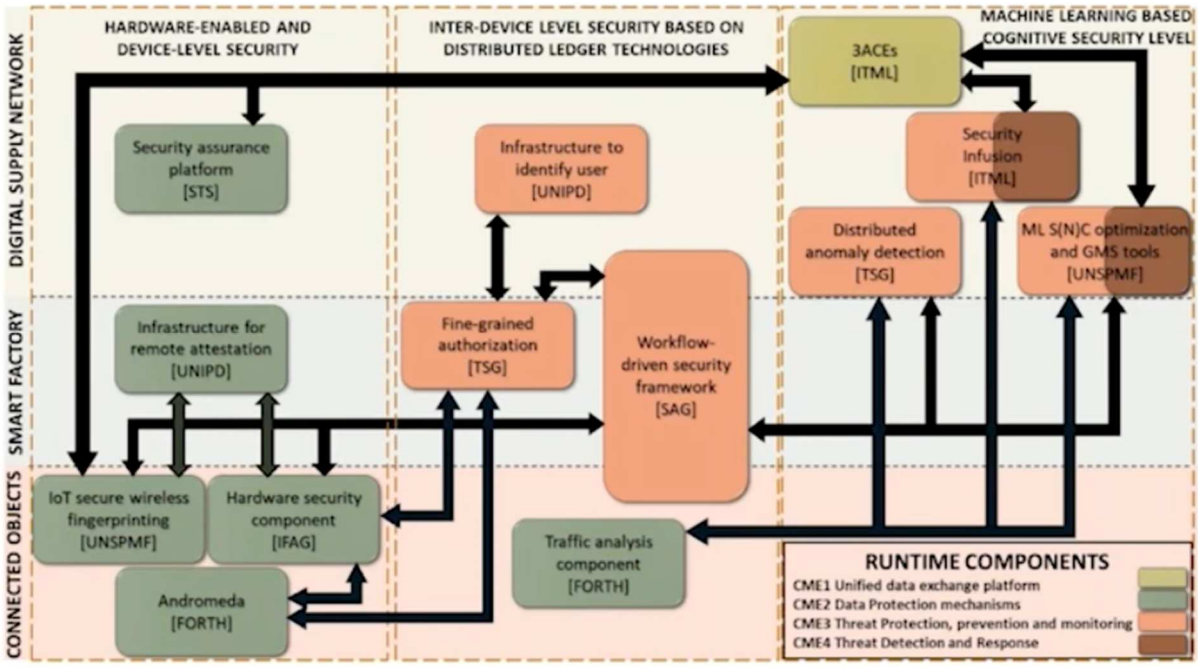


Figure 62 the COLLABS three-layered architecture and the interconnectivity of different CS-components © COLLABS project 2021

The security architecture being constructed indicates a complex interaction of developments on the basis of existing systems and technologies, aiming to serve different security functionalities that can be applied in the manufacturing companies following a series of scenarios. Specific technologies (minimal viable products – MVPs) which are being developed and could be considered by other DMP projects and related manufacturing companies building their digital manufacturing activities, such as 1) agent-based traffic analysis; 2) SE-based endpoint protection, 3) remote attestation mechanisms, 4) distributed anomaly detection and 5) fine-grained process-driven access control.

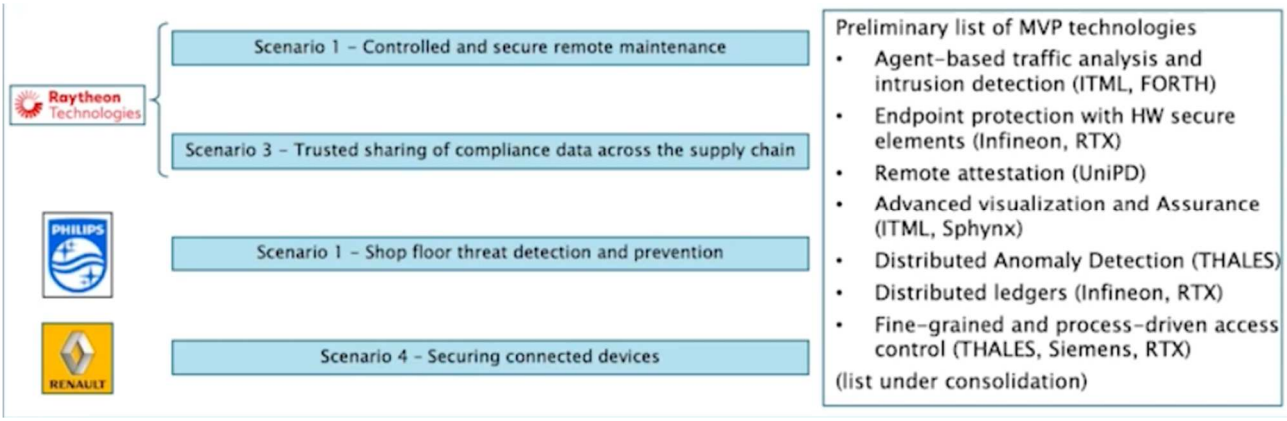


Figure 63 : COLLABS technologies that will be applied in a series of scenario's, scenario's which can be run in the pilot manufacturing companies, but equally in other manufacturing and digital manufacturing environments. © COLLABS project 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

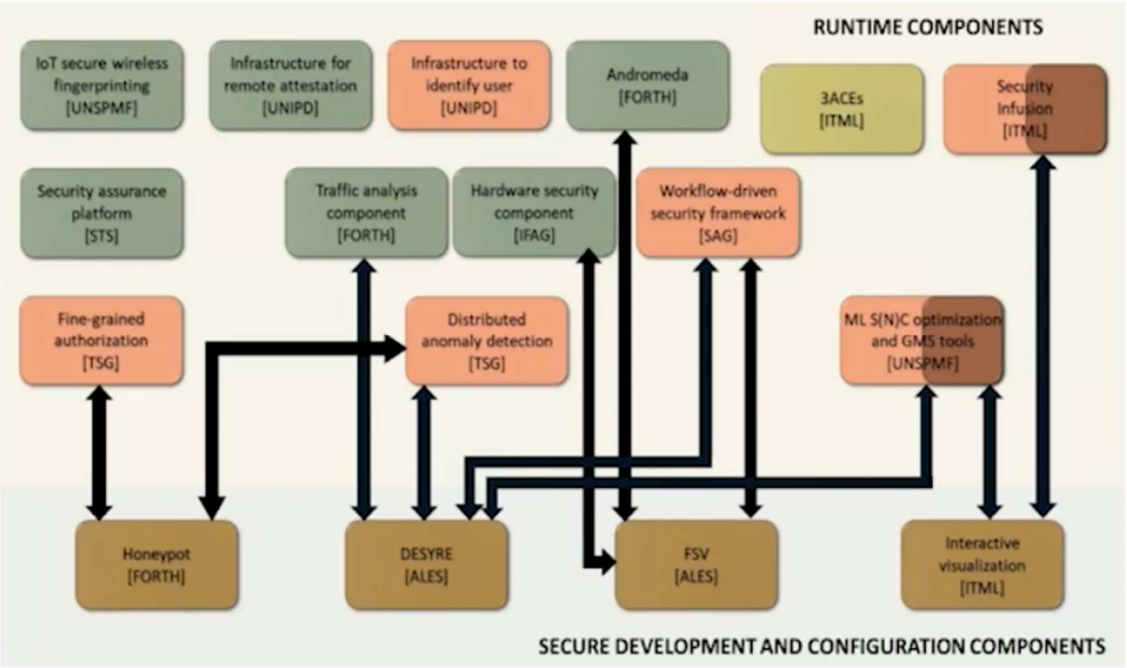


Figure 64 : COLLABS insight in the functioning of the CyberSecurity runtime components and the relation between the core functionalities of the CyberSecurity activities that can relate to a wider CyberSecurity framework © COLLABS project 2021

The different components identified by the CyberSecurity architecture indicate the complexity and the potential approach for Digital Manufacturing Platforms to consider in a production facility environment. Some indicators for the CyberSecurity Pathway are considerations of the 1) Fine grained authorization, 2) Remote attestation, 3) Distributed (anomaly) detection, 4) Traffic analysis, 5) (In)Fusion and ML optimization and visualisation.

Some basic components such as Honeypots, ID & AM and intelligence components could also be re-used by the DMP projects and manufacturing companies transforming to digital manufacturing.

The COLLABS project identifies that the main challenge is to derive from this approach a common security framework that can fit to several industrial settings and accommodate the constraints and variety of applications, functionalities, systems and devices. As they have the idea to validate this on different use-cases, the different DMP projects and related pilots and activities can have a benefit in closely following the requirements in order to use their environments to have the COLLABS frameworks being validated against.

The project also identifies the challenge of labelling datasets (metadata) for machine learning and use in supervised learning algorithms, also pointing to the related CyberSecurity challenges.

6.3.4 DT-ICT-02-2018 : Robotics – Digital Innovation Hubs (DIH) - TRINITY[26]

Under the Leadership in enabling and industrial technologies (LEIT) program of ICT the project Digital Innovation Hubs are being developed for Digital Technologies, where one of the selected projects is TRINITY.

[26] https://trinityrobotics.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

The TRINITY project focuses on Advanced Robotics, CyberSecurity and IoT for agile production. The project builds a series of pilot activities and technologies as demonstrators for European manufacturing companies. Next to this, the project is support innovative European projects with a Financial Support to Third Parties (FSTP)-program, a cascade funding project.

Within TRINITY, there are 17 different technology development activities, which are aimed to progress beyond the State of the Art by themselves, but also offer the results to manufacturing companies throughout Europe. An additional 19 innovative projects have been selected in the first Open Call which took place in 2020. A second Open Call will be launched in 2021 aiming to support an additional 10 – 15 projects.

The variety of innovative projects is a typical similar challenge to manufacturing companies looking to further improve their production environment. Many of these projects are applying digital technologies, or are using robotics to further improve their operations.

The project has applied a CyberSecurity assessment of the various technologies developed within the project, that resulted in an alarming result after the analysis of the overall approach towards CyberSecurity. Close to none of the pilot actions had performed any significant CyberSecurity assessment, and realized during the exercise the number of potential vulnerabilities and impact these could cause. While many project partners indicated that their main pilot development was only running within the lab environment (TRL 4-7), the aim of the project was to facilitate the uptake of the technologies by SMEs, and some even with the plan on going into production in factories. On the basis of the existing architecture and additional hardening exercise took place, in some cases improving the network security layer, the identity and access control layer, and monitoring of the activities on the endpoints, or limiting the direct access to the industrial equipment by utilizing secured hosts.

UseCase CyberSecurity Analysis (ß-stage)

High Level Analysis of Use Cases	Applicable Nr TR Use Cases	% of total nr of use cases
1. A CyberSecurity Risk Analysis defining potential risks and vulnerability threat assessment has been done and documented during DESIGN or PRIOR to the development of the use case?	none	0
2. CyberSecurity concerns and have been taking into account, and have been documented?	3, 4, 14, 15	24
3. Robotic System Developers and Engineers are aware of CyberSecurity concerns in the use case?	3, 4, 6, 7, 11, 12, 13, 14, 17	53
4. Our robotic systems are designed and operated only by vendor specific controllers.	1,10, 11, 16, 13, 14	35
5. Our robotic systems have been programmed, created and operated by PLC's	10, 14	12
6. Our robotic systems have been programmed and /or are being controlled and operated by ROS – ROS2, DDS, OPC, OPC-UA, or other available interfaces	1, 2, 3, 4, 6, 7, 9, 12, 13, 17	59
7. Our robotic systems have a web interface, can be accessed via intranet, mobiles, internet or can be operated via the cloud	6, 7, 8, 11, 12, 14	35





Critical Manufacturing Sector Cybersecurity Framework Implementation Guidance

CASE OF STUDY
MIR-100
THREAT: SAFETY PLC IS DIRECTLY CONNECTED TO THE ROBOT INTERNAL NETWORK

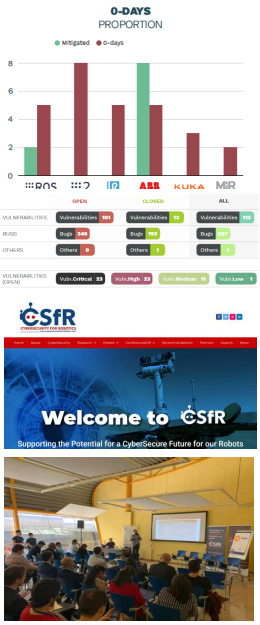
TRINITY

Figure 65 the original assessment of the various components of the TRINITY project presented an alarming image of the CyberSecurity state of the various use cases during the first review period. This resulted in a holistic approach to all pilot actions to design ways to further improve the CyberSecurity standing © TRINITY project 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

UseCase CyberSecurity Analysis (ß-stage)

The following cybersecurity measures have been taken into account:	Applicable Nr TR Use Cases	% of total nr of Use Cases
1. Isolation : the robotic systems has been taken offline, or has been implemented on a segregated network	1, 3, 4, 7, 10, 11, 12, 13, 16, 14, 17	65
2. White Listing : the robotic system, has been integrated in the network, but can only be accessed by a specific set of network operations and other machines	14	6
3. Access, Identity & Authentication Management : access to the robotics systems (development and operations) has been limited to a specific set of users, and other applications requiring access, to be granted upon authentication	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17	88
4. A vulnerability assessment (pentest) of the robotic system has taken place and all vulnerabilities have been reported and are being dealt with	3, 4	12
5. The application logic of the robotic system has been developed on the basis of security by design principles, taking into account application security	none	0
6. We are aware of the security capabilities offered by ROS2, and have implemented those measures, or at least have considered them in the use case	3, 4, 7, 12, 17	29
7. We are getting aware of CyberSecurity issues thanks to TRINITY (and others), we didn't yet take any serious preventative measures, but intend to do so	3, 4, 6, 9, 10, 11, 13, 14, 15, 17	59



TRINITY

The following list indicates an overview of potential hardening activities that can take place on the industrial automation systems, which are being integrated in the Digital Manufacturing activities of the factories.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

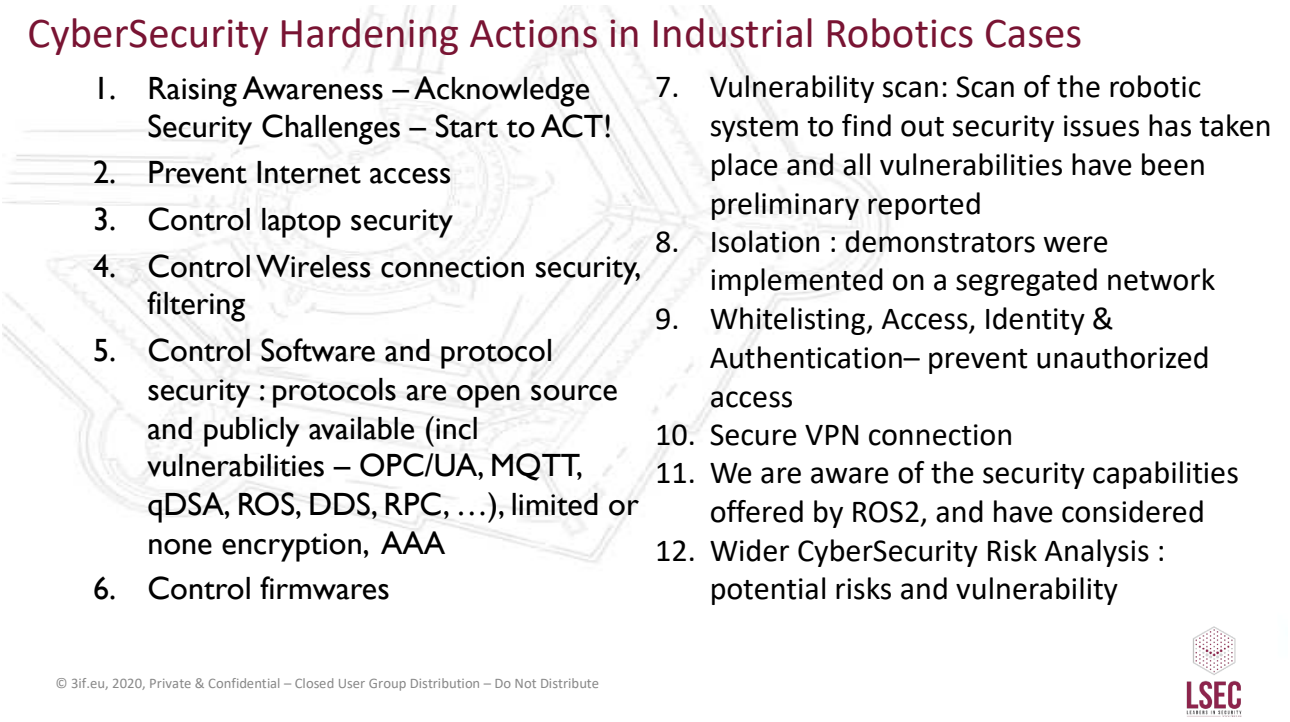


Figure 66 : series of actions to be followed by Digital Manufacturing transformation activities to harden the security layers of the various industrial components for automation and production. Specific attention was paid to the utilization of robotic systems which are either legacy environments working on industrial pc which have not been hardened, or the use of open source ROS (Robotic Operating System) – which is only gradually improving on CyberSecurity © TRINITY project, 2021

Key learnings for Digital Manufacturing Projects are the use of assessments and the sanitization of some of the basic components before applying additional CyberSecurity measures. The CyberSecurity is only as strong as the weakest link in the whole chain or environment. Different specific actions had been presented and hardening mechanisms proposed which can be applied into other Digital Manufacturing Platforms and digital manufacturing environments.

The next steps for the TRINITY project is to apply a similar top-down approach to the Open Call projects selected under the first Open Call and to provide a bottom-up (security by design) support to the projects selected under the second open call. The overall principles are to be proposed as a standardized approach for manufacturing companies increasing their use and applications of digital manufacturing systems and the use of robotics.

6.3.5 EFPF- European Connected Factory Platform for Agile Manufacturing

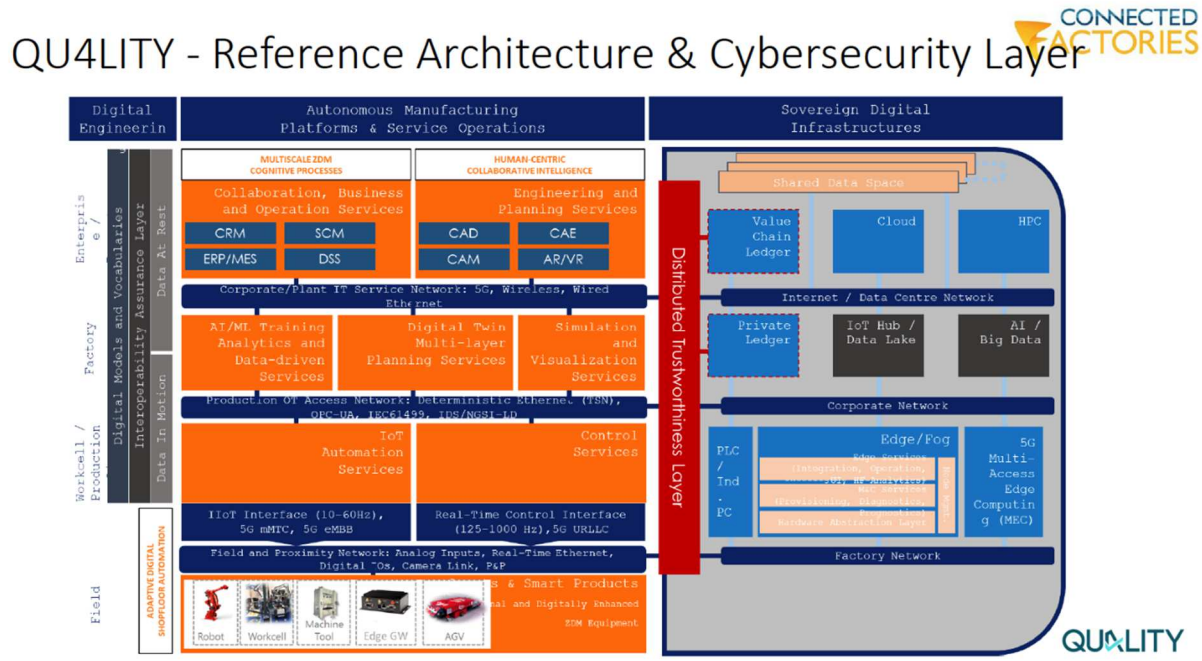
This project is still in process of development and have not yet contributed to the discussions on CyberSecurity, and will be integrated in the next version of this reporting

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

6.3.6 QU4LITY – Joining forces towards an European Industrial Autonomous Quality

The QU4LITY project aims to demonstrate a data-driven Zero Defect Manufacturing (ZDM) product and services model for Factory4.0 through 14 pilot lines, with 9 production lighthouse facility pilots and 5 strategic ZDM.

The project aims to provide a modular cybersecurity framework for manufacturing covering CyberSecurity, Privacy and Trust. It aims to provide integration of different tools in order to support the pilot factories and support distributed and critical functionality. Under consideration are challenges such as Digital Sovereignity and opportunities provided through Standardization.



The system architecture considers a separate CyberSecurity Layer (Distributed Trustworthiness) considering a Sovereign Digital Infrastructure (SDI), whereby the Autonomous Manufacturing platform would be distributing data and intelligencey to the SDI. The project aims to utilize an Open Secure IDS connecting the various manufacturing pilots (PRIMA, Philips, Siemens, Mondragon, Conti, Danobat, …) to the central Data platform, utilizing context-based authentication and digital traceability.

The project start from an enterprise (production company / factory) risk perspective and tries to provide additional security layers to facilitate the interaction between different manufacturing companies and other related entities. The identification of the persons and systems are important components, as well as the security layer for the data transmission.

Other considerations and the CF2 cybersecurity activities will further support additional perspectives on CyberSecurity for the manufacturing companies and the DMP being considered by the manufacturing companies. QU4LITY activities will enable manufacturing companies to mature on the CyberSecurity Pathway from level 3 to partial level 4, whereas components of level 3 might not have been completed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

More information and the presentation by QU4LITY can be found via the https://www.effra.eu/events/cybersecurity-workshoppresentations-and-recordings

6.3.7 ZDMP – Zero Defect Manufacturing Platform

This project is still in process of development and have not yet contributed to the discussions on CyberSecurity, and will be integrated in the next version of this reporting

6.3.8 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences.

This project is still in process of development and have not yet contributed to the discussions on CyberSecurity, and will be integrated in the next version of this reporting

6.3.9 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks.

This project is still in process of development and have not yet contributed to the discussions on CyberSecurity, and will be integrated in the next version of this reporting

In the meantime, please note that DigPrime is focused on the digitization of the circular chain and hence general cybersecurity standards and supply chain security standards are applicable, factory/shopfloor security is mostly relevant to internal systems of manufacturing partners, not to the DigiPrime platform per se. Our platform leverages KeyCloak / OAuth for the authentication, we comply to GDPR (mandatory), and we adopt principles from IDSA in our platform design.

For next version of the deliverable, DIGIPRIME will focus a bit further on the Supply Chain Management, for instance the use of TPRM – SIG – assessments for supply chain security.

6.3.10 SHOP4CF – Smart Human Oriented Platform for Connected Factories

The SHOP4CF, Smart Human Oriented Platform for Connected Factories - project, pursues a highly-connected factory model aiming to create a platform with 30 components based on RAMI 4.0 and FIWARE Technologies on Automation MarketPlace, which also includes Financial Support to Third Parties – cascade funding for selected SMEs.

Its industrial partners include manufacturing companies such as Bosch, Volkswagen, Arcelik and Siemens.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

For CyberSecurity, the project is at the time of this analysis assessing which target security levels with the Asset Owners (the Manufacturing companies) require in their environment, on the basis of interview methods. From this on this project will also consider both System Integrators and Product Suppliers in CyberSecurity conversations. In addition the project is considering specific integrations with cloud infrastructure.

The expected outputs will include best practice guidelines and specifically a risk assessment tool for integrators or component developers.

The SHOP4CF project will be able to utilize some of the works being prepared by CF2 and the Security and Resilience for Manufacturing projects, by means of the assessment and maturity frameworks and mechanisms to evaluate the CyberSecurity requirements from the Manufacturing environment on the basis of existing standards.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

7 Humans and manufacturing

7.1 General observations on human aspects.

With the advent of the fourth industrial revolution called Industry 4.0, the industrial world has shifted further towards automation, where advanced workplaces are replacing existing working stations. Moreover, human-machine collaboration has taken a big leap forward, placing human operators in the centre of attention. In the past, people were expected to adapt to machine requirements. Now, automation systems are being designed and developed so that they can recognise the users, remember their capabilities, skills and preferences, and adapt accordingly. Humans and automation are therefore taking advantage of each other's strengths, having a symbiotic relationship for enhancing the capabilities, skills and quality of their work[27]. factory floor solutions addressed by the five projects that make up the ACE Factories cluster reinforce the concepts introduced by the original Operator 4.0 topology by Romero et al. (2016). Figure 67 illustrates the ACE Factories cluster Operator 4.0 concepts. The Super-strong as well as the Augmented and virtual operator illustrate how new technologies empower operators with new capabilities and enhanced sensing. The Social and collaborative operator illustrates how operators and the whole work community can be engaged to influence on the work environment and work practices. The one-of-a-kind operator illustrates how manufacturing environments can empower workers by adapting to the different characteristics, skills and preferences of workers. The Healthy and happy operator emphasises that all the Industry 4.0 solutions should have positive impact on operator wellbeing.



Figure 67: ACE Operator 4.0 Topology (modified from Romero et al (2016)).

[27] Ace factories cluster white paper on "Human-centred factories from theory to industrial practice. Lessons learned and recommendations", October 2019.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

7.2 Reference documents on human aspects.

- Ace factories cluster white paper on "Human-centred factories from theory to industrial practice. Lessons learned and recommendations", October 2019.
- World Economic Forum, 2020, The Future of Jobs Report, October 2020.

7.3 Examples from projects (mapping of projects)

7.3.1 EFPF- European Connected Factory Platform for Agile Manufacturing

The EFPF platform interlink digital manufacturing platforms, smart factory tools and Industry 4.0 concepts to realise and support a connected and smart ecosystem of the future. The platform is offered to users through a unified Portal with value-added features to hide the complexity of dealing with different platform and solution providers.

Aerospace Pilot: The Aerospace Pilot in the EFPF project addresses the ad-hoc setup of a production

network involving Airbus Hamburg and local SME suppliers represented by the HanseAerospace (HAW) association. The Aerospace plot of EFPF focuses on B2B procurement type of interactions between SMEs and OEMs (or SMEs) in the aerospace industry. Hence "human factors in manufacturing" in this pilot case have rather low relevance.

Furniture Pilot: The furniture manufacturing pilot in the EFPF project, envisions the creation of a Lot Size 1 Consolidation Center to control small scale stocking and consolidation points for large manufacturers, such as LAGRAMA. In the Furniture pilot several user roles are foreseen. The Production Manager role should be supported with mechanisms to configure and optimise production processes.

Circular Economy Pilot: In this pilot, the partner KLEEMANN (KLE), a global manufacturer of Lift Systems, Escalators, Moving Walks and a specialist in lot-size-one projects such as anti-vandal lifts, oil rigs, marine solutions, requires agile relationships with different partners and suppliers in the waste management domain in order to be compliant with Life Cycle Assessment (LCA) regulations. The "Operations manager" role responsible for the production management will be supported with solutions to bring more visibility and real-time support across the supply-chain. Smart and analytics dashboards are expected to support this role in decision making.

7.3.2 QU4LITY – Joining forces towards an European Industrial Autonomous Quality

Qu4lity will realise a radical shift from state of the art production quality methods to the disruptive Autonomous Quality (AQ) concept, through enabling manufacturers and solution providers (including SMEs) to develop, validate, deploy and adopt innovative Cognitive Manufacturing solutions for ZDM. Qu4lity supports 14 industrial pilot cases. 9 pilot cases focus on manufacturing companies/pilot factories in a diverse range of the industries and 5 cases focus on equipment suppliers. In QU4lity the Analytics Operator and Augmented and Virtual Operator requirements are pertinent.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

7.3.3 ZDMP – Zero Defect Manufacturing Platform

ZDMP offers an open Industry 4.0 environment where a new generation of developed zero-defect service applications will be available in a marketplace contributing to create an ecosystem where ZDMP stakeholders would be able to interact with each other.

Automotive pilot case -1: The automotive pilot case involves the collaboration for the supply of casted engine parts from MRHS to Ford[28]. This case involves data sharing between FORD and MHRS as well as zero-defect prediction algorithms/solutions for the casted parts of MRHS. Human factors are related to information display through dashboards. In formation should be communicated to the user so that the model results are understandable, the rationale behind the model results is explained (i.e. explainable AI approaches are applied), recommendations for process parameter adjustments are delivered in a comprehensive manner.

Automotive pilot-case-2: The second automotive plot case involves the collaboration of FORD with EXT (machine provider). This is a Condition Based Monitoring / Predictive Maintenance case. In this case human factors are related to the delivery and interpretation of models' information (i.e. Analytical Operator).

Moulds manufacturing case-1: In this case a value chain between HSD, FIDIA and FORM is employed for moulds production. It is a typical condition monitoring and predictive maintenance case and the human factors are similar to the automotive case-2 above.

Moulds manufacturing case-2: In this case a value chain between HSD, FIDIA and FORM is employed for moulds production. The objective of this case is to optimize the process parameters so as to avoid quality defects. A key issue in this case is to create trust between the digital twin model and the operator. Moreover, the UI should provide clear indications on the parameter's modification (i.e. Analytical Operator).

7.3.4 KYKLOS4.0 – An advanced circular and agile manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences.

KYKLOS 4.0 aims to develop an innovative Circular Manufacturing ecosystem based on novel CPS and AI based technologies, enhanced with novel production mechanisms and algorithms, targeting on personalised products with extended life cycle and promoting energy efficient and low material consumption intra-factory production processes, resulting reduced greenhouse gas emissions and air pollutants.

In KYKLOS4.0 the pilot cases need further analysis in terms of the human factors involved towards smart manufacturing (Aerospace Pilot 1, Aerospace Pilot 2) and circular manufacturing (Electronic Devices/Equipment Pilot, Heavy Equipment Industry, Shipyard Pilot, Food Industry Pilot, Automotive Pilot). At this point of time KYKLOS4.0 pilot cases cannot be analysed in terms of human factors addressed in the project.

[28] ZDMP Deliverable D2.3 - Industry Scenarios and Use Cases

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

7.3.5 DIGIPRIME – Digital Platform for Circular Economy in Cross Sectorial Sustainable Value networks.

Digital technology plays a big role in our transition to a circular economy, which aims to make optimum use of resources within industries. Investing in innovation is good for the protection of the environment, and it also contributes to Europe's competitiveness. The EU-funded DigiPrime project will develop the concept of a circular economy digital platform in order to create circular business models based on the data-enhanced recovery and reuse of functions and materials. Specifically, it will create and operate a federated model of digital platforms for cross-sector business in the circular economy. DigiPrime will be validated through several cross-sectoral pilots, further detailed in 20 use cases covering different European industrial sectors (automotive, renewable energy, electronics, textile, construction), and by additional pilots in new sectors, funded through an open call mechanism.

At this point of time DigiPrime pilot cases cannot be analysed in terms of human factors addressed in the project.

7.3.6 SHOP4CF – Smart Human Oriented Platform for Connected Factories

SHOP4CF, Smart Human Oriented Platform for Connected Factories, aims to find the right balance between cost-effective automation, repetitive tasks and involve the human workers in areas such as adaptability, creativity and agility where they create the biggest added value. SHOP4CF aims to pursue the highly-connected factory model to reap the benefits of all the data generated within the factory[29].

SHOP4CF platform will provide technological solutions that will **improve the well-being and working conditions of human workers**, automatizing monotonous and exhaustive tasks and increasing their productivity due to technological support. In order to contribute to the human-robot collaboration on the shopfloor, SHOP4CF develops and integrates components and supporting tools to the platform that lead to a great support in the different stages of the manufacturing process. Moreover, the supporting tools will facilitate the design and deployment of the human-centric manufacturing processes. The components and supporting tools are highly designed to best complement the collaboration between human & technology. SHOP4CF fosters the ability to swiftly adapt the manufacturing capacities and will ensure the safety of the human operators while working in a highly robotic and digitized environment.

To mitigate such challenges, a set of augmented / virtual reality tools were developed in various projects by different partners associated in the SHOP4CF project. Those components include, for example, virtual planning of safety behavior, augmented reality projection of assembly instructions or digital twins of production lines to monitor the condition. The relevance of those tools has been already validated in different research projects and verified in various research scenarios.

SHOP4CF foresees pilot cases in four industrial users.

- ARCELIK case: The second ARCELIC case involves a central team of engineering experts that remotely support the local factories through augmented reality (AR) and virtual reality (VR) tools. The SHOP4CF augmented reality interface environment using interactive computer monitors and AR/VR

[29] https://www.shop4cf.eu/

glasses will be used. This will enable the efficient use of expert human resources to solve technical problems, reduce the efforts (site visiting, equipment transport and travel needs) and reduce the error-rate caused by humans.

- The Volkswagen Wrzesnia factory case aims at supporting workers to eliminate ergonomically incorrect work postures during Chassis Shielding. In the same manner, visual inspection of paint quality issues will relief workers from eye-tiredness and allow them to concentrate on other tasks that require more advanced human decision-making capabilities.
- Robert Bosch España Fábrica Madrid case aims to employ collaborative robot that picks up the Printed Circuit Boards (PCB) and transfers them to the working stations and/or to the testing stations. The human, assisted with an AR system which provides real-time instructions and records any action thus, improving quality and reducing errors, places the electronic components on the board, to be then transferred to the soldering station by the collaborative robot.
- Siemens pilot aims at supporting human operator during the assembly of a medical product with the use of collaborative robots.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

8 Conclusions

This deliverable has summarized the work carried out on CCFs along the first half of the project. The task is ongoing and will continue in the second half.

During this first half of the project, an important work has been developed describing and dividing the different CCFs. As a result, the structured wiki has been deeply modified.

The mapping of ICT-07 projects is still weak as most of the ICT-07 projects are in the initial phases and need time to map themselves. This mapping will be further developed in the second half.

The connection between CF2 and the DMP cluster is working properly and lots of interactions and collaborations are coming out of it.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.