Ecosystem for COllaborative Manufacturing PrOceSses – Intra- and Interfactory Integration and AutomaTION
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D7.1 Survey of successful elements with recommendations for COMPOSITION use cases I

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Index:

1 Executive Summary

The D7.1 “Survey of successful elements with recommendations for COMPOSITION use cases I” 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 do 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. These components must cover specific IT requirements of the use cases.

The present release of the D7.1 document (the first of three), is mainly focused on assessing results coming from Fitman (from here Fiware4Industry) and Industrial Data Space projects. Therefore, this task has performed an initial selection of the Fiware4Industry Specific Enablers in the view to make them available to COMPOSITION, as well as the Industrial Space Data project, identifying useful components to be part of the architecture of COMPOSITION. Taking into consideration the information provided by the Use Cases and the COMPOSITION architecture, an initial selection has been achieved.

In addition the deliverable also covers the initial actions carried out with other FoF-11 projects addressing the liaison and co-operation activities among them, which will contribute to platform building in Digital automation.

In a second iteration of the D7.1, once all FoF-11 projects have their final architecture defined and the different components that make up these identified, a new assessment of these components will be made, refining the initial selection of components and made definitive.

The results obtained in this Task will be taking into consideration and used as inputs for the future improvements in the final COMPOSITON Platform Architecture.

2 Abbreviations and Acronyms

Acronym	Meaning
RAMI 4.0	Reference Architectural Model Industrie 4.0
GE	FIWARE Generic Enabler
SE	Specific Enabler
FoF	Factories of the Future
EFFRA	European Factory of the Future Research Association
SF	Smart Factories
DF	Digital Factories
VF	Virtual Factories
API	Application Program Interface

3 Introduction

The aim of the deliverable is to perform an initial analysis and selection of components available in the FITMAN (from here 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.

The analysis has been done based on public information located on the Internet (assessment based on Open Specifications, on the FITMAN Specific Enablers Technical Roadmap and online webinars), as well as with some interactions with members of those projects.

3.1 Purpose, context and scope of this deliverable

This deliverable comprises an initial assessment of existing results coming from related projects, to identify which ones are interested to be reused in COMPOSITION. This assessment is done in terms of functionality provided, technology, license, status, etc. taking into consideration the information provided by the Use Cases and the COMPOSITION architecture. Up to now, this initial evaluation has been done on finished projects, but it is important to anticipate that most of the projects considered in the final survey will be other FoF-11 projects. 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.

3.2 Content and structure of this deliverable

The document is structured in four chapters, the first two focus on the FITMAN and Industrial Data Space projects, where an introduction of these projects and the components analysis is made. A third chapter focus on the cooperative actions with other projects of the FoF-16 call, which describes the actions carried out, and finally the last chapter where conclusions and future work is presented.

Following, it is given a brief description of the content of the different main chapters:

Chapter 1 - “Fiware4Industry”: This section describes the FITMAN project, the different reference architectures defined in it and an explanation of the different components (Specific Enablers), together with a list of their main features, which can be useful for COMPOSITION project.

Chapter 2 - “Industrial Data Space”: Same as the previous chapter but focused on the Industrial Data Space Project.

Chapter 3 - “Initiatives on Smart Industry and Collaborative Manufacturing and Logistics”: In this chapter the actions carried out in the different cooperation workshops held to date are presented, and information regarding the delivered report by the FoF-11 CSA Connected Factories.

Chapter 4 - “Conclusions and Future Outlook”: In this chapter the initial selection of identified components that can fit in the COMPOSITION architecture and also future activities in the context of the task 7.1 can be found.

4 FITMAN (Fiware4Industry)

The FITMAN project "FUTURE INTERNET TECHNOLOGIES FOR MANUFACTURING" is a FI-PPP Use Case project of Phase 2, which began in April 2013 (http://www.fitman-fi.eu/). One of the main objectives of the FITMAN project was to assess the suitability, openness and flexibility of FIWARE Generic Enablers in the context of manufacturing. To this end, firstly subsets of GEs from the FIWARE Core Platform were selected. This selection process was based on functional requirements coming from the ten FITMAN industrial trials and on a careful technical assessment of the GE's Open Specifications as available between April/December 2013. A preliminary experimentation of the existing reference implementations (installation, configuration, UI/API walkthrough) also contributed to the selection criteria. The final result of this process was a portfolio of 26 GEs, identified as the FIWARE Generic Enabler final selection for FITMAN. As an added value with respect to the generic Core Platform, FITMAN developed its own set of software assets called Specific Enablers, addressing needs and requirements specific to the manufacturing area.

For this purpose FITMAN provided the FI PPP Programme with 10 industry-led use case trials in several manufacturing sectors: automotive, aeronautics, white goods, furniture, textile/clothing, LED lighting, plastic, construction and manufacturing assets management with the ultimate goal to facilitate a wider adoption of FI PPP technologies by European manufacturing industries, by lowering the barriers for industry and particularly SMEs to access advanced ICT solutions to support the competitiveness of their business processes.

In order to merge these two threads, the identification and selection of FIWARE GEs together with the development of Specific Enablers, into reusable assets, three FITMAN Reference Architectures were designed by assembling some of these building blocks (GEs + SEs) into "baseline platforms", each one targeted at a specific manufacturing domain as envisioned by the European Factories of the Future Research Association (EFFRA):

- Smart Factory that focuses on agile manufacturing, process automation control, and tools for sustainable manufacturing;
- Digital Factory in which ICT is focused on improving the design of production and manufacturing systems, the product life cycle management;
- Virtual Factory that addresses supply chain management, product-service linkage and management of distributed manufacturing.

Each baseline platform is aimed at fulfilling a series of generic requirements that are intrinsic to its domain and, as the name implies, is intended as the baseline for more targeted ICT platforms to be custom-built in specific environments. Finally, a fourth Reference Architecture - called Industrial IoT - was been devised as synthesis and extension of the previous three, taking into account new knowledge gathered during the integration of and experimentation undertaken with some of FITMAN's largest trials.

FITMAN reference architecture, based on Future Internet technologies, for each of the three manufacturing domains identified by the EFFRA (European Factory of the Future Research Association):

4.1 Smart Factory Domain

The main objective of the components in this domain is the support of development of shop floor intelligence enhancing physical processes. Therefore, these components aim at enhancing physical processes and at enabling a more efficient, flexible and safe shop floor by supporting machine-vs-machine and human-vs-machine convergence. It builds on top of FIWARE's Internet-of-Things (IoT) Service Enablement Chapter. Four FITMAN SEs have been added to the five GEs selected from the FIWARE Core Platform, extending the data capture mechanisms of the IoT Chapter to RFID tags and to wireless sensor networks (SDC - Shop floor Data Collection), improving its event distribution mechanism (SEM - Secure Event Management), enabling complex real-time processing of the shop-floor events (DyCEP - Dynamic Complex Event Processing) and improving visualization mechanisms (DyVisual - Dynamic Visualisation and Interaction). Below is a diagram showing the relationship between these collaborating components.

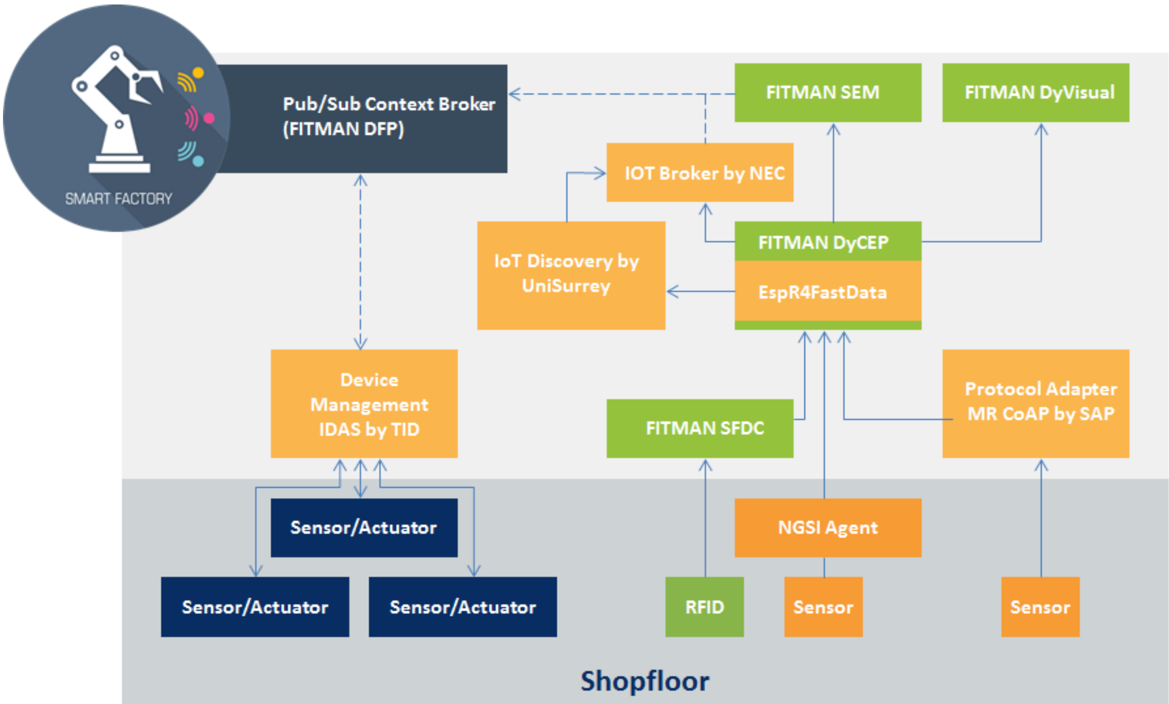

Figure 1. FITMAN Smart Factory Domain Reference Architecture.

The Specific Enablers assessed in this manufacturing domain and their functionalities are the following ones:

- **Shop floor Data Collection** (SFDC) is dedicated for the collection of data from the shop floor. At the same time this specific enabler also decouples the event producers from the event consumers to provide flexibility in the processing of production data and the dispatching mechanism of the events, possible through specific added-value event processing engines like “Secure event Management” which might be used in the scenario of FITMAN.

- **Secure Event Management** (SEM) provides asynchronous and fire-and-forget communication functions to collect event’s related data, typically from the shop floor, and dispatch them in a controlled way to interested applications and services.

- **Dynamic CEP** (DyCEP) enables complex real-time processing of the shop-floor events and other events relevant for manufacturing process (e.g. from MES). This SE is based on FIWARE GE Esper4FastData.

- **Dynamic Visualization and Interaction** (DyVisual) complements the DyCEP by providing visualisation and synchronisation functionality for different clients, in particular web clients. Triggered by the DyCEP SE, the visualisation updates 3D scene content on connected clients.

SFDC Powered by FITMAN DyCEP DyVisual SEM

4.2 Digital Factory Domain

The Digital Platform reference architecture organises the FIWARE assets to support the development of knowledge-based manufacturing processes aiming at improving the time-to-product and time-to-market of products and services, by managing more efficiently the product life-cycle information from heterogeneous sources (ERP, social networks, CRM, PLM). It wires together three GEs from two different FIWARE Chapters: Apps and Data/Context Management.

The Digital Platform targets product lifecycle management by introducing a continuous knowledge gathering process from sources which are typically external to the factory. It wires together three GEs from two different FIWARE Chapters: Apps and Data/Context Management. These basic components provide generic UI and event subscription services on the one side, and analysis of RSS data feeds on the other. This simple architecture is augmented by means of four FITMAN SEs:

- Anlzer – Unstructured and Social Data Analytics, which adds the capability of pulling user-generated content from web sites and social networks, and pushing it through the analysis / notification / presentation pipeline as a RSS data feed, turning user-generated content into useful knowledge (e.g., sentiment analysis) for manufacturing stakeholders.
- SEMed, offering semantics and virtual interoperability for the product lifecycle data.
- 3DScan, which provides modules for 3D Visualisation of high density/high resolution files consisting of millions of points in the format of point clouds and Mesh.
- C3DWV - Collaborative 3D Web Viewer, supporting the visualization of 3D models in and easy way (through web browsers).

The diagram below shows how these components are interlinked.

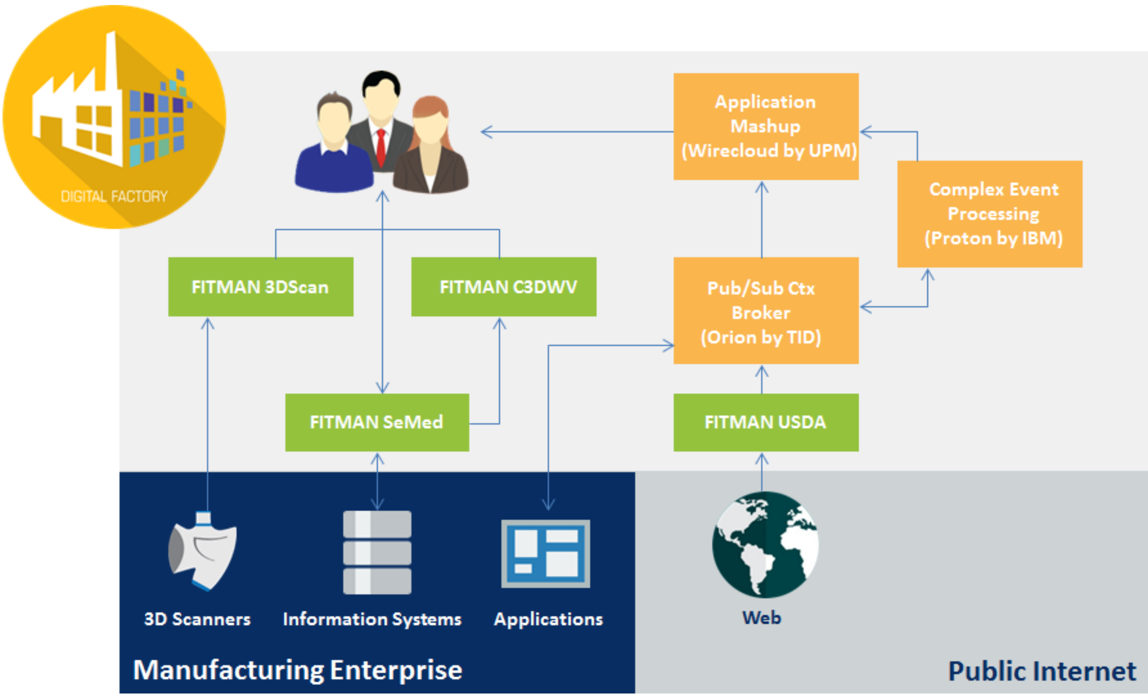

Figure 2. FITMAN Digital Factory Domain Reference Architecture.

The Specific Enablers assessed in this manufacturing domain and their functionalities are the following ones:

- **Collaborative 3D Web Viewer** is a framework for developing web applications with which elements of 3D scenes can be arranged and enriched with metadata. It is collaborative in the sense that multiple users are able to see and interact with the same scene at the same time. It is modular because it's easy to assemble customized applications with the building blocks of the framework, and that it is easy to extend the metadata model to accommodate a given usage scenario. Its main usage scenario is prototypical layouting (one might also say simulation) of a scene.

- **3DScan** offers comprehensive modules for 3D Visualisation of high density/high resolution files consisting of millions of points in the format of point clouds and Mesh. Additionally, it provides the management interface for 3D file storage with a relational database. There are two open source components provided by the Specific Enabler: storage and visualization. For the visualization part, it could work with an optical 3D non-contact scanning sensor of which output are displayed in the web viewer. Regarding the storage component, there are several options related with databases.

- **SEMed** is a mature middleware layer for semantic, virtual interoperability and integration specifically of item-level product lifecycle data. It facilitates a standards-based access to PLM data, for example through its support for the Open Group QLM Standard Open Messaging Interface (O-MI) and Open Data Format (O-DF). At the same time, it provides semantic interoperability for different kinds of common data sources like databases and file based repositories. It introduces a layer of semantics on top of existing syntactic data structure descriptions to avoid semantic integration conflicts and allows a scalable, efficient and comfortable interoperability of product data across all of the stakeholders and IT systems involved in digital factories.

- **Unstructured Social Data Analytics** (Anlzer) is a web platform that aims to extract unstructured data from selected social media platforms and turn such user-generated content to knowledge to be used for the benefit of any manufacturing stakeholder. Its functionalities indicatively include: the automated data retrieval based on predefined user settings, the filtering and cleaning of relevant information, the application of opinion mining and trend analysis techniques (based on Support Vector Machines) and the presentation of emerging topics, sentiments and trends in intuitive and interactive reports. Upon analysing the gathered information for every query, the Anlzer SE visualizes the topics identified while providing a trending timeline and the sentiment tag for every topic which has been tracked. The user may also save the queries that have been executed, in order to revisit / review the results whenever needed.

COLLABORATIVE 3D WEB VIEWER POWERED BY FITMAN | 3D Scan Powered by FITMAN | SEMed Powered by FITMAN | Anlzer powered by FITMAN

4.3 Virtual Factory Domain

The Virtual Platform reference architecture extends the "classic" supply chain processes with more advanced features, such as cloud manufacturing and digital marketplaces, targeted at distributed organizations and virtual enterprises. The Virtual Platform brings the business ecosystem framework from FIWARE's Apps Chapter into the manufacturing domain: six GEs, dealing with enterprise collaboration / interoperability and with digital asset sharing are the foundation of a higher-level software layer, which addresses a variety of use cases. In this layer each FITMAN SE has its own specific scope and responsibility:

- CAM – Collaborative Assets Management is a platform for the virtualization and management of digital virtualized assets in the scope of service-oriented Manufacturing Ecosystems.
- SCApp – Supply Chain & Business Ecosystem Apps is a web-based application for exploiting digital assets in the context of capacity scheduling and team building processes.
- CBPM – Collaborative Business Process Management is a web-based design and execution environment for semantically-annotated business processes.

- DIPS – Data Interoperability Platform Services is a platform, based on open standards like WSMO and WSMX, supporting semantic-based web service interoperability.
- SeMa – Metadata and Ontologies Semantic Matching is a desktop application which helps users define conceptual mappings (i.e., translations) between different OWL-based ontologies and XML schemas. The connections between all of these components are highlighted in the diagram below.
- GeToVa - Generation and Transformation of Virtualized Assets, helping with the management of virtualized intangible assets with semantic support.
- MoVA - advanced Management of Virtualized Assets, giving support with virtual representations of tangible and intangible assets within Manufacturing Ecosystems.

The diagram below shows how these components are interlinked.

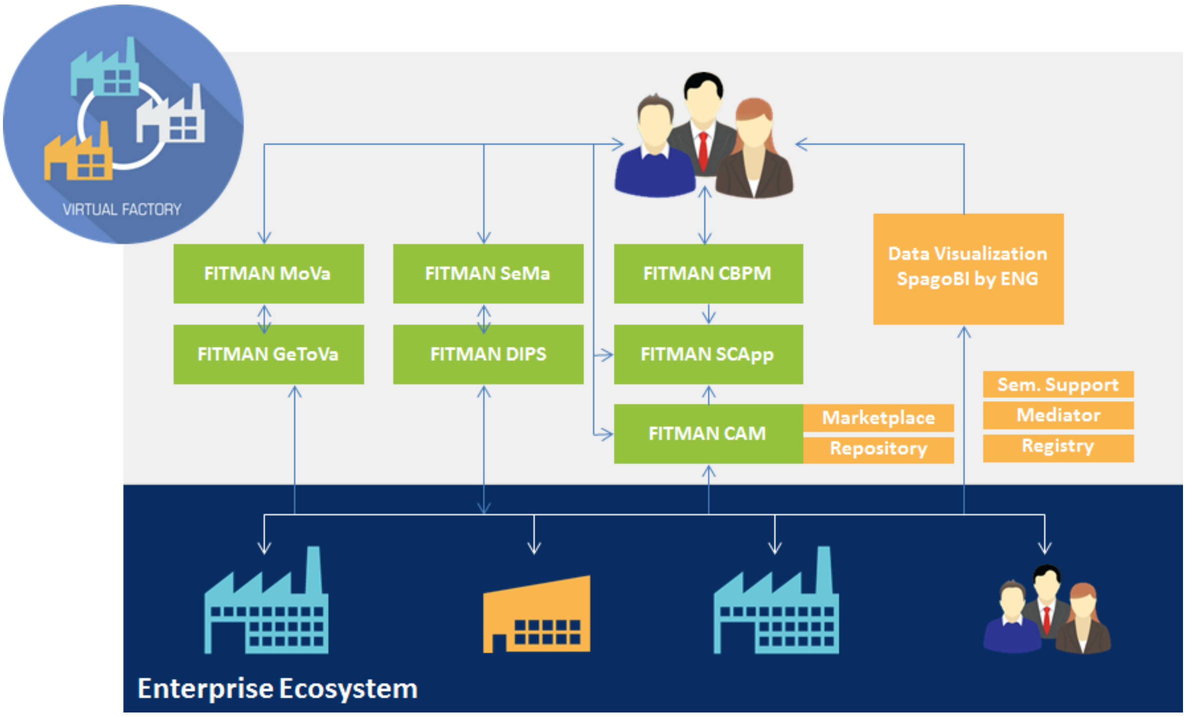

Figure 3. FITMAN Virtual Factory Domain Reference Architecture.

The Specific Enablers assessed in this Domain and their functionalities are the following ones:

- **Metadata and Ontologies Semantic Matching** (SeMa) is offered as an infrastructure containing installable software which supports users through the provision of an infrastructure which will allow the semi-automatic matching of different ontologies (OWL) and also of different XML schemas (XSD). To achieve efficient semantic matching, a number of different algorithms (ranging from context-dependent, fragment-based, and reuse-oriented matching) are used. The proposed matching is visualized in an intuitive and user-friendly graphical interface that allows for manual alteration and/or completion when needed.

- **Supply Chain & Business Ecosystem Apps** (SCApp) is a web-based application for exploiting ecosystem Tangible and Intangible Assets in relation with application in Collaborative Capacity Scheduling and Team Building. This assets work in strict cooperating with the FITMAN "Collaborative Asset Management" Specific Enabler (CAM), a web-based, integrated platform for the management of Virtualized Assets in the scope of service-oriented Manufacturing Ecosystems. The collaboration among supply chain or business ecosystem partners is a key aspect in order to exploit the potentialities of Virtual Factories. Every time there is a business opportunity, a company should decide to manage it alone or to exploit it with the network partners. To collaborate, it is nevertheless necessary to have information about which partner has the ability to do a task and the availability of resources to accomplish it. Only if the right information about partners is managed, it is possible for a Virtual Factory to quickly and easily involve other subjects in the process.

- **Collaborative Assets Management** (CAM) is a web-based, integrated platform for the management of Virtualized Assets in the scope of service-oriented Manufacturing Ecosystems. Targeted at the Virtual Factory domain, and based on open standards like Resource Description Framework (RDF), Web Ontology Language (OWL2) and Universal Service Description Language (LinkedUSDL), it is delivered as a web portal in order to maximize its collaborative nature.

- **Collaborative Business Process Management** (CBPM) is a web-based, integrated platform for the semantically-enhanced design, execution and monitoring of Business Processes in the scope of service-oriented Manufacturing Ecosystems. Targeted at the Virtual Factory domain, and based on open standards like Business Process Model and Notation (BPMN) 2.0, it is delivered as a web portal in order to maximize its collaborative nature. The development of business process in a formal notation requires multi-disciplinary teams, to share domain specific and ICT knowledge required to implement them. The CBPM simplifies this collaboration allowing a clear separation of concerns, and providing user friendly online tools.

- **Data Interoperability Platform Services** (DIPS) is a web-based platform for the management of Data Interoperability services in the scope of the exploitation of the interoperability service. Targeted at the Virtual Factory domain, and based on open standards like WSMO and WSMX, it is delivered as a web platform in order to maximize its collaborative nature. The interoperability is a key factor for the success in collaboration. Typically, interoperability problems are related to the exchange of information among different companies in a supply chain or in other forms of aggregation like Business Ecosystems. Applicability can be finding as well in information exchange between different parts of the same company or, even, in communication between individuals. At the time companies solves interoperability problems they create a value item that is subsequently used into collaborative business processes in order to execute data interoperability. A typical example of that is the creation of a transformation for a specific business document (e.g.: an invoice) from one standard (e.g.: UBL) to/from a private format.

- **Generation and Transformation of Virtualized Assets (GeToVA)** aiming to support Virtual Factories (VF) in semi-automatic generation and clustering of Virtualized intangible Assets (VAaaS) from real-world semi-structured enterprise and network resources. GeToVA enables as well multi-format ontology transformation between various representations of Virtualized in-/tangible Assets.

- **advanced Management of Virtualized Assets (MoVA)** aiming to support Virtual Factories (VF) in intuitively generating, composing, and transforming virtual representations of in-/tangible assets (VAaaS) within Manufacturing Ecosystems. Design and implementation of an intuitive user-centric graphical interface for dynamic discovery and flexible composition of Virtualized in-/tangible Assets (as a Service) targeting at team building applications as well as advances in production networks;

4.4 Industrial IoT Platform

The Industrial IoT Reference Platform (IoT for Manufacturing - IoT4 Platform) is the synthesis of the three Smart / Digital / Virtual factory domains into one unified Reference Architecture that brings together FIWARE GEs, FITMAN SEs and lessons learned during the development of FITMAN's ten Trial Platforms. Its broader scope addresses complex real-world use cases involving multiple facets of the Manufacturing Enterprise. In particular, new key enabling technologies like Big Data Processing and Machine Learning have been integrated. Shop floor security and IoT-specific issues (e.g., proximity of computation to physical systems) have been addressed by the introduction of a Smart Gateway layer which may play the role of an Edge Node in large scale distributed deployments. The diagram below depicts the relationships between the IoT4M Platform's components.

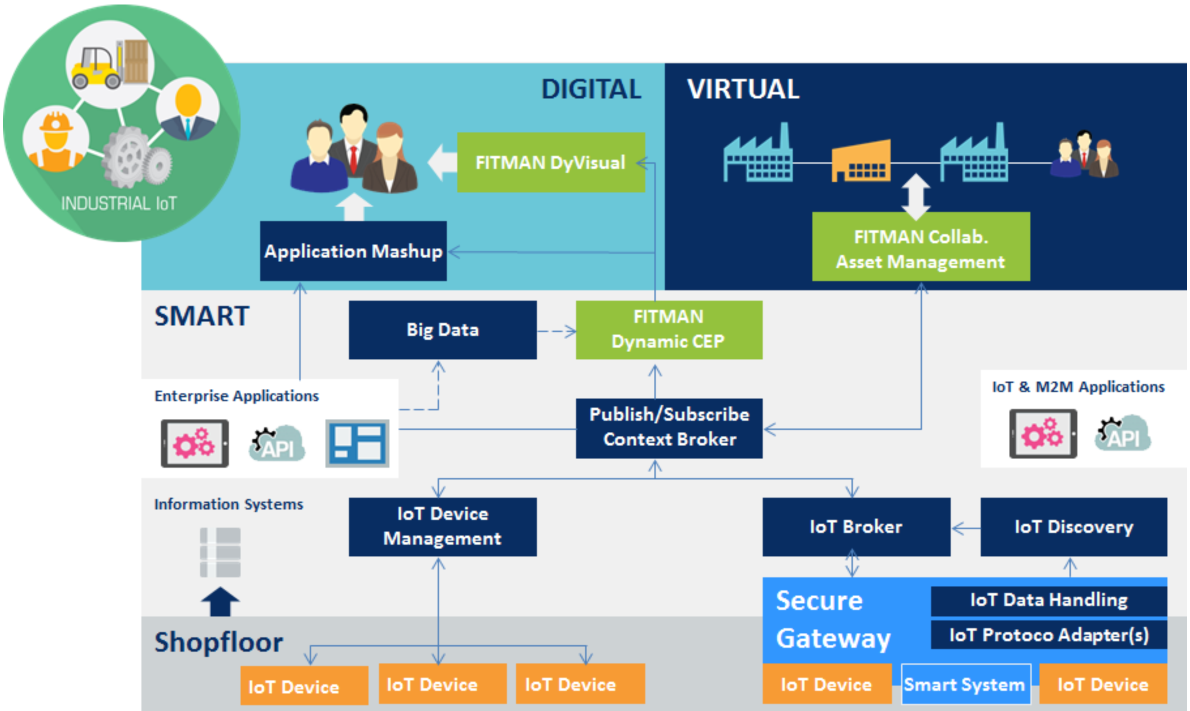

Figure 4. FITMAN Industrial IoT Reference Architecture.

4.5 FITMAN and COMPOSITION

As member of the FIWARE foundation and partner of FITMAN project, ATOS is continuously sharing information between the different teams involved in several projects; either through personal interactions between members of these teams or through specific meetings held for this purpose, with the main objective of identifying and reusing components, allowing an evolution of these, increasing their functionality and adaptability in different contexts.

There are two Specific Enablers which are most closely connected to COMPOSITION, and for which the viability of being part of the final architecture of COMPOSITION will be considered in T2.3 “COMPOSITION Architecture”:

- **DIPS**, who provides Interoperability enhancements, helping Virtual Factories in improving interoperability among network partners reusing knowledge artefacts created in or outside the network minimising the technical effort, and also providing standardized access. In this aspect, the GUI and the CORE can be accessed by users of a distributed organization, such as Virtual Enterprises in the typical Virtual Factory scenario; CORE by SOAP services calls while GUI by human users using browsers. Additionally, it offers support for services consumer. These are supported by the platform in the creation of the semantic goal, the browsing of results and the understanding of the service including: try-me, examples and other functionalities. In

COMPOSITION, the Inter-Factory scenarios can benefit from this component, facilitating the exchange of information in a standardized way.

- **DyCEP** represents a new generation of CEP (Complex Event Processing) systems which support complex real-time processing pipelines, required for IoT applications. Our approach assumes several processing elements which are connected in the way that ensures maximal efficiency of the processing task. This infrastructure is based on the Storm - the architecture for real-time (streaming) data processing. It uses custom created "spouts" and "bolts" to define information sources and manipulations to allow real-time distributed processing of streaming data. DyCEP follows Storm architecture with spout and bolts. There is one spout for receiving data and three bolts for processing data. The functionality provided by this component could be useful for the COMPOSITION project by improving the abilities to identify anomalous operations in some processes contemplated in some use cases, mainly at Boston Scientific (BSL).

Furthermore, in parallel, we are working on the identification of components of COMPOSITION that could become part of the FIWARE Catalogue (https://catalogue.fiware.org), but this is in a very early stage, for several reasons, first because most components of COMPOSITION are only in the specification phase and / or initial prototype and secondly and perhaps the most important that can condition this objective, is that the Generic Enablers must meet a number of specific requirements.

The first and most conditioning is that Generic Enablers (GEs) must offer well-defined APIs, together with their specifications and must be ***public and royalty-free***. Therefore, GEs must have their open source reference implementation, as well as alternative implementations, in order to be part of the FIWARE Reference Architecture. For this, each GE must be aligned and compliant with the FIWARE standards, and the GE owners must provide support to both developers and the bug solution that they report.

Finally, once all these requirements are met, the component must follow a process of acceptance by the FIWARE Foundation.

5 Industrial Data Space

The Industrial Data Space initiative aims to create a virtual data space, which facilitates the secure exchange of data and the connection of data in business ecosystems. The digital sovereignty of data owners is preserved. At the same time, better data exchange enables innovative business models and smart services. It addresses 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 are seen as the connecting piece between industrial production and smart services. The resulting modern data management is depicted in Figure 5.

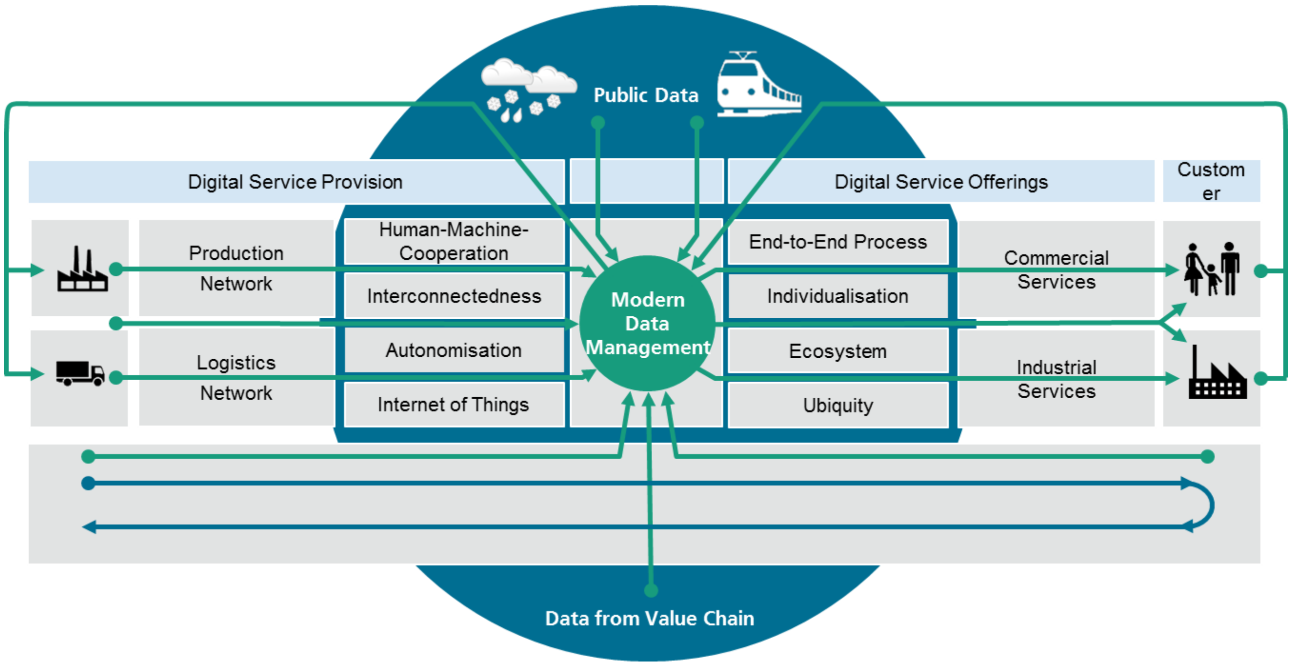

Figure 5. Modern Data Management (Translated from (Otto, et al., 2016))

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 certain use cases. The Industrial Data Space association (in German: "eingetragener Verein") identifies, analyses and assesses end user requirements. The association contributes to the reference architecture development and promotes its standardization.

5.1 Architecture

The Industrial Data Space reference architecture focuses on generalizing concepts for the creation of a secure network of data. It comprises of 5 layers and 3 additional perspectives (Otto, et al., 2017). Within the scope of this deliverable, we discuss only the system layer because this has most similarity to the COMPOSITION architecture.

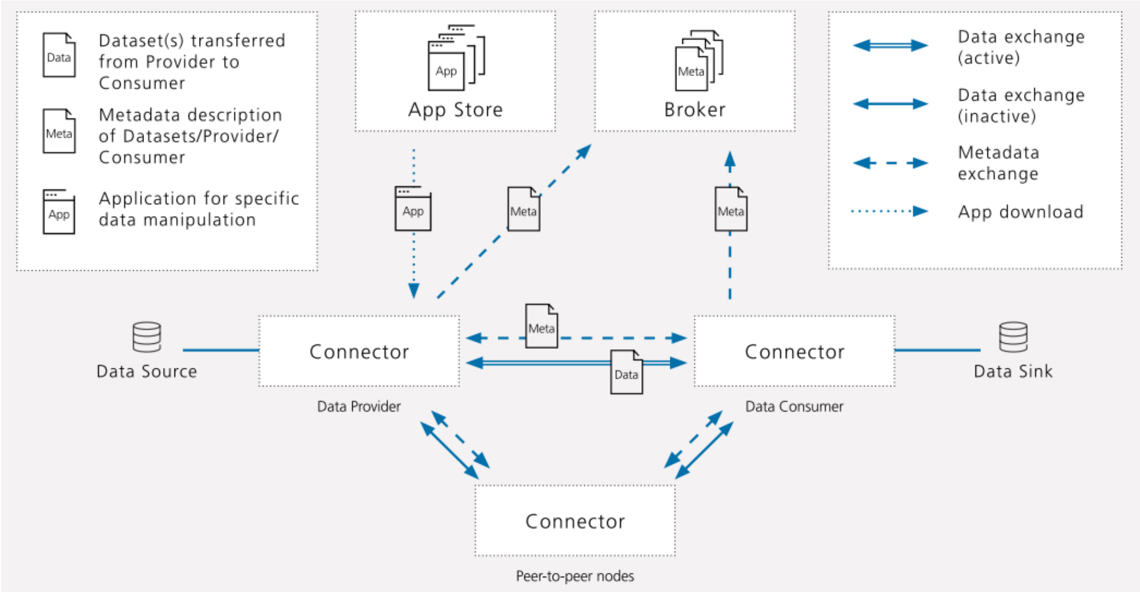

Figure 6. Interaction of components on System Layer (Otto, et al., 2017)

As in COMPOSITION, the Industrial Data Space defines a central entity, which enables stakeholders to connect to the data space (the COMPOSITION equivalent would be the marketplace). In Industrial Data Space, this is the Connector. The Connector is a dedicated communication server, which connects data sources and data sinks with the data space, thus enabling them for data space interaction and exchange. The Connectors also act as nodes in the peer-to-peer architecture of the Industrial Data Space. Hence, the connection way between data sources and data sinks is usually not only made up of only the Connectors that belong to the source or sink.

Metadata are always exchanged before the actual data exchange. This metadata contains syntax and semantics information, information about the data provider and usage information, such as pricing or usage policies. For the normal way of exchanging data, data providers register their metadata at the broker first. A data consumer can use this metadata then 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, 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 between app providers and app users. 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 content in COMPOSITION. This again is the same to 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.

5.2 Industrial Data Space and COMPOSITION

The Industrial Data Space project and the COMPOSITION project are in continuous knowledge exchange. This is mainly done through Fraunhofer FIT since they are member of both projects. Hence, representatives from both projects hold regular meetings in which they update each other about current topics and developments in each project. As a tangible outcome, COMPOSITION and Industrial Data Space generated ideas for use cases, which could be applicable for both projects. These ideas were used as input for the COMPOSITION use case elaboration phase. The ideas are presented in the following.

Stock Information Request

Clients are enabled to request information about suppliers' stock. This would give the clients better predictability and more certainty that their production process is not stopped by running out of supplies. In more detail, clients would only be allowed to request for a specific amount. For example, a request could be: "Do you have 2500 M4 screws in your stock, which are available for sale?" Restricting these requests to an upper limit would prevent access and distribution of critical information.

This service could not only be offered to existing customers. Instead, it would be beneficial for the supplier to offer this as service to all potential customers.

Location Information Request

Similar to what is currently possible for private customers, it would be beneficial for factories to acquire live knowledge about the exact location of their ordered goods. This would increase predictability. In addition, it creates an additional possibility for identifying reasons for delivery delays. Technology wise, supplier trucks need to be equipped with GPS technology. The location of the trucks must be connected with knowledge which goods are carried by the truck. Finally, suppliers can grant access to this information to their customers.

As extension, providers could offer virtual information about the delivery trucks, e.g., the inside temperature of cooling truck or if they are specialized on transporting a particular good.

The information could be transmitted using maps. A base map could be free of charge but every additional information layer could add to the price.

Load Information Supply

Often, supplies require special equipment or people for unpacking, such as forklifts, special ramps, specialists, etc. The problem is that this is often not clear to the customer up to the actual time of delivery. In worst cases, this can lead to having to send the truck back and issuing a new delivery at another time when the equipment was mounted. The idea of this use case is to enable suppliers to inform customers in advance about special requirements for unpacking.

As extension, it would be helpful for the customer to have access to an estimated duration for unpacking.

6 Initiatives on Smart Industry and Collaborative Manufacturing and Logistics

This section focuses on the cooperative activities carried out with other projects of the FoF-11 call, with the aim of exploiting synergies and increasing the impact of the initiative to platform building in Digital Automation. Therefore, joint events identified synergies between projects as how the Reference Architecture Model Industrie 4.0 (RAMI4.0) can be adopted in COMPOSITION.

6.1 FoF-11 Projects Cooperation

The FoF-11-2016 topic focused 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 Connected Factories 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 COMPOSION in this collaboration framework.

6.1.1 FoF-11 Projects Synergies

6.1.1.1 Reference Architecture Model Industrie 4.0 Mapping

In COMPOSITION, the Reference Architectural Model Industrie 4.0 (RAMI 4.0)[1] will be adopted to communicate the scope and design of the system, to further collaboration and integration with other relevant initiatives by framing the developed concepts and technologies in a common model.[2]

The following section provides a short overview of RAMI4.0 and how it has been applied in COMPOSITION to date.

[1] https://www.zvei.org/fileadmin/user_upload/Themen/Industrie_4.0/Das_Referenzarchitekturmodell_RAMI_4.0_und_die_Industrie_4.0-Komponente/pdf/5305_Publikation_GMA_Status_Report_ZVEI_Reference_Architecture_Model.pdf

[2] Pictures in this section copyright "Umsezungsstrategie Industrie 4.0 – Ergebnisbericht, Berlin, April 2015"

6.1.1.1.1 RAMI 4.0 Overview

6.1.1.1.1.1 Background & purpose

RAMI 4.0 is a reference architecture model for Industrial Internet of Things (IIoT). The first version has been developed by the Industrie 4.0 platform and submitted as DIN SPEC 91345. RAMI 4.0 is modelled on Smart Grid Architecture Model (SGAM), IEC 62262, Enterprise-control system integration (IEC62264, 2013) and the IEC 62890 ”Life-cycle management for systems and products used in industrial-process measurement, control and automation” (IEC, 2013). The focus of RAMI 4.0 is on manufacturing, primarily modelling systems for the production process and product life cycle.

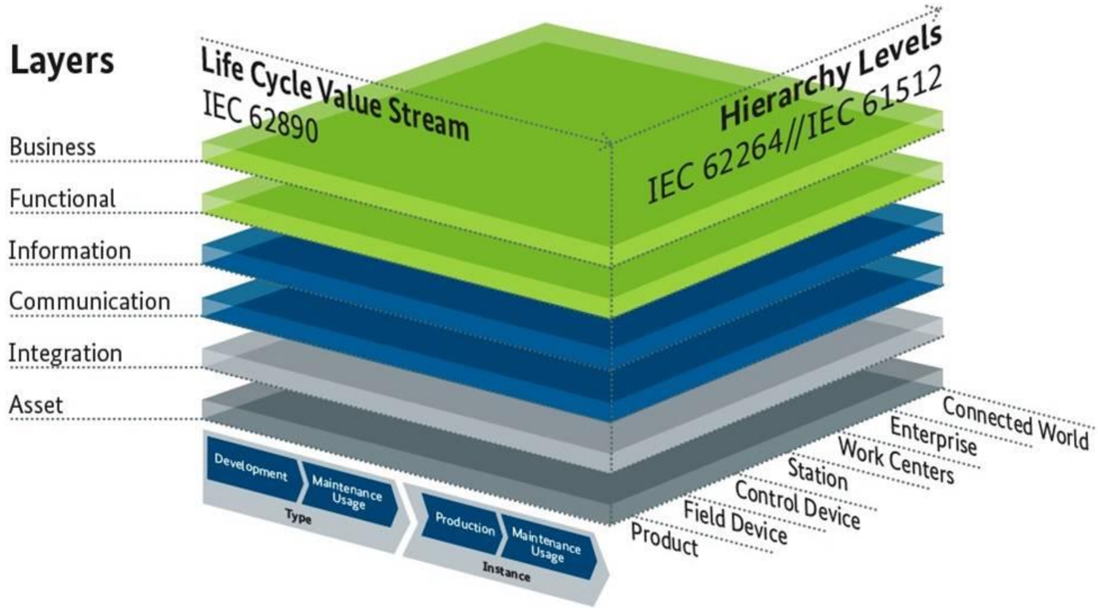

Figure 7. The three dimensions of the RAMI 4.0. (Status Report RAMI 4.0, 2015).

In the three dimensional model, existing standards and architectures and candidate solutions can be plotted and overlaps and gaps can be identified and resolved. It provides a three dimensional map of I4.0 components, solutions and requirements by the three axes IT Layers, Hierarchy Levels and Life Cycle and Value Stream.

The purpose of the reference architecture model is to promote common understanding of different architectures for industry 4.0. It can be used to derive specific architecture models and align existing solutions. Examples of applications are:

- Provide a shared understanding of the function provided by every layer and the defined interfaces between the layers.
- To see where existing and emerging architectures fit in, and allow discussing associations and details of components.
- Identification of overlaps and the scope of preferred solutions.
- Identification of existing standards, closure of gaps and loopholes in standards, minimization of the number of standards involved.
- Identification of use cases for Industry 4.0.

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6.1.1.1.1.2 IT Layers

The six layers on the vertical axis represent a layered IT system structure, with loose coupling between the layers and high cohesion within each layer. The layering is strict; i.e. components in a layer may only communicate internally or with adjacent layers.

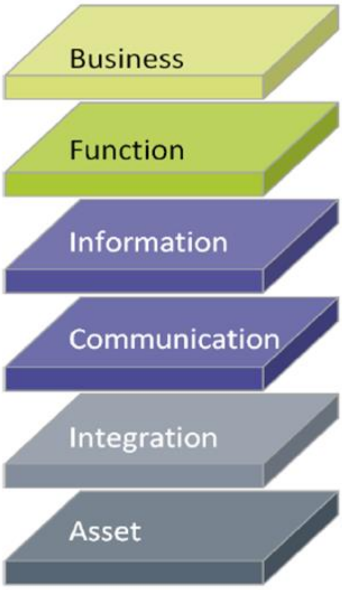

Figure 8. The IT Layers of RAMI 4.0.

Asset Layer

The asset layer spans the physical components of a system; physical things in the real world. E.g. production lines, manufacturing machinery, field devices, products and the humans involved.

Integration Layer

The mapping from the physical world to the digital is performed by the Integration layer, which performs provisioning of information on the assets in a form which can be processed by computer. This involves all digitization of assets, such as connected sensors and other field devices, but also Human Machine Interfaces (HMI).

Communication Layer

The Communication Layer performs transmission of data and files. It standardizes the communication from the Integration Layer, providing uniform data formats, protocols and interfaces in the direction of the Information Layer. It also provisions the services for controlling the Integration Layer.

Information Layer

In the Information Layer, data and events are processed, integrated and persisted. This layer ensures the integrity of data, performs message translation and annotation and manages data persistence. It provides the service interfaces to access structured data from the Functional Layer and applies event rules and transformation of event to the models and formats used in that layer. This is the run-time environment for Complex Event Processing (CEP), data APIs and data persistence mechanisms.

Function Layer

The Function Layer is the primary location of rules and decision-making logic and contains the formal descriptions of functions and service models. It is the run time environment for applications and services that support the business processes.

Business Layer

The services provided by the Functional Layer are orchestrated by the Business Layer. It maps the services to the business (domain) model and the business process models. It also models the business rules, legal and regulatory constraints of the system. The Business Layers receives events that advance, link and integrate the business processes.

6.1.1.1.1.3 Hierarchy Levels

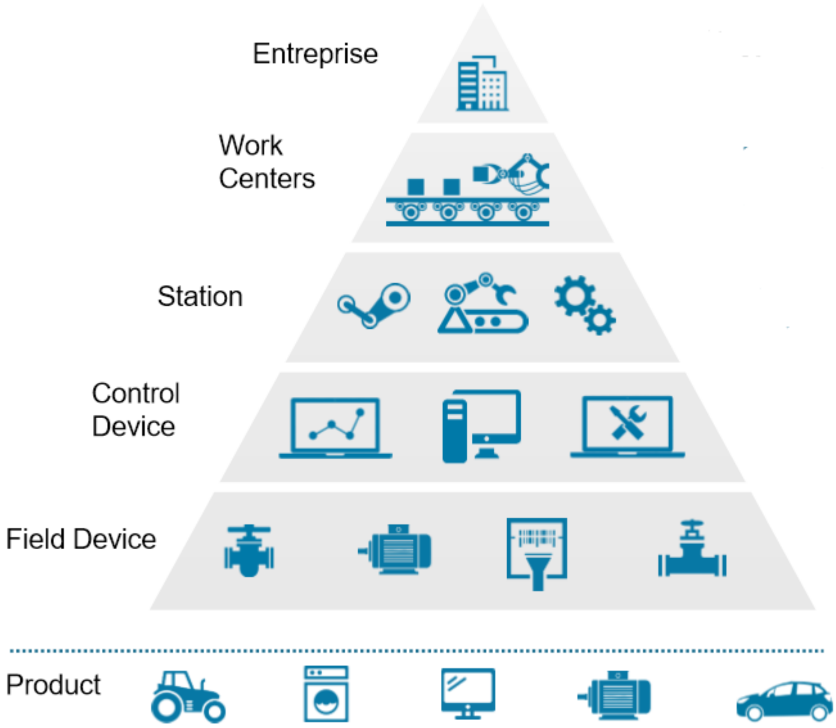

Figure 9. Hierarchy Levels of RAMI 4.0 (Status Report RAMI 4.0, 2015).

The right horizontal axis represents a hierarchy of different functionalities within factories or facilities. The ones shown in the pyramid in Figure 9, from "field device" to "enterprise" are derived from the IEC 62264 (IEC62264, 2013) international standards series for enterprise IT and control systems. The standard originated by modelling "wired" connections between functions performed by hardware in the factory, but today the functions are implemented in software. To represent the Industry 4.0 environment, the functionalities of IEC 62264 have been expanded to include workpieces, labelled “Product” (both the type and the instance, through the entire lifecycle), and the connection to the Internet of Things and Services, labelled “Connected World”. The "Connected World" involves the manufacturing ecosystem: groups of factories, collaborations with external engineering firms, component suppliers and customers.

6.1.1.1.1.4 Life Cycle and Value Stream

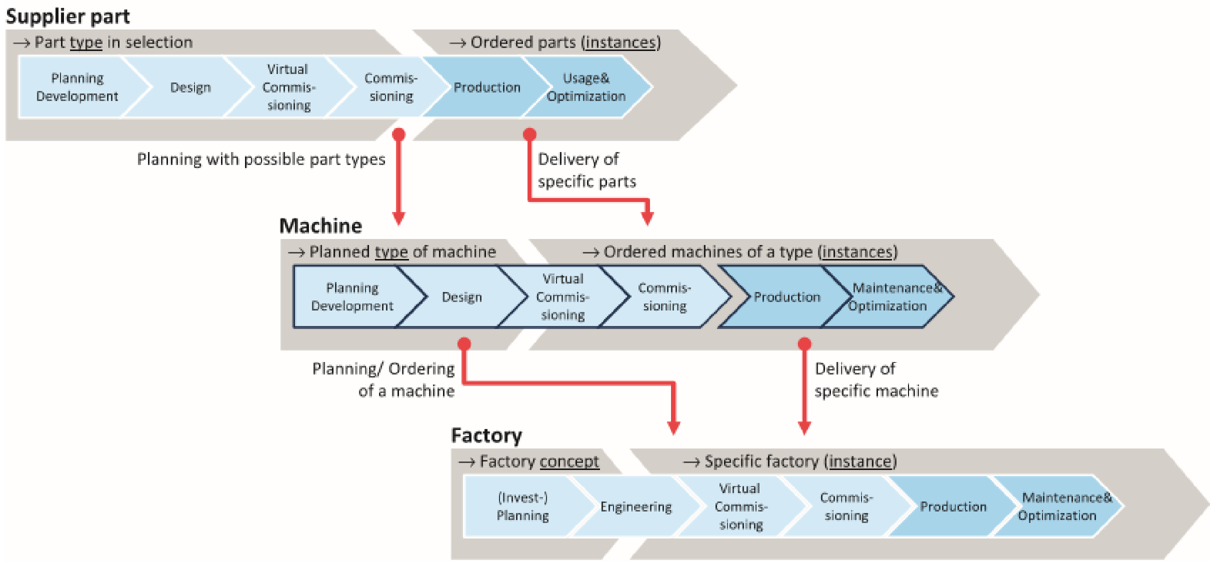

Figure 10. Type and instance lifecycles in RAMI 4.0 (Status Report RAMI 4.0, 2015).

The left horizontal axis in RAMI 4.0 represents the life cycle of facilities and products, based on the IEC 62890 (IEC, 2013). Distinction is made between types and instances; design and prototyping involve types, and each actual product being manufactured is an instance of this type.

As illustrated by Figure 10, this life cycle and value stream does not only cover the planning, design, production and maintenance of parts and products, but also types and instances of production equipment and factories.

6.1.1.1.1.5 Industrie 4.0 Component Administrative shell

An I4.0 component is the digitization of assets in the manufacturing process: it can be a factory, a production system, an individual station, or an assembly inside a machine. It consists of one or more assets and an administrative shell. The administrative shell is the virtual representation of an asset. The manifest of the administration shell describes the data provided by the asset and the resource manager provides access to the data and functionality of the asset. The I4.0 component is located within the layers of RAMI 4.0, up to the Functional Layer. It can adopt various positions in the life cycle and value stream, and occupy various hierarchical levels.

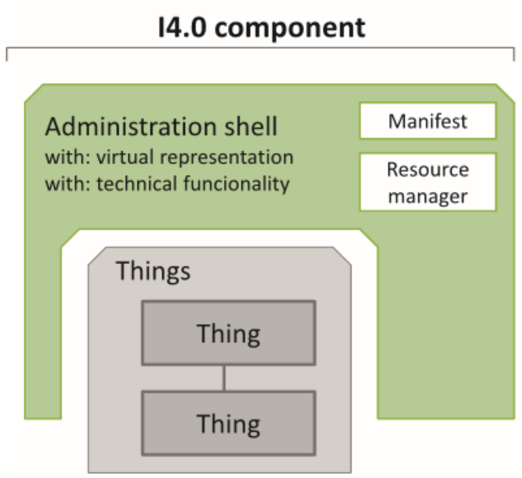

Figure 11. The I4.0 component (Status Report RAMI 4.0, 2015).

An asset may have several administration shells for different purposes and aspects of the manufacturing process. I4.0 components may be nested and accessed directly of as part of the implementation of the services of another I4.0 component. The administrative shell may be deployed in the run-time environment of the asset – if it possesses the necessary computational capabilities – or remotely, e.g. in a cloud environment.

6.1.1.1.2 Mapping of COMPOSITION functional packages

A mapping of the functional packages in the first iteration of the COMPOSITION system to RAMI 4.0 Layers can be seen in Figure 12. The Integration Layer packages map the assets and HMI input to administrative shells and forwards the data to the communication layer, where the broker forwards the information in a standardized format to the recipients in a secure manner, using the requested communication pattern. The information layer packages handle the annotation and translation of events and the generation of new events from rules and trained ANNs (Artificial Neural Networks) is also performed in this layer. The functional layer provides forecasting, decision support and other functionality which is orchestrated into business processes for e.g. compliance monitoring, machine failure prediction and material location tracking. (The security package is integrated in each layer and is drawn as spanning all layers – this in not to imply that the strict layering is not applied.) This diagram is expected to evolve further over the duration of the project.

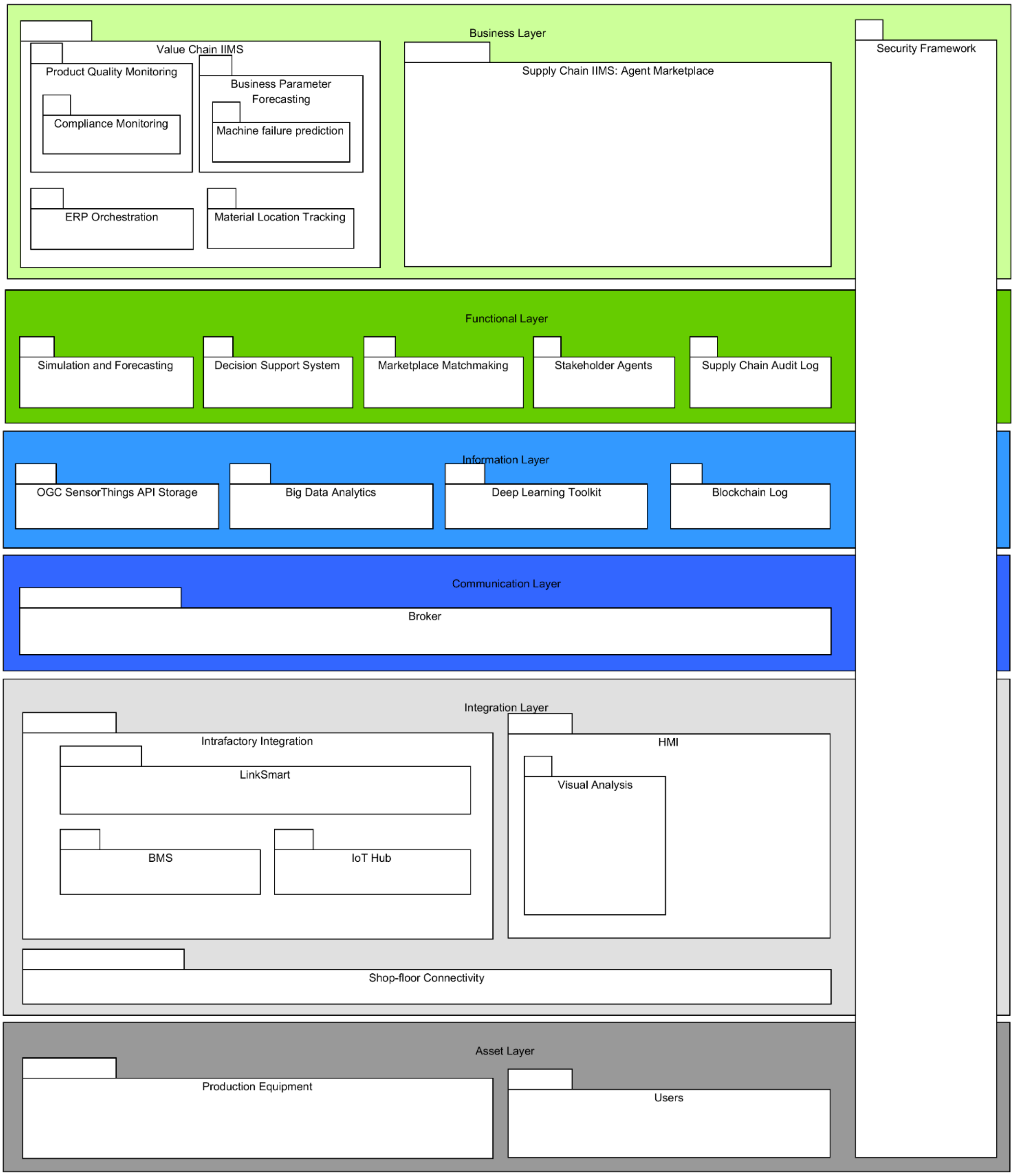

Figure 12. A mapping of COMPOSITION functional packages to the RAMI 4.0 Layers.

The COMPOSITION system scope and pilots cover the intra-factory functionality from "Field Device" to "Work Center" via the IIMS and has a special emphasis on the inter-factory ecosystem of the "Connected World", provided by the interoperable agent-based marketplace and the blockchain-based log-oriented architecture, providing secure and trusted exchange of supply chain data between independent parties.

Life cycles of both types and instances of products and machines is covered by COMPOSITION, where complex pattern detection, deep learning networks and simulation capabilities may be used both for operational management and continuous improvement of factory equipment and products.

Administrative shells for the production assets are implemented at multiple levels in the COMPOSITION system. The Intra-factory Integration provides administrative shells for the connected assets. More complex administrative shells for production lines are implemented inside the IIMS using other components such as the Big Data Analytics, Decision Support System or Simulation and Forecasting Tool. The I4.0 components will be layered on top of each other and more than one administrative shell may exist for the same asset or combination of assets. Further work will be performed to align the configuration of a COMPOSITION system instance with the concept of I4.0 components.

6.1.1.2 EFFRA Innovation Portal

EFFRA has implemented what it is called the EFFRA Innovation Portal (https://portal.effra.eu/projects) the main goal of this portal is to share information among projects. All FoF-11 projects listed in table 1 will 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.

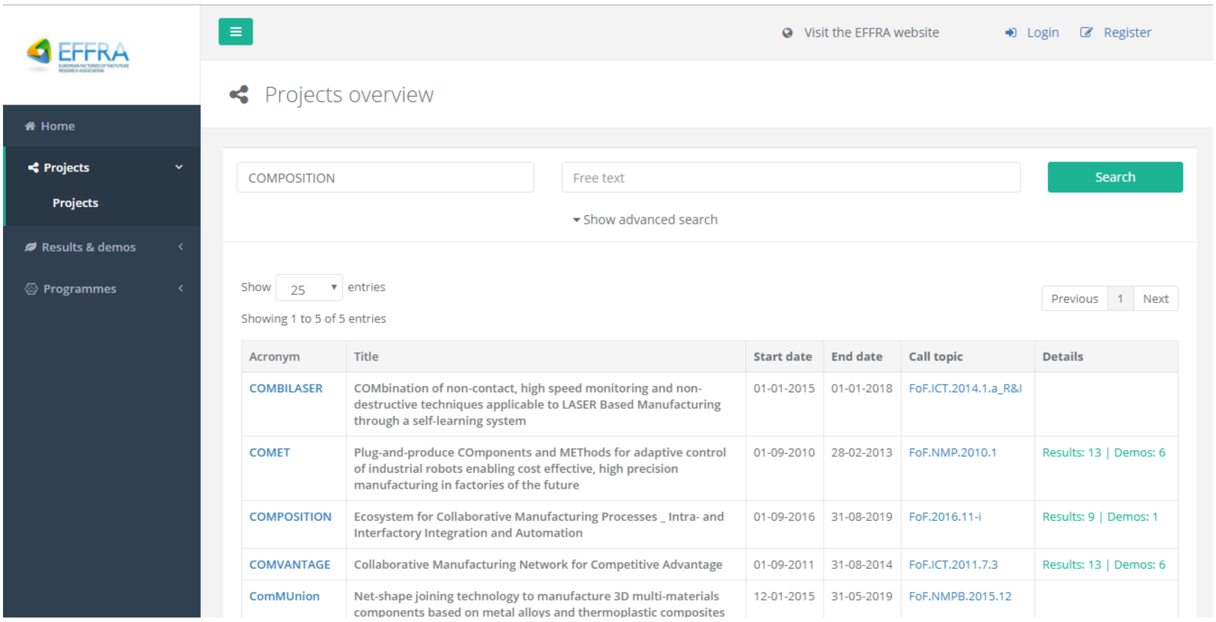

Figure 13. EFFRA search results

The ***essentials*** of the project include the website, duration, start date, end date, participants, budget and public summary. On top of this introductory information, the results that have already been publically published by the consortium 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***, in whatever form they may become available, as COMPOSITION progresses.

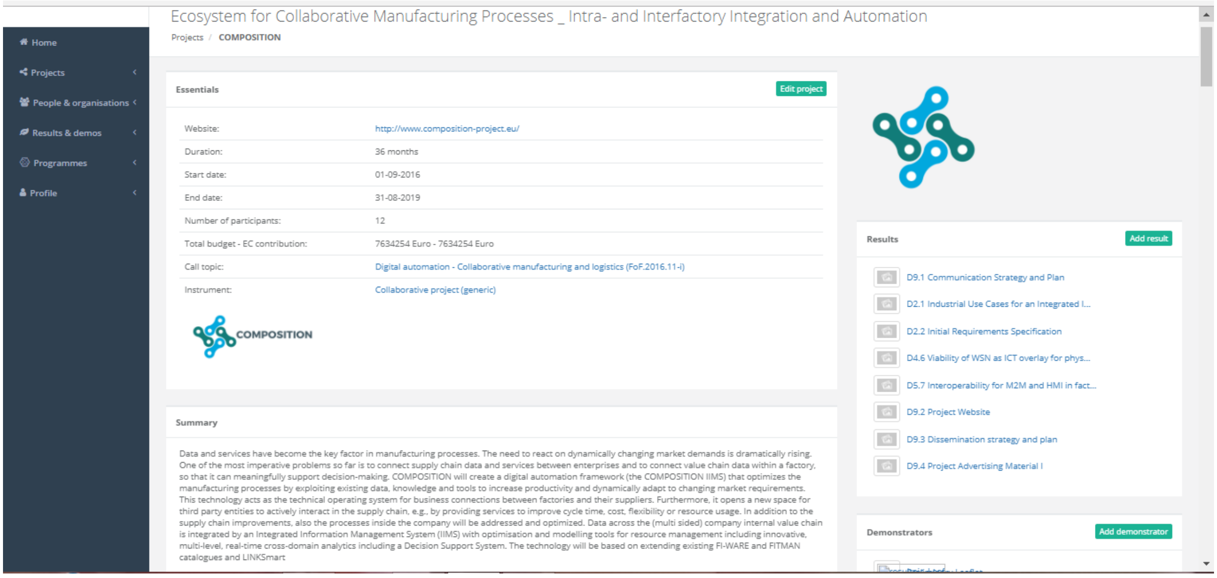

Figure 14. COMPOSITION Introductory information

The essentials of the project are followed by its ***Characteristics***. It should be mentioned that at the moment the information available in the characteristics part are an essential take and that it will be updated as the project advances in collaboration with the responsible each time partners. The first 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").

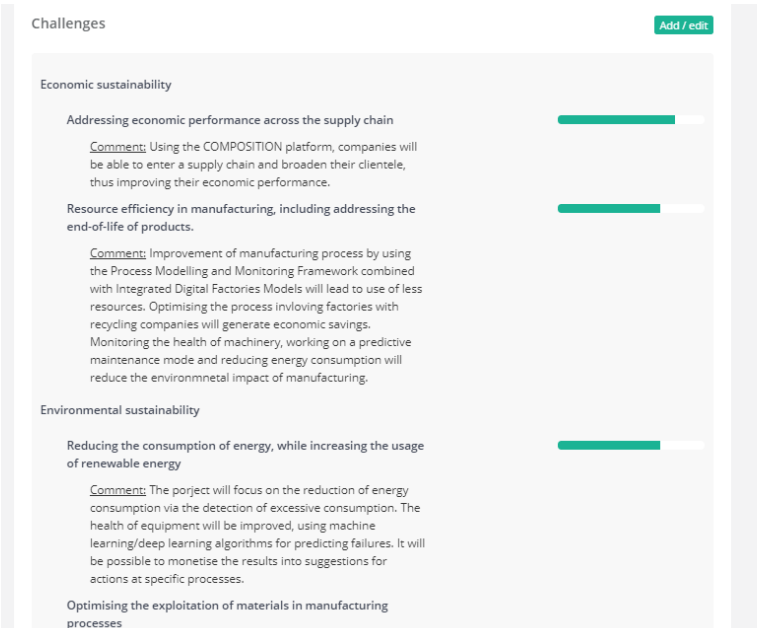

Figure 15. COMPOSITION Challenges section

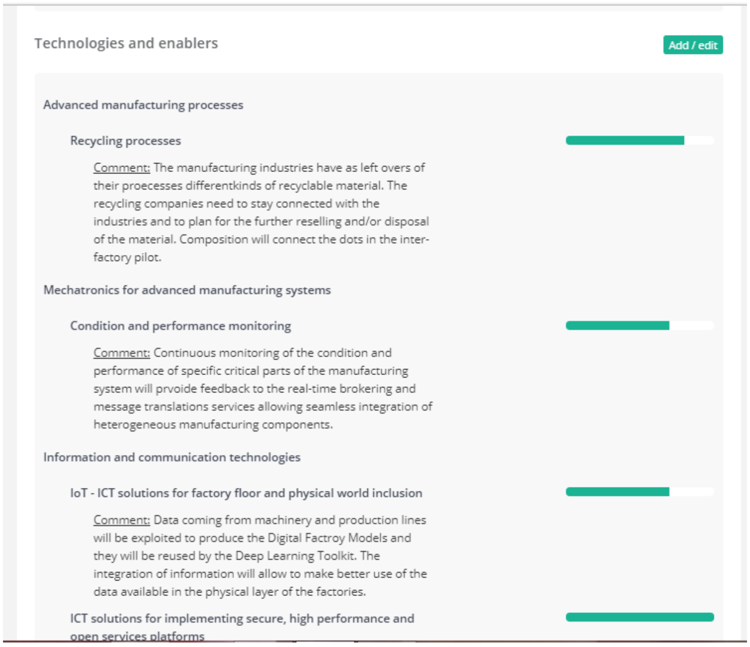

Figure 16. COMPOSITION Technologies and enablers section

In the next part, the ***Technologies and enablers*** used in the COMPOSITION project are presented and described. The six (6) 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”.

Following is the ***Digital Mapping framework***, that EFFRA itself is very keen on, as it allows to map projects steming from different calls and sectors in a unified manner. In this segment of the portal, information has been made available on seven (7) 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”.

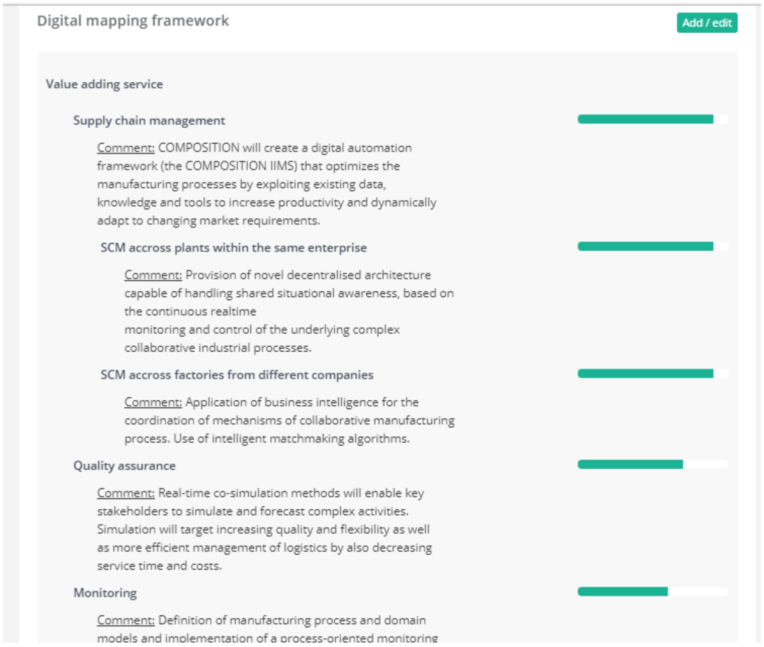

Figure 17. COMPOSITION Digital mapping framework section

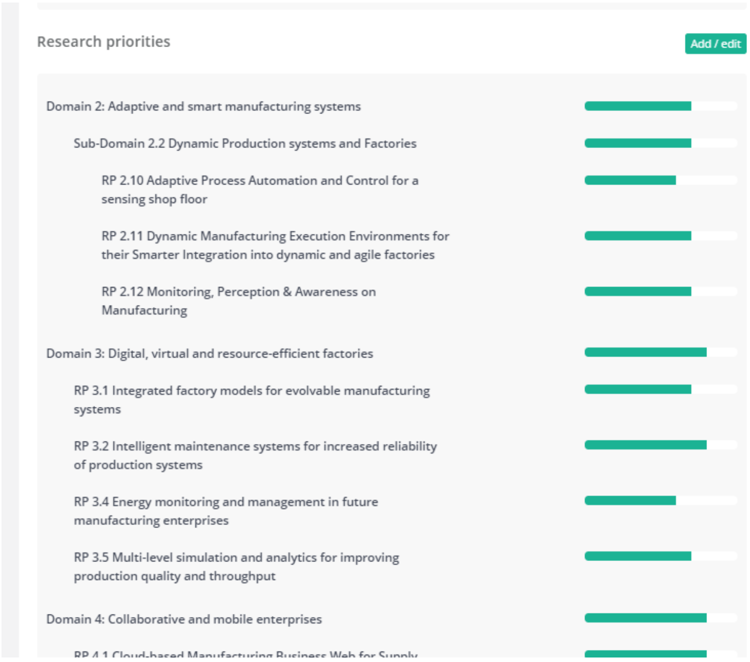

Figure 18. COMPOSITION Research priorities section

Additionally, the project is described as active in four (4) specific domains of ***Research priorities***. The partners are devoted to conduct research on "Adaptive and smart manufacturing systems", "Digital, virtual and resource-efficient factories", "Collaborative and mobile enterprises" and "Human-centric manufacturing".

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

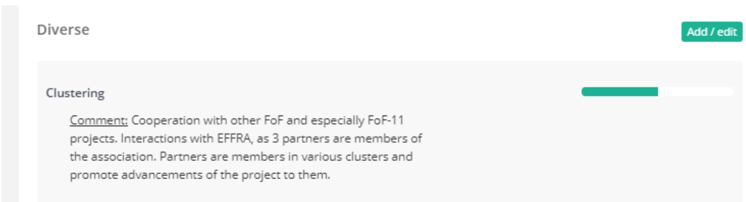

Figure 19. COMPOSITION Diverse section

At this point it is suitable to mention that 3 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 will be continuously revisited throughout the lifetime of COMPOSITION.

6.1.2 Workshops and Joint Events

The COMPOSITION project participated actively in several workshops and joint events with the other FoF-11 projects. During the workshops, several results were jointly produced. During this period, several Workshops have been held:

- **24th May 2017** in Brussels - Pre-Workshop of FoF-11 projects

  The first workshop in this series started even before one of the funded projects was started. It was meant to put the FoF-11 projects into contact as early as possible in order to initiate collaboration. The goal was to align on cooperation on platform building and to identify cross-cutting issues and clusters.

The workshop was organized by the European Commission, DG CONNECT, unit: Complex Systems & Advanced Computing in cooperation with EFFRA. The organizers gave an overview of activities in research and industries regarding platforms for the manufacturing area.

COMPOSITION participated with both, coordinator and technical coordinator from FIT, respectively CNET. Each project presented itself in a short talk, after which the participants tried to identify topics for clustering in self-organizing group discussions.

As outcome of the workshop, a common task on collaboration on platform building and cooperation with the CSA project Connected Factories was added to the DoA of each FoF-11 project. Since COMPOSITION had already included a similar task about interaction with external initiatives (T7.1), we added this as subtask 7.1.1 - Collaboration with other FoF-11 projects.

- **13th October 2017** in Brussels – Kick-off Meeting

  In this workshop all FoF-11 projects were invited to present a brief description of their project and an initial mapping of the COMPOSITION outcomes was done using the RAMI architecture.

  The workshop was organised by EFFRA as leader of the Connected Factories CSA.

  EFFRA collected all the inputs from the different projects to be used in first population of the Innovation Portal.

- **16th May 2017 -** FoF-11 projects workshop at Brussels. (EFFRA)

  During the 1st Factories of the Future Community Day by EFFRA, which was mainly a one-way event, i.e. a whole-day sequence of 10-min pitches from the different projects, with little/no time for questions / discussions some slides about COMPOSITION project were presented.

  Additionally, the European Commission organized an 'Impact workshop' on 17 May, where all projects were invited.

- **27th - 29th June 2017** - ICE/IEEE ITM: 23rd International Conference on Engineering , Technology and Innovation in Madeira Island – Portugal

  (promoted by the vf-os project) http://www.ice-conference.org/

  There was a FoF-11-2016 cluster workshop - "Factories of the Future: Engineering, Technology & Innovation Management Beyond 2020". Attended by Arian Zwegers, representing the EC FoF-11 A2 Unit, and in charge to deliver the plenary keynote "The role of the Horizon 2020 programme in implementing the Digitising European Industry imitative".

  There was also a session of FIWARE for INDUSTRY Open Platform for Connected Factories, where the FIWARE for INDUSTRY Platform in H2020 was presented together with some expressions of Interest for FIWARE for INDUSTRY by vfOS, COMPOSITION and NIMBLE projects.

6.1.3 Plans for next steps in FoF-11 working groups

During the FoF-11 workshop in the ICE/IEEE Conference (Madeira) organised by the Vf-OS project, the main outcome was an initial proposal for FoF-11projects to collaborate in a structured way.

An identification of thematic working groups was established as follows:

- WG DA – 01 IoT / Middleware
- WG DA – 02 Blockchain / Security
- WG DA – 03 Business models
- WG DA – 04 Data analytics
- WG DA – 05 SDKs
- WG DA – 06 FIWARE
- WG DA – 07 Marketplace

- WG DA – 08 Reference Architectures, Open Platforms, Open APIs
- WG DA – 09 Code Sharing, Developers Engagement Hub, Open Source Licensing
- WG DA – 10 Privacy, Data Protection, IPR

Each working group will have a leading project and contributing projects and will be self-organised.

The main goal of each working group is to foster collaboration between projects in a certain area, e.g., cybersecurity and get advantage of the other's progresses avoiding to "reinvent the wheel".

COMPOSITION project will initially lead the **"WG DA – 07 Marketplace"** working group and will contribute to **"WG DA – 02 Blockchain / Security"** and **"WG DA – 04 Data analytics"** working groups.

This initiative is expected to kick off by the **beginning of October-2017**.

6.2 FoF-11 CSA Connected Factories

EFFRA produced deliverable 1.1 "Reference structure for market analysis" submitted on February 2017. The main goal of this deliverable is to have a solid approach for describing and analysing what is present on the market in terms of technologies that support the deployment of digital manufacturing platform.
This reference structure or mapping framework will be used to characterize R&D projects like the FoF-11 projects.

The benefits of using this reference structure are:

- The application of the mapping framework will allow to analyse specific aspects (coverage of life-cycle stages, applied technologies, standards, security approaches,…) much more systematically. The information will also be collected in a database (The EFFRA Innovation Portal) which will make the analysis and the extraction of information for dissemination purposed much easier
- The ultimate situation is that suppliers of digital solutions will be closely involved in the mapping of their solutions in the mapping framework, where the provided information is public information and where this information can be made available to other stakeholder (not the least the potential users of digital platforms).
- With respect to the mapping of research and innovation projects, the mapping would bring to the surface the commonalities, overlaps and difference in the approaches of the FoF11 projects. It will enable the projects to take into account what other projects are doing are even cooperate across projects.

6.3 Other Initiatives

Section 6.1.1.1 introduced the RAMI Industry 4.0 reference architecture. An equivalent reference architecture model is the industrial internet reference architecture (Lin, et al., 2015).

BaSys 4.0 aims at establishing a basis system and runtime environment for production plants (Basissystem Industrie 4.0, 2017). While having some similarities with COMPOSITION with regard to the overall idea of establishing a commonly usable platform, BaSys 4.0 focuses control of production plants, which COMPOSITION does not.

IUNO analyzes real and relevant scenarios from the production industry based on four use cases (IUNO - IT-Sicherheit in der Industrie 4.0, 2017). It identifies threads and risks for the smart factory. For these threads, IUNO implements protective measures on a prototypical base. The idea is to create IT security solutions that are widely usable for industry so that especially small and medium enterprises can use them as best practice for secure Industry 4.0.

The Austrian version of Industrial Data Space is the Data Market Austria (Data Market Austria, 2017). This initiative aims at creating a secure data space for exchanging confidential company data.

7 Conclusions and Future Outlook

Deliverable D7.1 has provided structured information about the FITMAN and Industrial Data Space projects, together with an initial identification and selection of software components that could possibly be reused in the COMPOSITION project providing functionality required by some of the use cases. At the moment two components have been identified *DIPS* and *DyCEP* from FITMAN project that can be useful in COMPOSITION given the nature of these since they are Open source and offer open APIs based on standards. Also reflects some ideas from the Industrial Data Space project which were used as input in the COMPOSITION use case elaboration phase.

The document also provides detailed information of the work carried out during this first period in cooperation with the other ten FoF-11 Projects with the overall objective to achieve a platform for Digital Automation.

The identified actions planned in the second year are:

- Create a complete selection of components of the different projects selected, evaluating the risks of implementing in the COMPOSITION solution and their customization if needed.
- To track the evolution of FITMAN Specific enablers in H2020 Program, mainly in Crema[3], C2Net[4], Symbiosys[5] and BeinCPPS[6] projects, in which some of the components of Fiware4Industry are being used.
- Run proactive role in the FOF-11 workshops trying to contribute to platform building in Digital automation.

[3] http://www.crema-project.eu/
[4] http://c2net-project.eu/
[5] http://www.psymbiosys.eu/
[6] http://www.beincpps.eu/

8 Tables and Figures

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