Ecosystem for COllaborative Manufacturing PrOceSses – Intra- and Interfactory Integration and AutomaTION
(Grant Agreement No 723145)

D7.2 Survey of successful elements with recommendations for COMPOSITION use cases II

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Helene Udsen - IN-JET	2018-08-30	Sections 4 and 5 provide a good overview, The Exec. Summary to some extent fails to serve its purpose. There are some formatting issues, including the Reference List

Index:

1 Executive Summary

The *D7.2 "Survey of successful elements with recommendations for COMPOSITION use cases II"* is an update to the Month 12 release of the D7.1 deliverable, *"Survey of successful elements with recommendations for COMPOSITION use cases I"*. It is a public document delivered in the context of WP7, Task 7.1: Survey of Successful Elements in External, Related Initiatives. The aim of Task 7.1 is to identify and undertake an assessment of existing results coming from related projects in order to be reused in COMPOSITON, to be part of the final solution provided by COMPOSITION project.

The present release of the D7.2 document (the second of three), is focused on continuing the work described in D7.1, identifying and assessing results coming from other FoF-11 projects and initiatives identified in the context of Industrial Internet and Digital Automation, mainly FIWARE4Industry and International Data Spaces (previously called Industrial Data Spaces – IDS). Thus, the International Data Spaces and the FIWARE4Industry initiatives are presented, together with a list of their main features, which can be useful for COMPOSITION. An interesting co-operation action among the two initiatives in order to implement the Industrial Data Space Reference Architecture using FIWARE is also described.

The document also identifies other reference architectures for Industrial Internet such as IIRA and IVRA, and their alignment with RAMI4.0.

The deliverable also covers the actions carried out during this second period (September 2017 – August 2018) to co-operate and exploit synergies between FoF-11 projects with the objective of building a common platform for digital automation and share information among projects. Therefore, the different cooperation workshops held to date, and information regarding the delivered reports and documents by the FoF-11 CSA Connected Factories are presented.

Since it is an update of the previous deliverable, in some sections, several paragraphs of the first deliverable have been maintained to facilitate reading.

2 Abbreviations and Acronyms

Acronym	Meaning
DoA	Description of Action
EFFRA	European Factory of the Future Research Association
FoF	Factories of the Future
IDS	International Data Spaces
IIRA	Industrial Internet Reference Architecture
IOF	Industry Ontology Foundry
IVRA	Industrial Value Chain Reference Architecture
JRA	Joint Research Activity
NGSI	Next Generation Service Interfaces
PMIC	Power Management Integrated Circuit
RAM	Reference Architecture Model
RAMI 4.0	Reference Architectural Model Industrie 4.0

3 Introduction

The aim of this deliverable is to update *D7.1 Survey of successful elements with recommendations for COMPOSITION use cases I*, which presented an initial analysis and selection of components available in the Fiware4Industry and Industrial Data Space projects, as well as providing information on the cooperation actions carried out between the different projects of the FoF-11 2016 call and other existing initiatives in the context of COMPOSITION.

Seeing the evolution of FIWARE4Industry and the International Data Spaces, and their close cooperation, the main objective has been to continue analysing the solutions provided by these initiatives and understand how these solutions fit in COMPOSITION, mainly for inter-factory purposes, and in particular how to share information in a safe and reliable way. The analysis has been done based on public information located on the Internet, but also interacting directly with different members of those initiatives.

In the same way, COMPOSITON has continued maintaining a proactive role in FoF-11 workshops, contributing to platform building in Digital automation and contributing to standardization issues.

3.1 Purpose, context and scope of this deliverable

This deliverable is an evolution of D7.1, and comprises and updates the initial assessment of existing results coming from related projects, with the objective of identifying modules or components that can be reused in COMPOSITION. As described in the DoA, the assessment has been done in terms of functionality provided, technology, license, status, etc. As in the first deliverable, the evaluation has been done on ongoing FoF-11 projects and initiatives, but it is important to bear in mind that at the moment, many of the components are still in development. At the end, the main objective of the liaison and co-operation activities with other projects will be to contribute to platform building in Digital automation.

A final deliverable in this series, *D7.3 Survey of successful elements with recommendations for COMPOSITION use cases III*, will follow in M36 (August 2019).

3.2 Content and structure of this deliverable

As for D7.1, the document is structured in three chapters: the first chapter is focused on the FIWARE4Industry and International Data Space initiatives, where some updated information about roadmap and the evolution is reflected. A second chapter describes the cooperative actions carried out with other projects of the FoF-16 call. The last chapter presents conclusions and future work.

4 Fiware4Industry and Industrial Data Space

4.1 Fiware4Industry, Industrial Data Space and COMPOSITION

CERTH and ATOS attended a FIWARE Global Summit Meeting in Porto in May 2018, participating in training workshops related to Industrial Data Spaces and FIWARE. As member of International Data Spaces Association (IDSA), CERTH examines the possibility of adding the COMPOSITION fill level sensors and the corresponding use cases to IDSA use cases. Some initial discussions with IDSA lead members are in progress. Moreover, CERTH participates in IDSA's general working group related to Use cases and Requirements.

In parallel ATOS plays a proactive role in Fiware4Industry to co-operate with the IDS initiative.

4.1.1 Update on Industrial Data Space

The Industrial Data Space initiative aims to create a virtual data space, which facilitates the secure exchange of data and the commoditization of data in business ecosystems. The *sovereignty* of data owners is preserved by means of defining and (technically) enforcing formal *usage control policies*, thus addressing the concerns of business partners to share sensitive company data. Dedicated metadata registries leverage the semantical annotations of data (*Broker*) and software resources (*App Store*) allowing for an easy search and mediation of appropriate resources. The consecutive resource exchange takes place among the certified *Participants* of the IDS networks by means of the *Connector* software (secure endpoints of the Data Space). Agile data exchange processes allow innovative business models and data-based smart services to emerge. They address key characteristics of modern factory processes: Interconnection of people and machines, automation of processes and systems, pervasive information transparency and decision support by assistance systems. Thus, data is seen as the connecting piece between industrial production and smart services. The resulting modern data management approach is depicted in Figure 1.

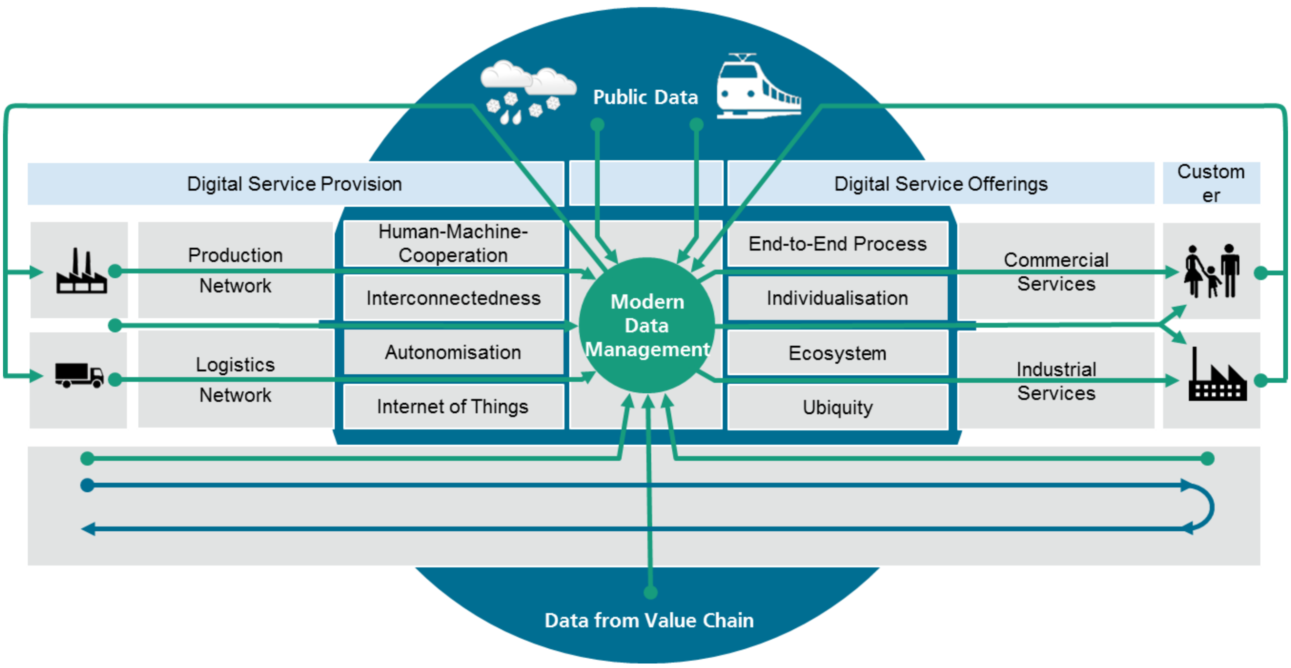

Figure 1. Modern Data Management (Translated from (Otto, et al., 2016))

The Industrial Data Space initiative is divided into two parts. A research project, funded by the German research ministry and executed by 12 Fraunhofer institutes, develops a reference architecture, which is piloted in a variety of industrial use cases. The Industrial Data Space Association (*IDSA*, in German: "eingetragener Verein", e.V.) identifies, analyses and assesses end user requirements. The association contributes to the reference architecture development and promotes its standardization. The various working groups provide a central means of stakeholder participation (currently approximately 90 companies).

4.1.1.1 Architecture

The Industrial Data Space Reference Architecture Model (RAM, version 2.0) is the main conceptual outcome of the project, accompanied by a variety of resources – reference software implementations (e.g., Secure Connector), the Ontology for annotation of digital resources (IDS Information Model), etc. RAM comprises 5 layers and 3 cross-cutting perspectives (Otto, et al., 2017, cf. Figure 2).

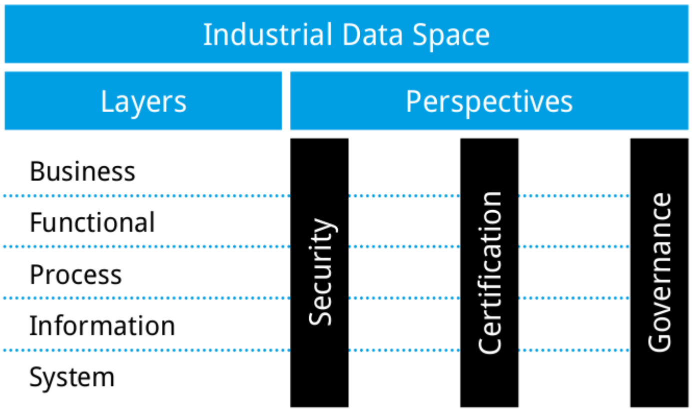

Figure 2. IDS Structure of Reference Architecture Model (Otto, et al., 2017)

Within the scope of this deliverable, we discuss only the “System Layer”, because it has most similarity to the COMPOSITION architecture. It is concerned with the definition of software components and their interaction.

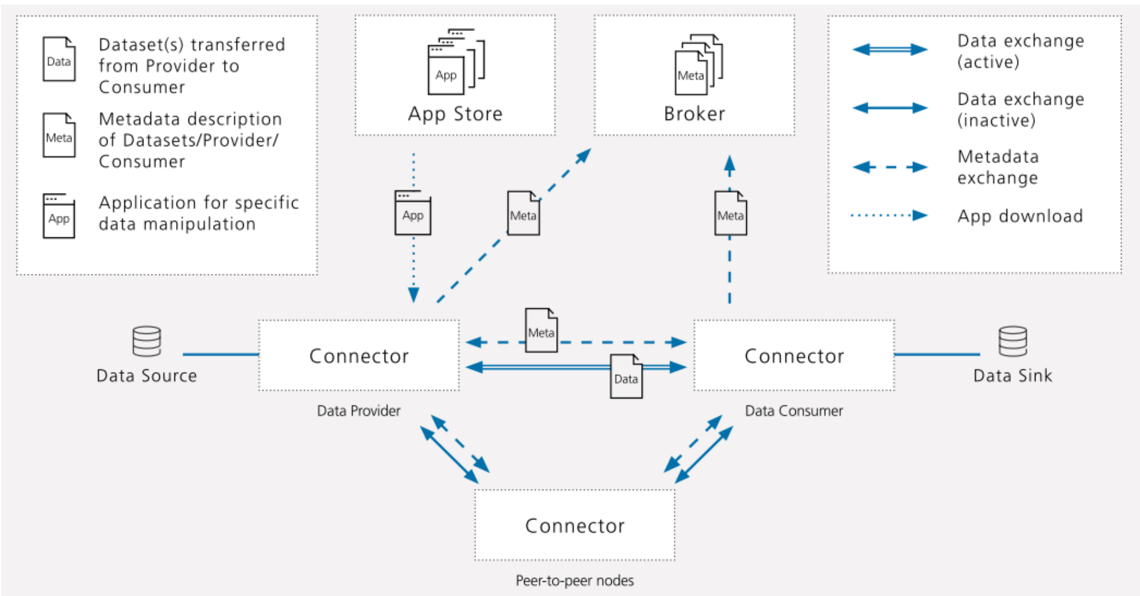

Figure 3. Interaction of components on System Layer (source: Otto, et al., 2018)

As for COMPOSITION, the Industrial Data Space introduces the notion of dedicated software nodes enabling stakeholders to connect with the Data Space system, the Connectors (the COMPOSITION equivalent would be the Marketplace). The Connector is a dedicated communication server, which exposes data sources and data sinks in the Data Space. The Connectors act as terminal nodes in the decentralized Industrial Data Space, providing endpoints for data exchange and tamper-proof, managed runtime for data processing and other applications (Data Apps).

Digital resources exposed by a Connector are advertised and resolved via metadata description in the Registries (upper layer components of Figure 2). The metadata is always exchanged before the actual data exchange. This metadata contains syntax and semantic information, information about the data provider and usage information, such as pricing or usage policies. In a default data exchange scenario, data providers first register their metadata at the broker. A data consumer can then use this metadata for connecting to the data provider. Nevertheless, the Industrial Data Space also foresees direct connection establishment without involving the broker in cases where the connection information is already known to the data consumer. Hence, the broker is mainly a metadata repository, which is not involved in the actual data exchange. This is the main difference to COMPOSITION, where the broker probably will not only distribute metadata but also the messages themselves.

In Industrial Data Space, Data Apps are defined as software components, which provide dedicated data-related service functionality. Therefore, their functionality is restricted to data enrichment or transformation. The App Store is the central distribution instance of Data Apps. This is 1:1 comparable to the app stores known from smartphones. App providers upload their app to the app store. App users can browse the app store repository and download, install and update the apps from there. So, in Industrial Data Space, apps are only used as part of the system. In contrast to that, apps are in most cases embedded in the COMPOSITION solution. This again is the same as smartphone app stores, where users do not only find system software, but most software there is providing system-independent functionality. Both types of apps can be found in COMPOSITION as well.

4.1.2 Industrial Data Space Architecture Implementation using FIWARE

The Reference Architecture model created by the International Data Space Association (IDSA) and described in the previous subsection aims to provide a common frame for designing and deploying Industry IoT infrastructures. Based on the cooperation between the FIWARE foundation and the IDS, one of the objectives has been to implement this reference architecture based on FIWARE open source software components (Generic Enablers).

The first prototype implementation of the proposed architecture has been validated by deploying and testing it in a real industry use case, trying to improve the maintenance and operation of milling machines. The Pilot described in the paper “Industrial Data Space Architecture Implementation Using FIWARE“ (Alonso, et al., 2018), consists of two real machines in a factory, a Milling machine and a CMM machine, which send data to an IDS Connector deployed by the factory. These data are consumed by two different services. The Predictive Maintenance System performs data analysis to predict when the Milling machine needs a maintenance procedure. On the other hand, the Quality Control service studies the measurement data to evaluate the quality of production processes. Both services can subscribe to the data produced by each machine through two new IDS Connectors deployed in their respective infrastructure.

For the implementation, one of the most important components is the Context Broker (Orion) which act as the core component of the IDS Connector in FIWARE-based implementations of the IDS Architecture. In fact, the Context Broker offers the FIWARE NGSI APIs and associated information model (entity, attribute, metadata) as the main interface for sharing data by the IDS participants.

The combination of well-defined domain-specific data models and a harmonized API (NGSI) enables Data Producers and Consumers to participate seamlessly in the IDS. Essentially, Data Producers use NGSI to publish or expose the data they offer (normally through a System Adaptor), and Data Consumers retrieve or subscribe (to be later notified) to the data offered. The operations concerning Data publication, consumption, subscription and notification are performed through the NGSI API.

Figure 4 below shows the different functional modules implemented and the interactions between them.

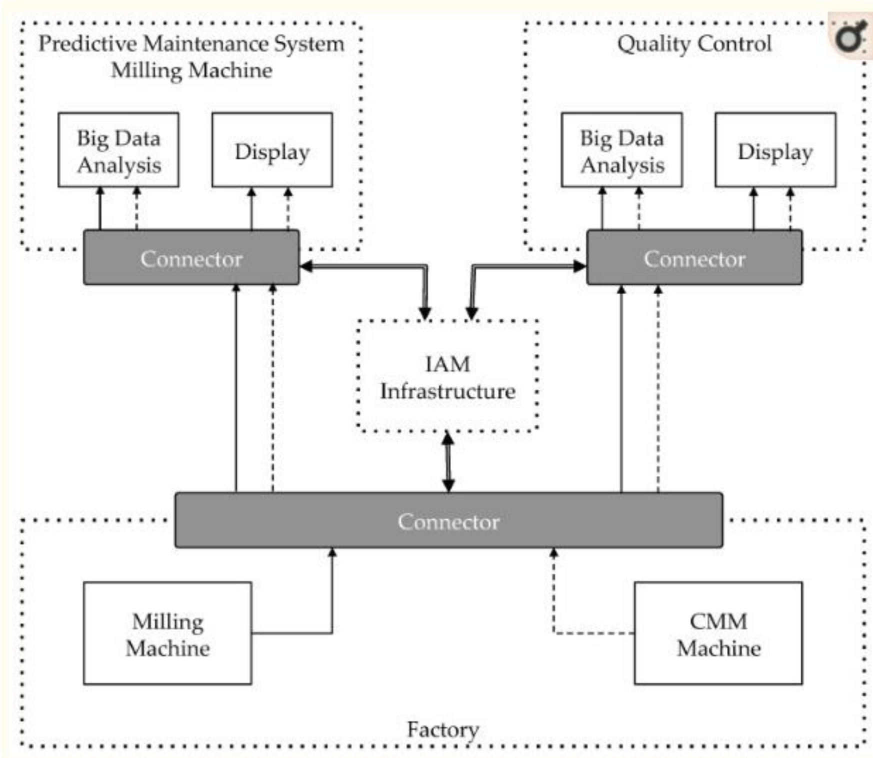

Figure 4. Use case modules and interaction (source: Alonso, et al., 2018)

The pilot uses big data mechanisms because it is necessary perform data analysis with the data received. Once the data has been processed, there are services in charge to show the output in a graphical way. One of the objectives of the pilot is illustrate how configuring the right permissions and establishing a trust relationship between the connectors allows data to flow in a secure way between the participants. Finally, the paper concludes that the FIWARE-based IDS implementation fits the requirements of the IDS Reference Architecture, providing open source software suitable to any Industry 4.0 environment.

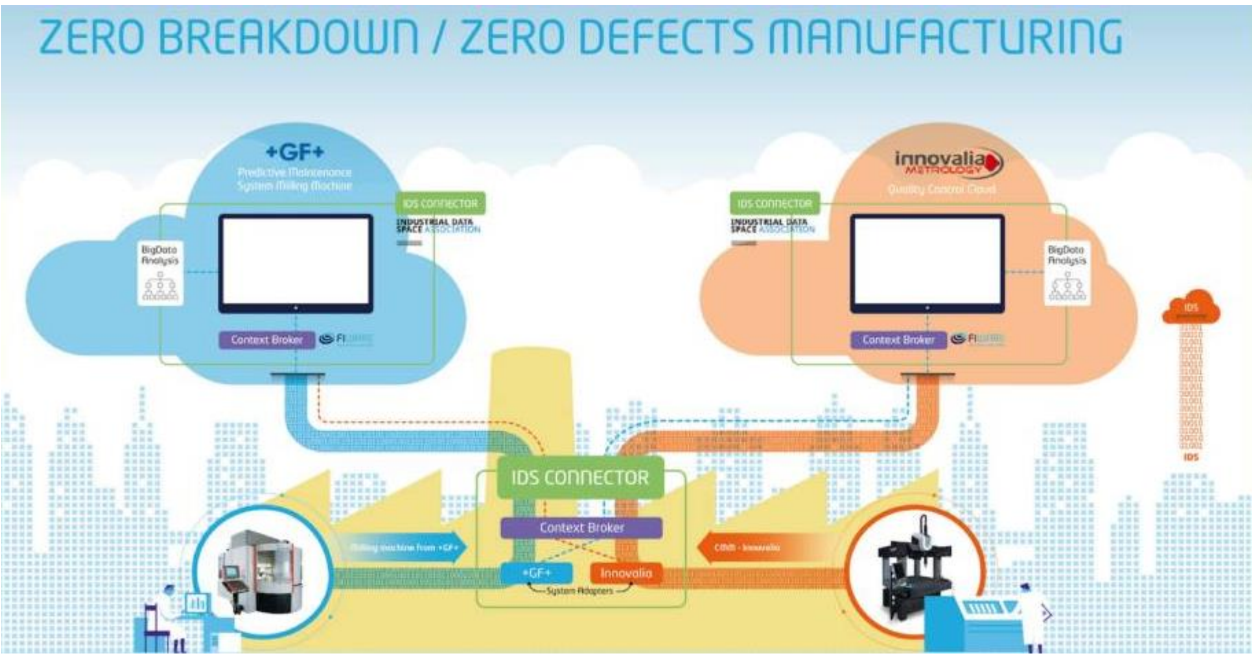

Figure 5. Pilot of the IDS architecture implemented by FIWARE Components (source: Alonso, et al., 2018)

5 Initiatives on Smart Industry and Collaborative Manufacturing and Logistics

This section summarises the cooperative activities carried out with other organisations working on smart industry, collaborative manufacturing and logistics. Special, focus is put on collaboration with projects of the FoF-11 call, with the aim of exploiting synergies and increasing the impact of the initiative on platform building in Digital Automation. Therefore, joint events identified synergies between projects on how the Reference Architecture Model Industrie 4.0 (RAMI 4.0) can be adopted in COMPOSITION and on other issues as well.

5.1 FoF-11 Projects Cooperation

The FoF-11-2016 topic focused on Digital Automation was the origin of eleven funded projects, 10 RIAs and 1 CSA. In the table below is a FoF-11 project list:

#	Project Name	Coordinator	Type
1	AUTOWARE	SOFTWARE QUALITY SYSTEMS SA	Factory Automation
2	DAEDALUS	SYNESIS SCARL	Factory Automation
3	DISRUPT	CENTRO RICERCHE FIAT SCPA	Factory Automation
4	FAR-EDGE	ENGINEERING – INGEGNERIA INFORMATICA SPA	Factory Automation
5	SAFIRE	X/OPEN COMPANY LTD	Factory Automation
6	ScalABLE4.0	INESC TEC	Factory Automation
7	COMPOSITION	FRAUNHOFER FIT	Collaboration
8	DIGICOR	FRAUNHOFER IPA	Collaboration
9	NIMBLE	SALZBURG RESEARCH FORSCHUNGSGESELLSCHAFT MBH	Collaboration
10	vf-OS	INFORMATION CATALYST FOR ENTERPRISE LTD	Collaboration
11	ConnectedFactories	EUROPEAN FACTORIES OF THE FUTURE RESEARCH ASSOCIATION AISBL	CSA

Table 1: FoF-11 Projects

There is an initiative led by the ConnectedFactories project (CSA) to foster collaboration among the ten FoF-11 projects. This CSA is led by EFFRA (http://www.effra.eu/). In the following sections, there is a description of the activities done by COMPOSITION in this collaboration framework during the last period (September 2017 – August 2018). It is noted that COMPOSITION is in closer contact with the projects listed as type "Collaboration".

5.1.1 FoF-11 Projects Synergies

5.1.1.1 The digital mapping framework

The main goal of the 'digital mapping framework' is to have a solid basis for describing and analysing what is present on the market in terms of technologies that support the deployment of digital manufacturing platforms. Recently, ConnectedFactories published v12.0 of the Structured Glossary, which is a dynamic document whose structure is kept aligned with the digital mapping framework. This is deployed on the EFFRA Innovation Portal, with the objective of mapping projects, and also used for describing commercial solutions on the market.

The mapping framework addresses questions like technologies used, standards supported and services delivered by Digital Manufacturing Platforms. Therefore, this mapping framework is used by the ConnectedFactories project in order to characterize available solutions that are already in the market or on their way, and also to collect and share information on R&D projects. The information is collected through the EFFRA Innovation portal, thus facilitating the consultation, analysis and extraction of information, and at the same time giving visibility between projects of what is being done, enhancing cooperation between projects.

EFFRA as a baseline for this reference structure is based on existing frameworks and structures such as RAMI 4.0 Reference Architecture Model Industrie 4.0, and work done by other FoF related projects.

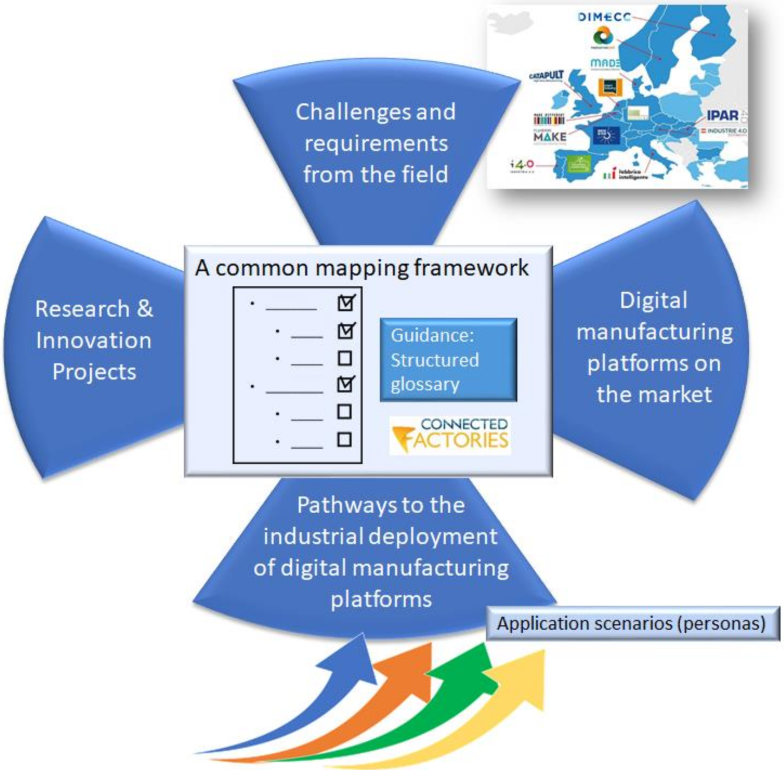

Figure 6. Digital Mapping Framework (source: EFFRA)

The Common mapping framework depicted in Figure 6 feeds on information coming from:

- Research and Innovation Projects
- Challenges and requirements from the field
- Digital manufacturing platforms on the market
- Pathways to the industrial deployment of digital manufacturing platforms

Regarding the R&I projects, includes mainly the ten FoF-11 projects but also has already involved more projects within and outside the FoF public-private partnership within its activities to stimulate synergies. From the FoF-11 projects contemplates six of them focusing on digital platforms for factory automation:

Figure 7. FoF-11 projects on Digital Platforms for Digital Mapping Framework (source: EFFRA)

And four projects focussing on supply chains and logistics

Figure 8. FoF-11 projects on supply chains and logistics (source: EFFRA)

One of the main goals of ConnectedFactories is develop forward-looking scenarios or pathways of how the different platforms and architectures will co-exist, cooperate and compete in a concrete environment. For exploring these pathways to reach the digital integration and interoperability of manufacturing systems and processes in different application areas, ConnectedFactories defines so called 'personas' which are different perspectives. At this moment three pathways with a particular scope have been developed:

- The Hyperconnected Factories: focusing on networked enterprises in complex, dynamic supply chains and value networks
- The Collaborative Product-Service Factories: focusing on data-driven product-service engineering in knowledge intensive factories
- The Autonomous Smart Factories: focusing on the factory automation pyramid.

In addition, it is important to note that the need for a perspective or persona to cover SMEs must be considered. This perspective is called the Small-scale Digitised Factories persona.

5.1.1.2 EFFRA Innovation Portal

EFFRA has implemented the EFFRA Innovation Portal (https://portal.effra.eu/projects). The main goal of this is to share information with everyone who is interested in EU funded R&D results and among projects. All FoF-11 projects listed in table 1 contribute to this Innovation Portal.

The COMPOSITION project is presented on the EFFRA Innovation Portal with a public profile. It can be found as a result of a search effort with keywords such as collaborative manufacturing or automation and, of course, as a FoF-2016-11 project. The maintenance of the information on the portal is a joint effort led by the Coordinator and the Dissemination Manager, in cooperation with all members of the consortium.

The COMPOSITION consortium strongly believes in knowledge sharing. This has led to a direct interaction of the project with EFFRA, where the project submitted a recommendation for including a Lessons Learned section in the Innovation Portal. This recommendation has been accepted by EFFRA and a section on "Use Case Requirements and Lessons Learned" has been added. It is the consortium's intention to communicate as much as possible with the Factories of the Future (FoF) community and to whoever is interested in the fruits of the European Union's Horizon 2020 Framework Programme for Research and Innovation.

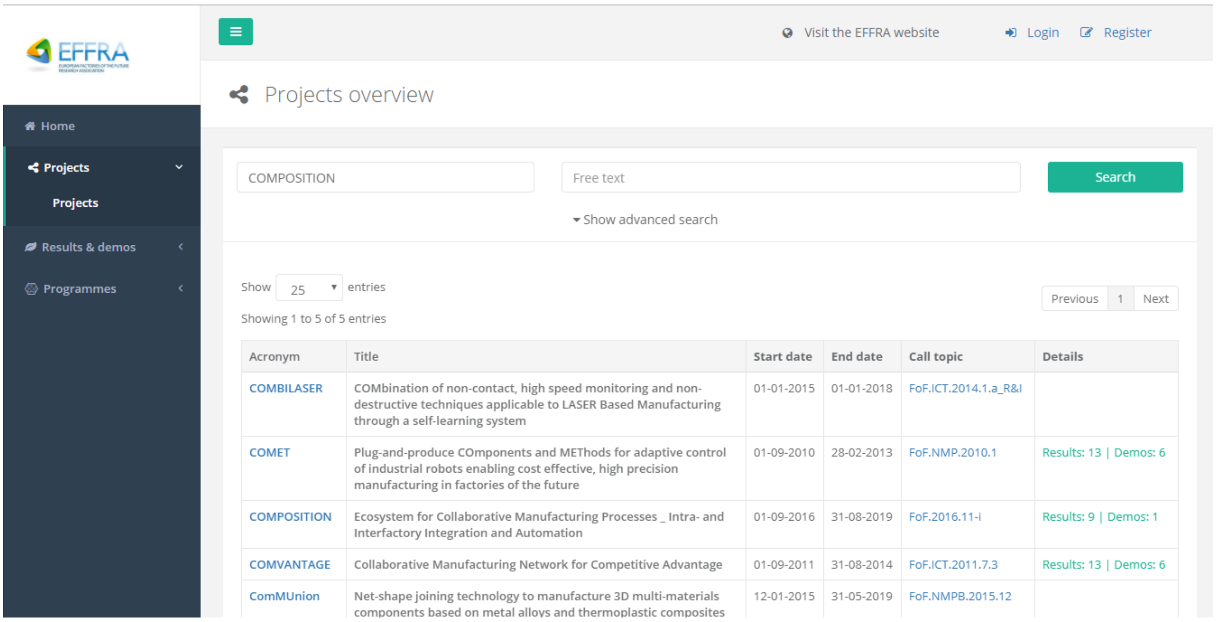

Figure 9 EFFRA search results

Navigating through the Portal, there is first a public ***Summary*** and some ***More information*** about the project including the website, duration, start date, end date, participants, budget. In addition to this introductory information, results that have already been published by the consortium in public deliverables are available in the ***Results*** section. It should be noted that this is continuously updated, in order to offer the possibility to the research community and general public to benefit from the project's findings. The same goes for the ***Demonstrators***, as COMPOSITION progresses.

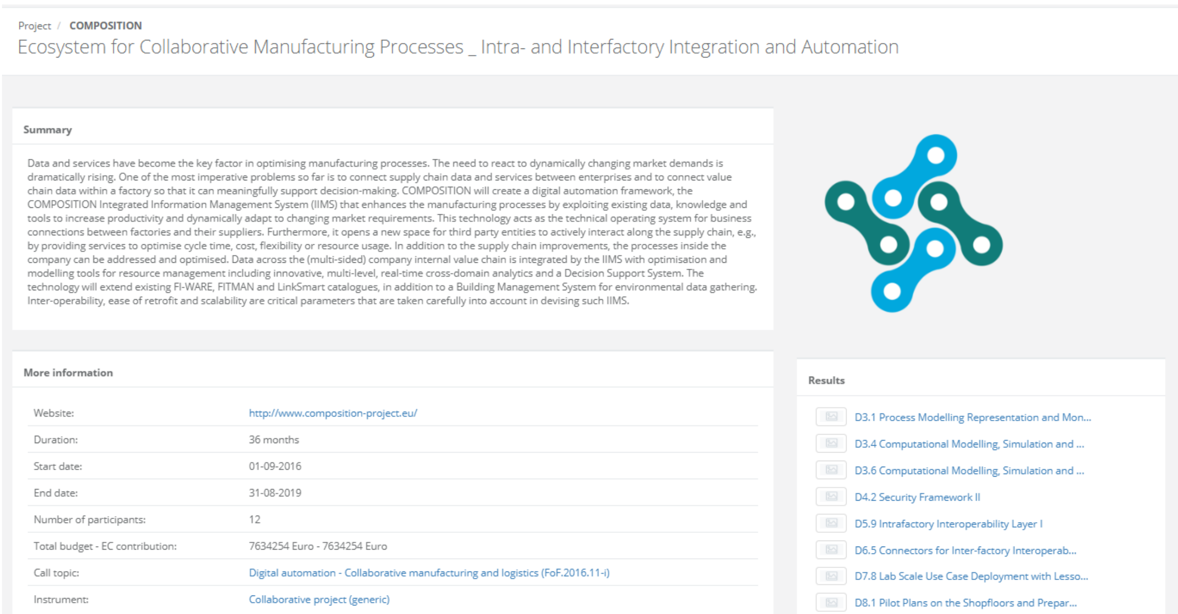

Figure 10 COMPOSITION Introductory information

The essentials of the project are followed by its ***Characteristics***. It should be mentioned that as the project advances, the information available in the characteristics part is continuously updated and enriched in collaboration with the responsible partners.

The first part is actually the ***Use Case Requirements and Lessons Learned***, which is the newest addition to the EFFRA Innovation Portal.

Use Case Requirements and Lessons Learned - (3) ▾ View Kanban

Use Case Requirements and Lessons Learned

Specific use case requirements

Comment:

1. The COMPOSITION Marketplace Management System shall enable stakeholder to gain access to the COMPOSITION open marketplace.
2. COMPOSITION Marketplace(s) should have possibility of restricted access.
3. The line visualization shall compare the actual processed units to the target ones.
4. Alarms/Notifications are forwarded to subscribers depending on their impact level.
5. It must be possible to reset an alert when the necessary measures have been taken.
6. Ecosystem components should be deployed as Docker images.
7. Agents shall be writable in any programming language.
8. The Decision Support System shall import data coming from the simulation and prediction engines.
9. Supplying companies register their products/services in specific topic(s) within the ecosystem.
10. The needs and requirements of companies shall be registered/published within the ecosystem.

Lessons learned

Comment:

1. Early design decisions on deployment and communication protocols were made. (Docker, MQTT, AMQP). Deciding on the deployment and communication platforms has made test deployment and integration work easier to manage.
2. Inception design (from the DoA) did not specify some components, e.g., for operational management or configuration. The architecture needed additional components to cover system configuration and monitoring.
3. Blockchain is still not a plug-and-play technology and requires a substantial amount of low-level configuration.
4. The Matchmaker should match agents (requester and suppliers). Moreover, the Matchmaker should match a request with the best available offer.
5. Use cases need to be solidly anchored in the real world of the actors and end users. They must not solely represent what is feasible from a technical point of view, but also reflect non-functional requirements such as regulations and business practices. Otherwise, the business cases would become unsustainable for further exploitation.

Figure 11 COMPOSITION Use Case Requirements and Lessons Learned

The second part is devoted to the ***Challenges*** that COMPOSITION faces and attempts to solve following the specific approach that has been set up by the technology providers and end users and which is continuously monitored. The sectors discussed cover two aspects; the *economic* ("Addressing economic performance across the supply chain" and "Resource efficiency in manufacturing, including addressing the end-of-life of products") and *environmental* sustainability ("Reducing the consumption of energy, while increasing the usage of renewable energy", "Optimising the exploitation of materials in manufacturing processes" and "Co-evolution of products-processes-production systems").

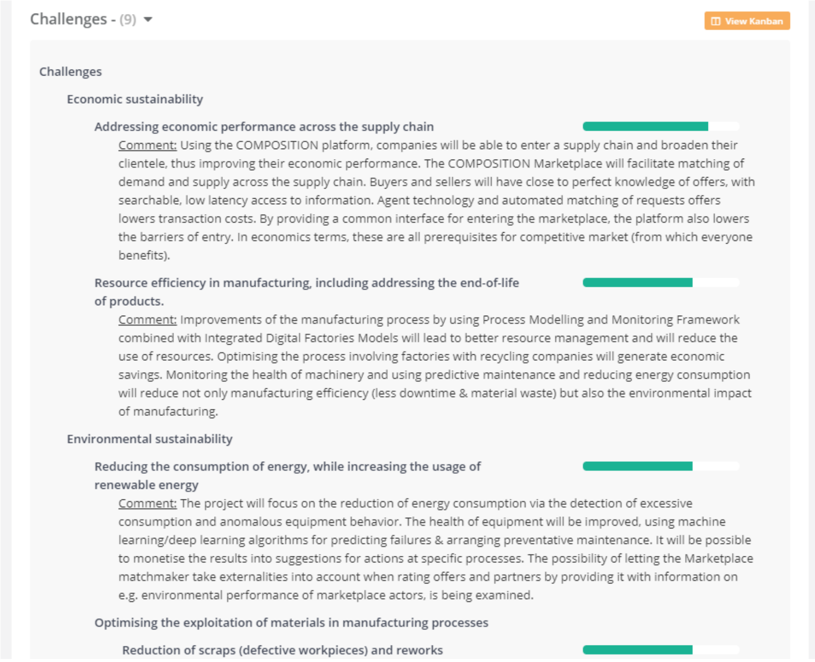

Figure 12 COMPOSITION Challenges section

In the next part, the ***Technologies and enablers*** used in the COMPOSITION project are presented and described. The six sectors that have been chosen at the present state are “Advanced manufacturing processes”, “Mechatronics for advanced manufacturing systems”, “Information and communication technologies”, “Manufacturing strategies”, “Modelling, simulation and forecasting” and “Standards”.

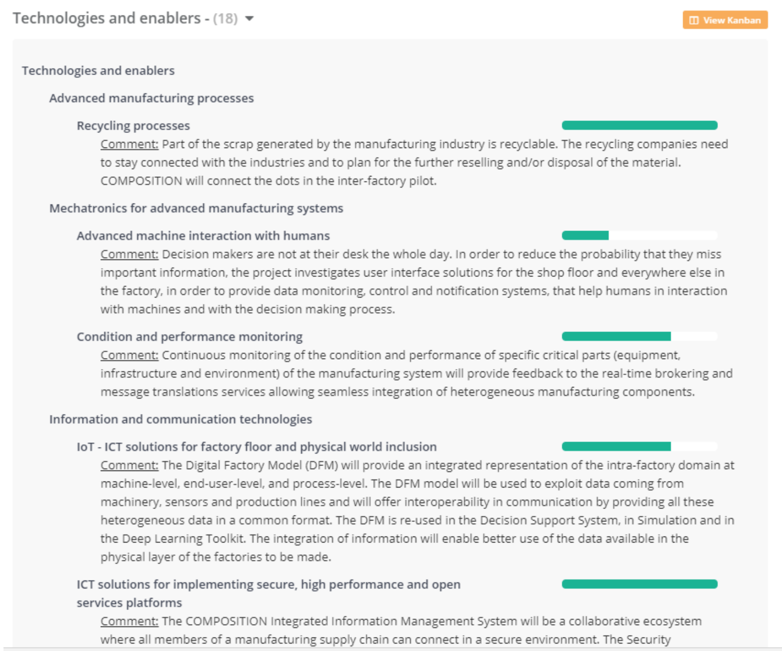

Figure 13 COMPOSITION Technologies and enablers section

Following is the ***Digital Mapping framework*** that EFFRA itself is very keen on, as it allows mapping of projects from different calls and sectors in a unified manner. In this segment of the portal, information has been made available on seven parts of the map. More specifically, one can find the take of COMPOSITION on: “Value adding service”, “Business model of platform supplier”, “Technology”, “Performance characteristics", "Human aspects", "Manufacturing system levels and life-cycle stages" and "Product levels and life-cycle stages".

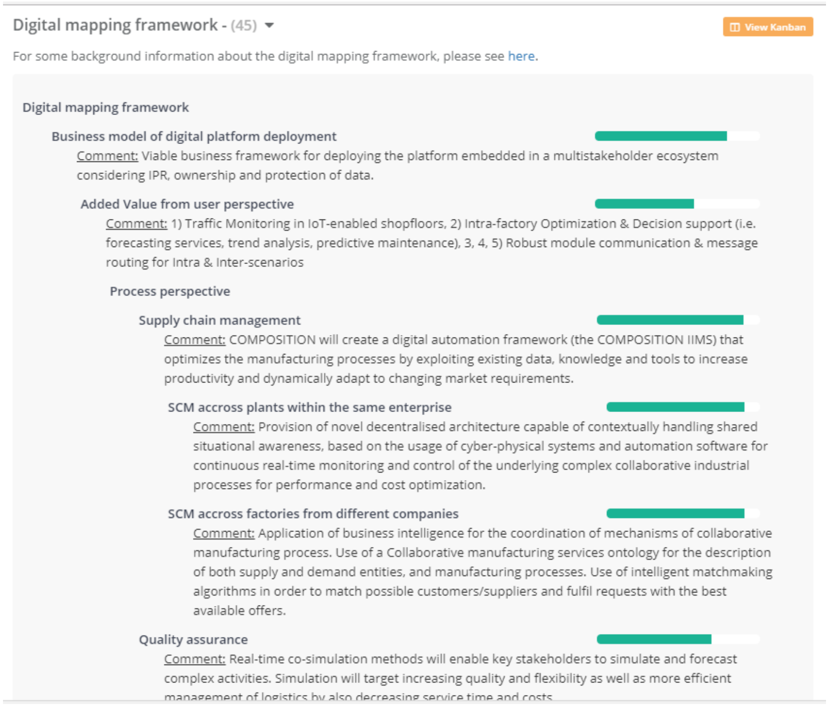

Figure 14 COMPOSITION Digital mapping framework section

An addition to the Portal is also the ***Digitisation pathways*** section. As mentioned in the EFFRA website "The ConnectedFactories project explores pathways to the digital integration and interoperability of manufacturing systems and processes and the benefits this will bring." The COMPOSITION project describes its journey along the applicable pathways: Hyperconnected Factories, Autonomous Smart Factories.

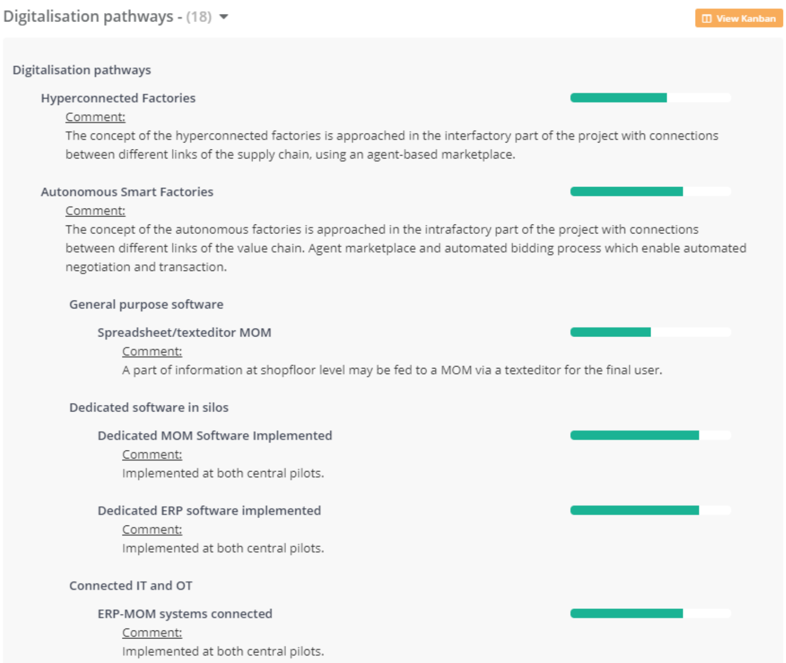

Figure 15 COMPOSITION Digitalisation pathways section

Moreover, the project is described as active in four specific domains of ***Research priorities***. The partners are devoted to conducting research on “Adaptive and smart manufacturing systems”, “Digital, virtual and resource-efficient factories”, “Collaborative and mobile enterprises” and “Human-centric manufacturing”.

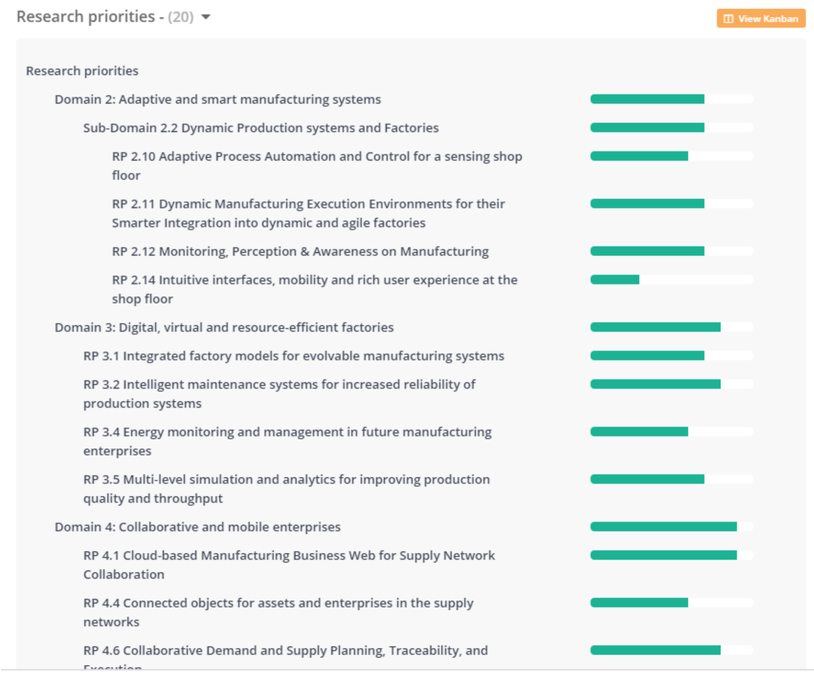

Figure 16 COMPOSITION Research priorities section

Finally, in the ***Diverse*** information section, COMPOSITION has selected to highlight the clustering and standardisation activities that partners are engaged in, as it is of importance to the concept and the realisation path of the project.

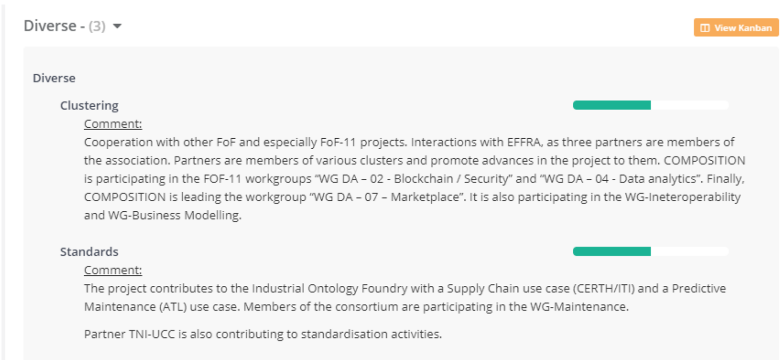

Figure 17 COMPOSITION Diverse section

It should be mentioned that three partners of the consortium are active members of the Association. Hence, it is of importance also to them to share the outcomes and advancements of the project with this community and the public. Moreover, as mentioned above, the information in the EFFRA portal is continuously revisited throughout the lifetime of COMPOSITION.

5.1.1.3 Standardization

Regarding standardization, several initiatives have been identified and analysed based on COMPOSITION requirements, and some actions have been carried out:

Communications Protocol Standards

Existing communications standards are adequate for the data transfer challenges that the COMPOSITION project faces. To date, standard Ethernet and Bluetooth communications protocols have been utilised. There are no unique communications challenges faced to date in the project that requires the use or design of proprietary protocols.

Sensor Protocol Standards

Wherever possible, off-the-shelf sensors have been selected that meet the requirements of the project. Typical protocols used are I2C and SPI.

Whilst there is no merit in developing new protocols there is a need for standardisation in the characterisation of parts within the sensors, particularly wireless sensors that use some type of energy harvesting and/or micro-power management to maximise battery life. COMPOSITION partner Tyndall is actively involved (co-ordinator) in an EU H2020 research infrastructure project 'EnABLES' (730957) and is leading a JRA (Joint Research Activity) within the project to address this issue.

> ***EnABLES JRA 3 – Simulation Tools for Power Module Sizing***
>
> This is specifically concerned with development of system simulation tools to enable development of storage, transducers and loads in IoT applications. In addition, this tool is intended for use by IoT sensing system integrators. Part of this work involves standardizing the simulated parameters from the individual elements of the system (transducer, PMIC, storage, load) to enable system simulations, development tools and deployment tools to be easily assimilated. As a result, it will be possible to do direct comparison of various combinations of parts at system level and estimate battery life, in some cases determining if an energy-harvesting source would potentially prolong battery life or even eliminate the need for battery replacement. This is one of the biggest problems with wireless sensors, the battery life (uncertainty and duration).

Industrial Ontologies Foundry

Industry Ontology Foundry (IOF) is an initiative to create a suite of interoperable high quality ontologies covering the industrial domain and especially industrial manufacturing (https://emmc.info/wp-content/uploads/2017/12/EMMC-IntOp2017-Cambridge_Smith_Buffalo.pdf). CERTH and ATL are members and they contribute in Supply Chain and Predictive Maintenance use cases, respectively.

COMPOSITION partner CERTH presented online the COMPOSITION Semantic Framework at the general working group of the Industrial Ontology Foundry on 30 March 2018. The Collaborative Manufacturing Services Ontology and the Matchmaker were presented as the core parts of the semantic framework. The COMPOSITION supply chain scenario related to the online bidding in accordance with the ontology and matchmaking services was presented as well. Currently, CERTH participates in a new IOF sub-group (started in July 2018) devoted to the supply chain. The COMPOSITION use case (with its corresponding COMPOSITION Semantic Framework) is one of the first two use cases submitted and presented in the sub-group. The sub-group aims to create a list of requirements for supply chain ontologies and to add concepts (or create ontologies) to the high-quality ontologies from IOF. Already some concepts and terms from COMPOSITION Collaborative Manufacturing Services Ontology have been selected.

5.1.2 Workshops and Joint Events

During this second period (September 2017 – August 2018), several Workshops have been held:

- **27th-28th September 2017** in Brussels - ConnectedFactories Consortium and Cluster meeting ConnectedFactories Scenario Building workshop

  The aim of this event organized by ConnectedFactories was to discuss and draft future visions and together explore possible pathways and identify practical implications. The workshop information will increase the consistency and usability of the visions and pathways, so they can be used in later regional workshops.

  Draft "future visions" and pathways towards digitised and connected Factories of the Future were made available prior to the workshop. These pathways take into account that companies, mainly manufacturing companies and manufacturing technology suppliers, are not all in the same position on this pathway.

  COMPOSITION participation: KLE, ATOS

- **9th-10th November 2017** in Budapest - ICT Proposers' Day 2017

  This networking event centred on European ICT Research & Innovation, in particular the Horizon 2020 Work Programme for 2018-20 in the field of Information & Communication Technologies and Future and Emerging Technologies (FET).

  The event was organised by the European Commission, and COMPOSITION gave a talk under the session "Introduction to Digital Platforms and Manufacturing".

  COMPOSITION participation: CERTH

- **5th-6th February 2018** in Brussels - ConnectedFactories Public Event

  The event organised by ConnectedFactories focused on the results obtained from the FoF-11-2016 projects and on associated projects. Since many projects under the Factories of the Future programme have addressed the digitisation of manufacturing, it was important to capture how these projects have contributed to the deployment of digitisation. The event also provided an interesting insight in relation to the calls 'DT-ICT-07-2018-2019: Digital Manufacturing Platforms for Connected Smart Factories'.

  COMPOSITION gave two talks. One presented first concrete results and use cases, and the other one gave examples of the application of the e^3value model **in a dedicated business model workshop**.

  COMPOSITION participation: FIT, NXW

- **29th-31th May 2018** in Cork, Ireland - EnerHarv 2018

  The event was organised by PSMA (Power Sources Manufacturing Association). This workshop event brought together energy harvesting and micro power experts and users from all over the world with the objective of creating a collaborative energy harvesting ecosystem. There were sessions covering transducers, applications, low power loads, power management, storage and system integration. Under the COMPOSITION banner the following papers, demonstrations and papers were presented.

    - Paper: Industry 4.0 IoT device retrofit and energy harvesting use cases, by Luis Martins from BSL
    - Poster: COMPOSITION – Condition monitoring and asset tracking sensors for Industry 4.0, by Tracy Brennan from BSL
    - Demonstration: COMPOSITION – Condition Monitoring and Asset Tracking Case studies for Energy Harvesting Opportunities in Industry 4.0, by Bobby Bornemann, James McCarthy and Peter Haigh from TNI-UCC.

  COMPOSITION flyers were also distributed at the event.

- **29th June 2018** in Bilbao, Spain – Taller de digitalización

  This event was organised by Tecnalia under the umbrella of ConnectedFactories CSA. The main goal of the workshop was to get feedback (mainly from Industrial SMEs) on their digitalisation status. 30 companies participated, most of them industrial SMEs, but also some big industrial and ICT companies.

  The workshop had two different parts. Initially some introductory presentations were shown:

  - a welcome speech by Tecnalia
  - a couple of keynote presentations on digitalization strategies and human resources impact from Dassault and ATOS
  - and finally, a couple of short presentations about ConnectedFactories CSA and Watify as an example of EC initiatives to help organisations in their digitalization process from Tecnalia and ATOS.

  In the second part of the workshop the audience was split into small groups where the digitalisation status of each company was discussed. Interesting feedback was collected, which will be integrated with similar results coming from other countries by the Connected Factories CSA.

  COMPOSITION participation: ATOS

- **27th June 2018** in Brussels - Factories of the Future Community Day

  This major brokerage event organised by ConnectedFactories was centred on the Factories of the Future 2019 call. The aim of the Community Day was to present and discuss the Factories of the Future 2019 call topics and to facilitate brokerage around the call topics. In addition, existing Factories of the Future projects were presented.

  COMPOSITION collaborated with DIGICOR, NIMBLE and vf-OS on a talk named "Towards the Realisation of Hyperconnected Factories" where preliminary results from these FoF-11-2016 projects were presented.

  COMPOSITION participation : ATOS, NXW, ATL.

5.1.3 Further Planned Collaborative Activities with FoF-11-2016 Projects

COMPOSITION has intensified its collaboration with the other three "Collaborative manufacturing and logistics" projects DIGICOR, NIMBLE and vf-OS. As such, the four projects have prepared a joint proposal for bringing together FoF-11-2016 project outcomes under the DT-ICT-07-2018-2019 call "Digital Manufacturing Platforms for Connected Smart Factories". Furthermore, the projects will collaboratively host a workshop on "Showcasing Recent Developments in the Smart Manufacturing Arena" at the 9th international Conference on Intelligent Systems 2018. Lastly, together with EFFRA, the projects have applied for a joint networking session at the ICT2018 "Imagine Digital" event. More details about the mentioned event are described in the following.

- **25th-27th September 2018** in Funchal - Workshop on Showcasing Recent Developments in the Smart Manufacturing Arena, 9th international Conference on Intelligent Systems 2018

  The workshop brings together industrial representatives from the digital manufacturing, FIWARE and IoT domain alongside the researchers from the areas of smart manufacturing, enterprise information systems, IoT, cloud computing, risk management, big data, standardisation, process engineering and business modelling to discuss the ongoing developments in the broad area of Connected Smart Factories, including Digital Automation and FIWARE initiatives.

  The aim of the workshop will be on generating awareness and knowledge exchange in the above-mentioned areas. The workshop program will be composed of four thematic sessions plus one demo and one specific concluding session to define overall common goals to the participants and establish collaborations for the future.

  The workshop is organised by Information Catalyst, Salzburg Research, Fraunhofer FIT, IK4-Ikerlan, UNINOVA (Conference Organizer) and Knowledgebiz.

COMPOSITION participation: FIT, ISMB

- **17th October 2018** in Brussels - Cybersecurity for Manufacturing Environments

  EFFRA, ECSO and the European Commission's DG Connect will co-host a workshop centred on cybersecurity for manufacturing environments. The workshop will draw attention to the fundamental importance of cybersecurity challenges in manufacturing environments, where they are not yet fully recognised and addressed. COMPOSITION project has applied for a slot to present the progress on blockchain-based cybersecurity during the first two years of the project.

  COMPOSITION participation: ATOS

- **4th-6th December 2018** in Vienna - ICT2018 "Imagine Digital"

  ICT2018 is the key European ICT research and innovation event organised by the European Commission. Among other components of this year's event, networking sessions will be organised by stakeholders. The aforementioned Workshop organisers have submitted an application to host a networking session, and this collaboration has already resulted in the establishment of synergies among them.

  The objective of this networking session is to promote the idea of establishing a federated smart factory ecosystem in Europe. The session will stimulate a forward-looking collaboration between the manufacturing sector in Europe and the creators and developers of smart factory platforms, to deliver disruptive innovations to industry in a highly flexible and agile model. The session will introduce the conceptual federation of four platforms currently being developed in the EC funded NIMBLE, COMPOSITION, DIGICOR and vf-OS projects, aiming to boost exchange of ideas between all participants.

  The workshop is organised by Atlantis, Fraunhofer FIT, Information Catalyst, Salzburg Research and EFFRA.

  COMPOSITION participation: ATL, FIT.

5.1.4 Plans for next steps in FoF-11 working groups

As described in D7.1, during the vf-OS ICE/IEEE workshop in Madeira (June 2017), a new process was introduced with the objective of allowing FoF EU projects to collaborate in a regular and structured way, aiming to increase the performance of their respective project outcomes through more effective collaboration.

After the identification of the different thematic WGs, all related FoF projects were asked to assist in completing the setting-up of the working groups. A Collaboration Plan was agreed in September 2017, with a kick-off meeting of formed WGs taking place in October 2017, organised by Telecom. The list of the final working groups identified, as well as the project(s) that will lead them, is the following:

- WG DA - 01 - IoT/Middleware - *Leader CREMA*
- WG DA - 02 - Blockchain/Security - *Leader FAR-EDGE/COMPOSITION*
- WG DA - 03 - Business models - *Leader DIGICOR*
- WG DA - 04 - Data analytics - *Leader COMPOSITION/SAFIRE*
- WG DA - 05 - SDKs - *Leader vf-OS*
- WG DA - 06 - FIWARE - *Leader BEinCPPS*
- WG DA - 07 - Marketplace - *Leader COMPOSITION*
- WG DA - 08 - Reference Architectures, Open Platforms, Open APIs - *Leader vf-OS*
- WG DA - 09 - Code Sharing, Developers Engagement Hub, Open Source Licensing - Leader NIMBLE
- WG DA - 10 - Privacy, Data Protection, IPR - Leader TBD

Several project partners from COMPOSITION are involved in these FoF-11 WGs:

- ATOS as participant in WG02 – Blockchain/Security.
- FIT as participant in WG04 – Data Analytics
- CNET as leader of WG07 – Marketplace.

Concerning operational issues, each WG is self-organised, and it determines about the frequency and dates of the telcos (approx. every 3-4 months), the duration, agenda and for writing the minutes. In the same way, the WGs are responsible for storing and managing participant information, using the infrastructure provided by the ConnectedFactories project for this.

WGs are also responsible for organising physical meetings, taking advantage of possible EU events or conferences in order to share their progress and outcomes. At this moment, the WGs have not been very active and have not started many activities, which need to be made up for in the final year of the project.

5.2 FoF-11 CSA Connected Factories

In the period between August 2017 and August 2018, EFFRA and the CSA Connected Factories have produced some material (deliverables, reports, etc.) and held some workshops. This is a summary of the main outputs produced:

- A report containing the findings of the Digital Manufacturing Platforms for Connected Smart Factories workshop. This was published in November 2017. The main objectives of this were to discuss and identify what digital platforms should address, developed and piloted at EU level. At the same time, it also undertook an overview of the new technologies such as the Internet of Things (IoT), Cloud computing, 5G, Big Data and data analytics, robotics, artificial intelligence and 3D printing and see how these can help industries to become more competitive and more efficient.

  Some of the conclusions to be highlighted are:

  > The reference implementations are a valid way to demonstrate the power of the platforms in the industry.
  >
  > The piloting helps to adopt new technologies and also to work on interoperability and open standards.
  >
  > The importance of the human factor inside the industry ecosystem and in collaborative manufacturing environments.

  The report is accessible here.

- In March 2018, EFFRA and BDVA (Big Data Value Association) signed a Memorandum of Cooperation (MoC) during the Digitising European Industry Stakeholder Forum, with the objective of cooperation to contribute to the EU's Digital Agenda through strategic documents (including roadmaps), pilots and related activities; also for exchanging best practices and approaches between projects, trying at the same time to be more efficient in exploiting the results of projects. Another objective of the cooperation is to identify pathways from the current industrial state of play to visions of factories of the future.
- In May 2018, EFFRA launched the Factories of the Future Horizon Europe Consultation, with the objective of identifying the future research and innovation priorities for Factories of the Future, preparing for Horizon Europe (the official name for FP9). This consultation gave industrial companies, research organisations, universities and the general public the opportunity to help shape these priorities. In this way, EFFRA as the official partner of the European Commission in the Factories of the Future partnership is responsible for preparing a strategic research agenda, defining research and innovation priorities for the partnership, based on inputs from across Europe.
- ConnectedFactories published the v12.0 of the Structured Glossary associated to the digital mapping framework on the EFFRA Innovation Portal. (described in subchapter 5.1.1.1)
- In the last year, EFFRA has also published monthly newsletters, indicating the different activities in which they have been working or participated.

5.3 Other Initiatives

An equivalent reference architecture model to the RAMI Industry 4.0 Reference Architecture is the Industrial Internet Reference Architecture (IIRA) of the Industrial Internet Consortium (Lin, et al., 2017). Although this is cross-domain, the IIRA, like RAMI 4.0, provides recommendations and guidelines to articulate the creation of Industrial Internet Systems and Cyber Physical Systems as fundamental building blocks for the industrial internet. In addition, a Japanese initiative called Industrial Value Chain Initiative, has provided the Industry Value Chain Reference Architecture (IVRA). As reflected in Figure 18, IVRA (Nishioka, Y., 2017) provides three perspectives to understand manufacturing industry as a whole: the knowledge-engineering flow, the demand-supply flow and hierarchical levels from the device level to the enterprise level. A key element is the introduction of Smart Manufacturing Units in a way that allows to smoothly integrate human beings as elements with their autonomous nature.

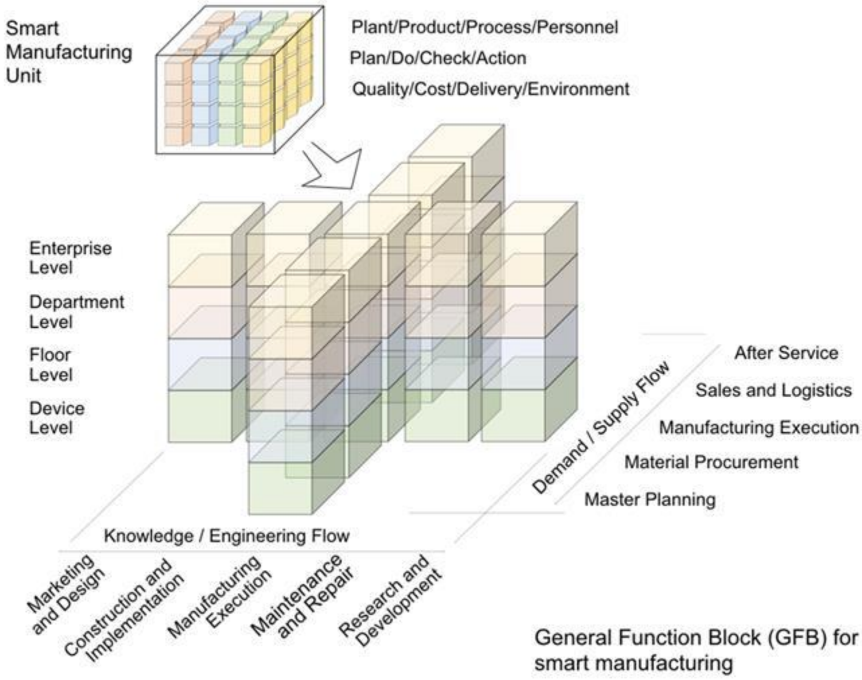

Figure 18 Industrial Value Chain Reference Architecture (source: Nishioka, Y., 2017)

Regarding IIRA, their design defines the shapes and forms of an Industrial Internet of Things Architecture by starting with the viewpoints of the stakeholders. These IIRA viewpoints are arranged in a particular order to reflect the pattern of interactions that occurs between the four elements, because the decisions from a higher-level viewpoint impose requirements on the viewpoints below it. Therefore, the IIRA can be considered a layer model that takes into consideration four different viewpoints which provide a kind of checklist that breaks down the system design requirements into four different viewpoints (business, usage, functional, and implementation), focusing on the capabilities from the perspective of the software and their business processes. This allows designers to iteratively think through a comprehensive list of architectural features, looking at the architecture from a variety of perspectives.

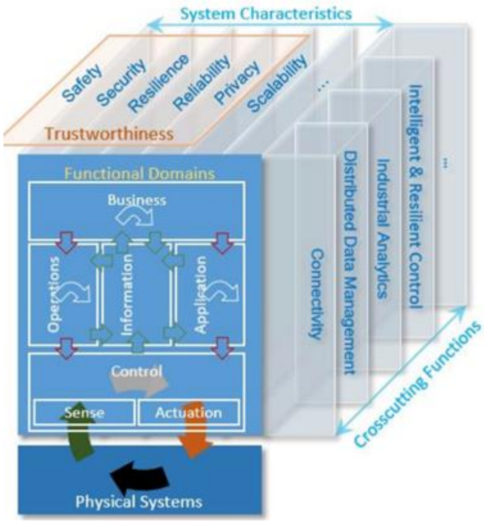

Figure 19 IIRA Functional Domain, crosscutting functions and System Characteristics (source: Lin, et al., 2017)

Currently, the Working Group JTG2 from the Industrial Internet consortium (IIC) is working on the convergence between RAMI and IIRA. In June 2018 they presented a whitepaper "Architecture Alignment and Interoperability: An Industrial Internet Consortium and Platform Industrie 4.0 Joint Whitepaper" where they try to map the RAMI 4.0 with the IIRA viewpoints (Lin, et al., 2018).

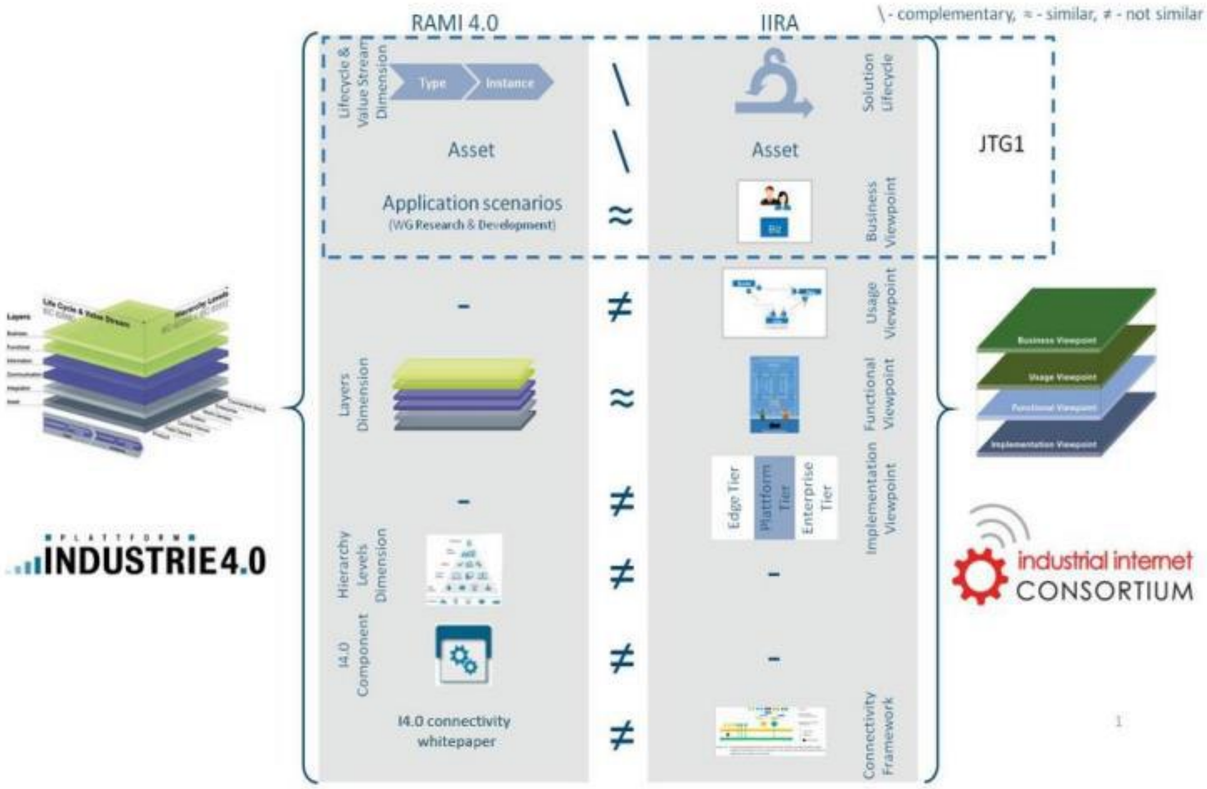

Figure 20 IIRA and RAMI4.0 Similarities (source: Lin, et al., 2018)

As described in the IIRA specification (Lin, et al., 2017), the data-driven implementation of the IIRA foresees four main Databus layers where data exchange/sharing processes are taking place. The Machine Databus is the real-world databus, to be implemented in a factory shopfloor, in the operations of a product or in transportation-logistics scenarios. The Unit Databus is usually implemented by dedicated edge-fog data gateways as a bridge between Real and Digital worlds. The Site Databus implements the databus of a single administrative domain, whether this is a company, an IT department, a plant or a fleet of logistics vehicles. On top of that, the Inter-site Databus materializes B2B data exchange/sharing business processes across at least two different administrative domains. Therefore, from the whitepaper it can be concluded that if we take the IIRA data-driven reference architecture as a paradigm, we can easily map any development vs. RAMI and consequently achieve a full alignment and compatibility with Platform Industrie 4.0.

Complementing those described in D7.1[1], other initiatives/projects aligned with the requirements and functionalities required in COMPOSITION have been identified:

- Ocean Protocol (Oceanprotocol, 2018) is a non-profit foundation based in Singapore that leverages the Blockchain technology for implementing the "Ocean Network", a decentralized network for the supply of large volumes of high-quality data. Its Data Marketplace (DM) is designed to use the services of the Ocean Network, provide access to data resources and increase the liquidity of data supply and demand.
- Adamos (ADAMOS, 2018), a Joint Venture of DMG MORI, Dürr, Software AG, ZEISS, and ASM PT aims at establishing a digital marketplace for "ADAMOS Apps" (industrial App Store) covering areas of planning, predictive maintenance, etc., with a strong focus on mechanical engineering.
- The European research project BIG-IoT (BIG-IoT, 2018) intends to set up a digital Marketplace allowing companies to monetize their data resources and services. Interoperability is ensured by leveraging a uniform, standard Web of Things API (W3C, 2018).

[1] BaSys 4.0, IUNO and Data Market Austria

6 Conclusions and Future Outlook

Deliverable D7.2 has provided detailed information about ongoing initiatives such as FIWARE4Industry and International Data Spaces, together with an initial identification and selection of possible software components that can be reused in COMPOSITION project.

The document also provides a detailed description of the work carried out during the second year (September 2017 – August 2018) in cooperation with the other ten FoF-11 Projects with the objective of achieving a common platform for digital automation.

The identified actions planned in the third year are to:

- Study the viability of incorporating the IDS open source solution into COMPOSITION
- Track the evolution of the Open Source implementation of the International Data Spaces Reference Architecture based on FIWARE, and identify possible modules/components where COMPOSITION can contribute
- Continue in a proactive role in the FOF-11 workshops, trying to contribute to platform building in Digital automation providing ideas and trying to identify components coming from these projects that may be useful or add value to the final COMPOSITION architecture.

7 Tables and Figures

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