

# Towards the Realisation of Hyperconnected Factories

Preliminary Results and Future Directions  
COMPOSITION, DIGICOR, NIMBLE and vf-OS  
(FoF-11-2016)

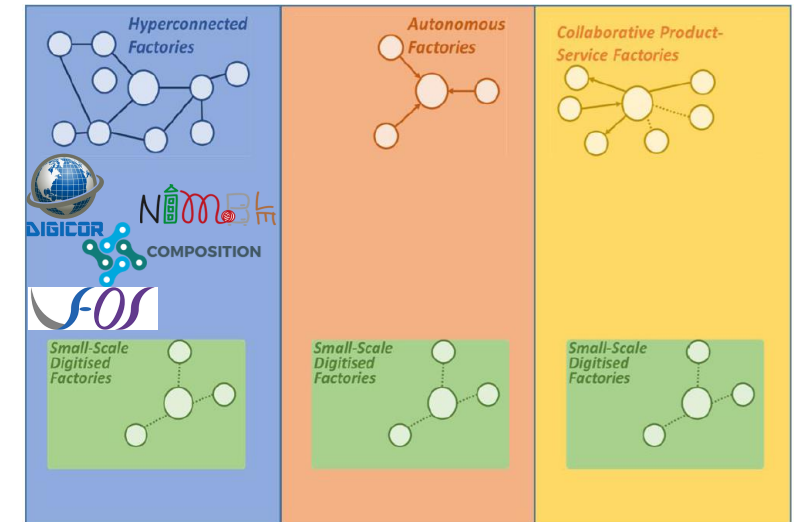
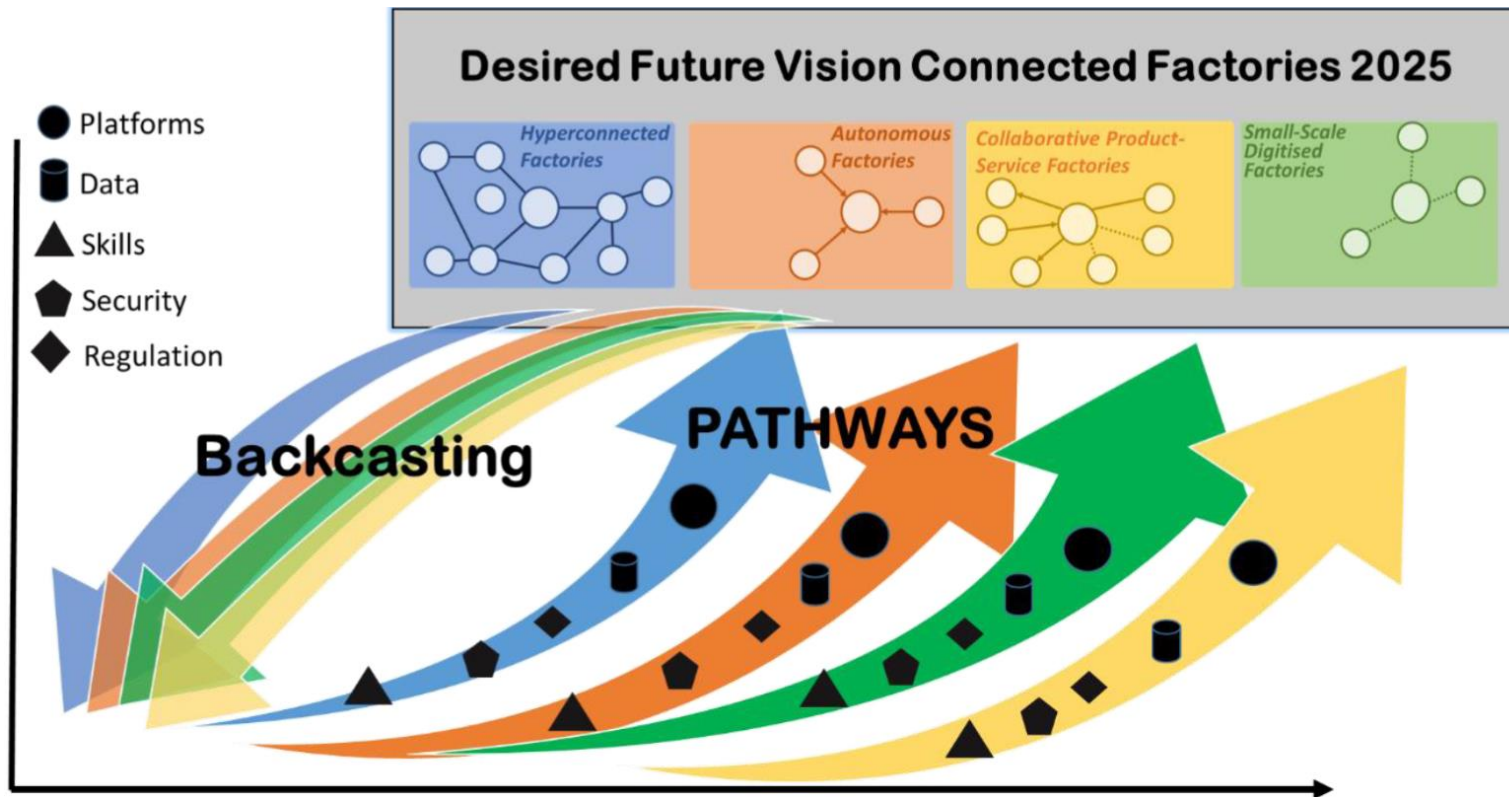
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# Future Vision and Pathways

Connected Factories (CSA) defined scenarios and pathways describe desired future for digital manufacturing platforms

- **Personas** describe different contexts, purposes or user characteristics
- **Pathways** reflect on how digital platforms can bring value to different kinds of processes



“Small-scale digitised factories” could be developed within the three other personas. Therefore, small-scale digitised factories are part of other three personas

# Hyperconnected Factories

*Networked enterprises in complex dynamic supply chains and value networks*

Future vision for digital integration and interoperability of systems and processes in the manufacturing sector

## Description of Persona

- International supply chains producing of complex products
- Trusted interdependent ecosystems, including supply partners
- Digitalised, connected and automatically exchanged information
- Intensive use and sharing of supply and value chain data
- 1-to-many relationship between horizontal and vertical platform

## Platform Characteristics

- Fully automated and integrated design process of new products
- Collection, sharing and transparent management of real-time data
- Advance modelling and analytics of supply chain data
- Match making and new business models for supply chain
- Continuous interactions and distributed control and decisions



### Pathway to Hyperconnected Factories:

#### General purpose software

Spreadsheet, mails, textfiles,  
paper files...

#### Dedicated software in silos

ERP implemented

SCM implemented

#### Basic internal connectivity

ERP and SCM connected

#### Dedicated IT connection to some supply chain partners

Administrative transactions  
digitalised

High level planning using  
dedicated digital connections

Forecasting of required  
capabilities

#### Dynamic IT connections to new supply chain partners

Dynamic detailed scheduling and  
rescheduling

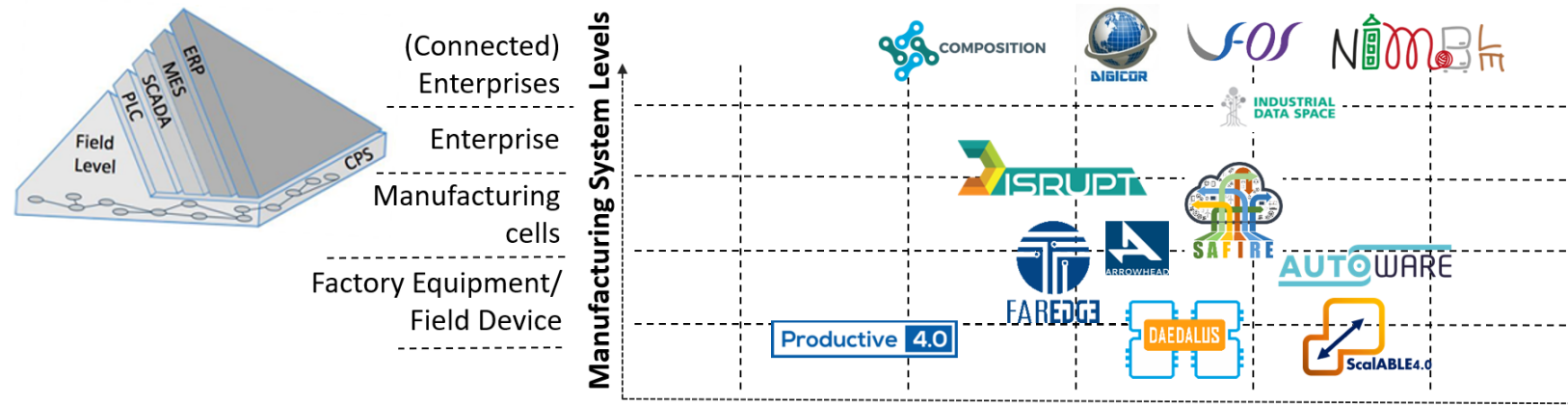
Visibility of work in progress

Common digital platform used  
for tenders and bidding

# Hyperconnected Factories

*Networked enterprises in complex dynamic supply chains and value networks*

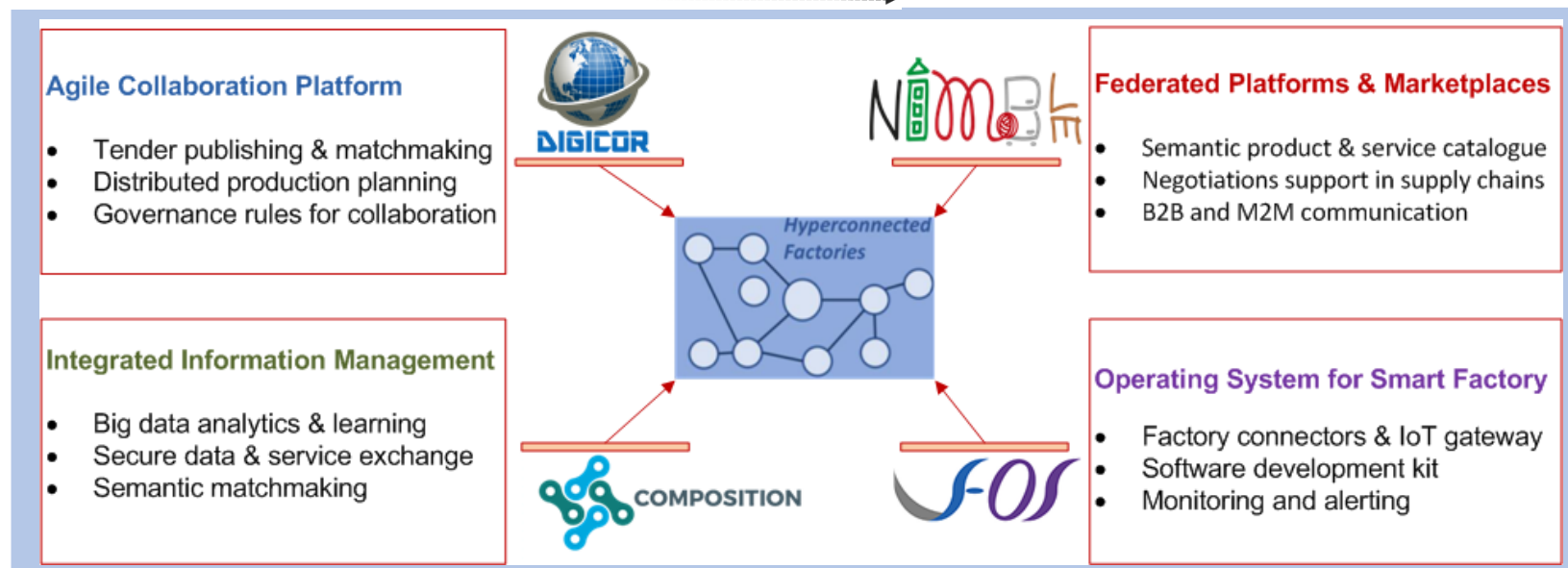
No FoF-11-2016 project had an all-encompassing vision, albeit the following cover a well-argued subset of functionalities



The mapping of FoF-11-2016 projects against manufacturing system levels highlight the end-to-end coverage of smart factory needs\*

\*Chris Decubber, September 2017

The complementary solutions offered by these 4 projects can adequately fulfil the needs of connected smart factories



# DIGICOR

*Decentralised Agile Coordination Across Supply Chains*



Technology platform, tools & services that allow the creation and operation of collaborative networks across the value chain

## Use cases

**Aviation Ad-hoc Supplier Network:** Ad-hoc supply chain for customised aircraft parts within a SME network using the platform and governance approach

**Collaboration Across SMEs:** Visibility of business opportunities and provision of available tools for SME collaborations

**Flexible Automation System Integration:** Integration of adaptive production facilities into complex supply chains with clarity on current and forecasted health



### Strategic Collaborations

DIGICOR collaboration platform provides vital communication and decision support services to companies, particularly SMEs, allowing them to plan and control collaborative production and supply networks.



### Marketplace and Toolstore

DIGICOR marketplace provides match making functionalities, allowing SMEs to find and interact with suitable partners. The primary function of the Marketplace is to facilitate the contracting of business with potential suppliers.



### Governance Framework

DIGICOR governance framework and procedures sets out the terms of collaboration and rules of doing business on the DIGICOR platform. The framework allows SMEs to collaborate and exchange information in a trustworthy environment.



# DIGICOR

*Decentralised Agile Coordination Across Supply Chains*



Roadmap		1 <sup>st</sup> release	2 <sup>nd</sup> release	3 <sup>rd</sup> release
Component	Phase 1	Phase 2	Phase 3	
DIGICOR Portal	<ul style="list-style-type: none"><li>Partial implementation</li></ul>	<ul style="list-style-type: none"><li>All GUIs functioning</li></ul>	<ul style="list-style-type: none"><li>Configurable layout</li><li>Personalization</li></ul>	
Tools	<ul style="list-style-type: none"><li>Partial functionality</li></ul>	<ul style="list-style-type: none"><li>All reference tools working</li></ul>	<ul style="list-style-type: none"><li>Advanced algorithms</li></ul>	
Security	<ul style="list-style-type: none"><li>User authentication</li></ul>	<ul style="list-style-type: none"><li>Complete access control</li></ul>	<ul style="list-style-type: none"><li>Full data security</li></ul>	
Factory connectivity	<ul style="list-style-type: none"><li>One way (Factory-&gt; DIGICOR)</li><li>Limited data model</li></ul>	<ul style="list-style-type: none"><li>Two way communication</li><li>ISA-95 implementation</li></ul>	<ul style="list-style-type: none"><li>Pub-Sub OPC-UA</li><li>Controlling factories from DIGICOR</li></ul>	
Tool store	<ul style="list-style-type: none"><li>CD implementation</li></ul>	<ul style="list-style-type: none"><li>Testing environment</li><li>Tool subscription</li></ul>	<ul style="list-style-type: none"><li>Tool approval process</li><li>Payment gateway</li></ul>	
Infrastructure	<ul style="list-style-type: none"><li>Infrastructure services in place and running</li></ul>	<ul style="list-style-type: none"><li>Centralized logging and monitoring</li></ul>	<ul style="list-style-type: none"><li>Advanced Infrastructure diagnostic</li></ul>	
Use cases Integration	<ul style="list-style-type: none"><li>None</li></ul>	<ul style="list-style-type: none"><li>Single sign-on</li><li>Accessing DIGICOR services from outside DIGICOR platform</li></ul>	<ul style="list-style-type: none"><li>Full integration of all three use cases</li></ul>	
Developers Support	<ul style="list-style-type: none"><li>Service template</li><li>Basic documentation</li></ul>	<ul style="list-style-type: none"><li>More detailed documentation</li></ul>	<ul style="list-style-type: none"><li>Extensive documentation available online</li></ul>	
Community support	<ul style="list-style-type: none"><li>Guided presentations</li></ul>	<ul style="list-style-type: none"><li>Access to testing version</li></ul>	<ul style="list-style-type: none"><li>Subscription to Portal</li></ul>	

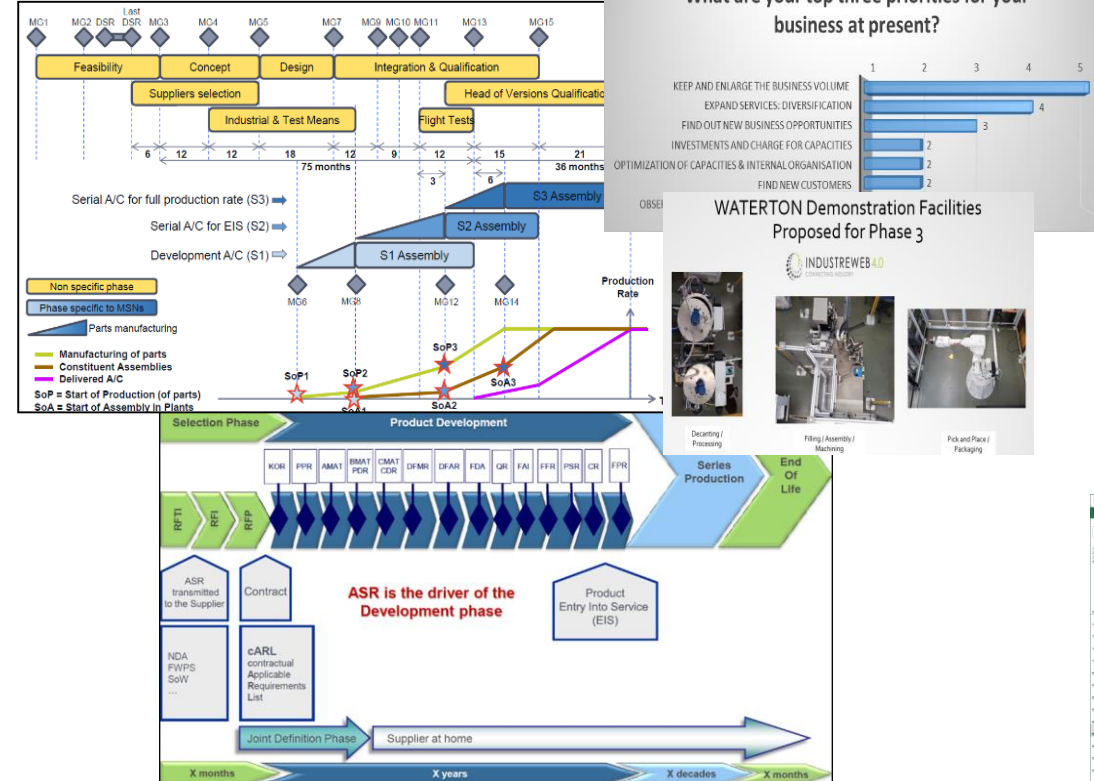
# DIGICOR

Decentralised Agile Coordination Across Supply Chains

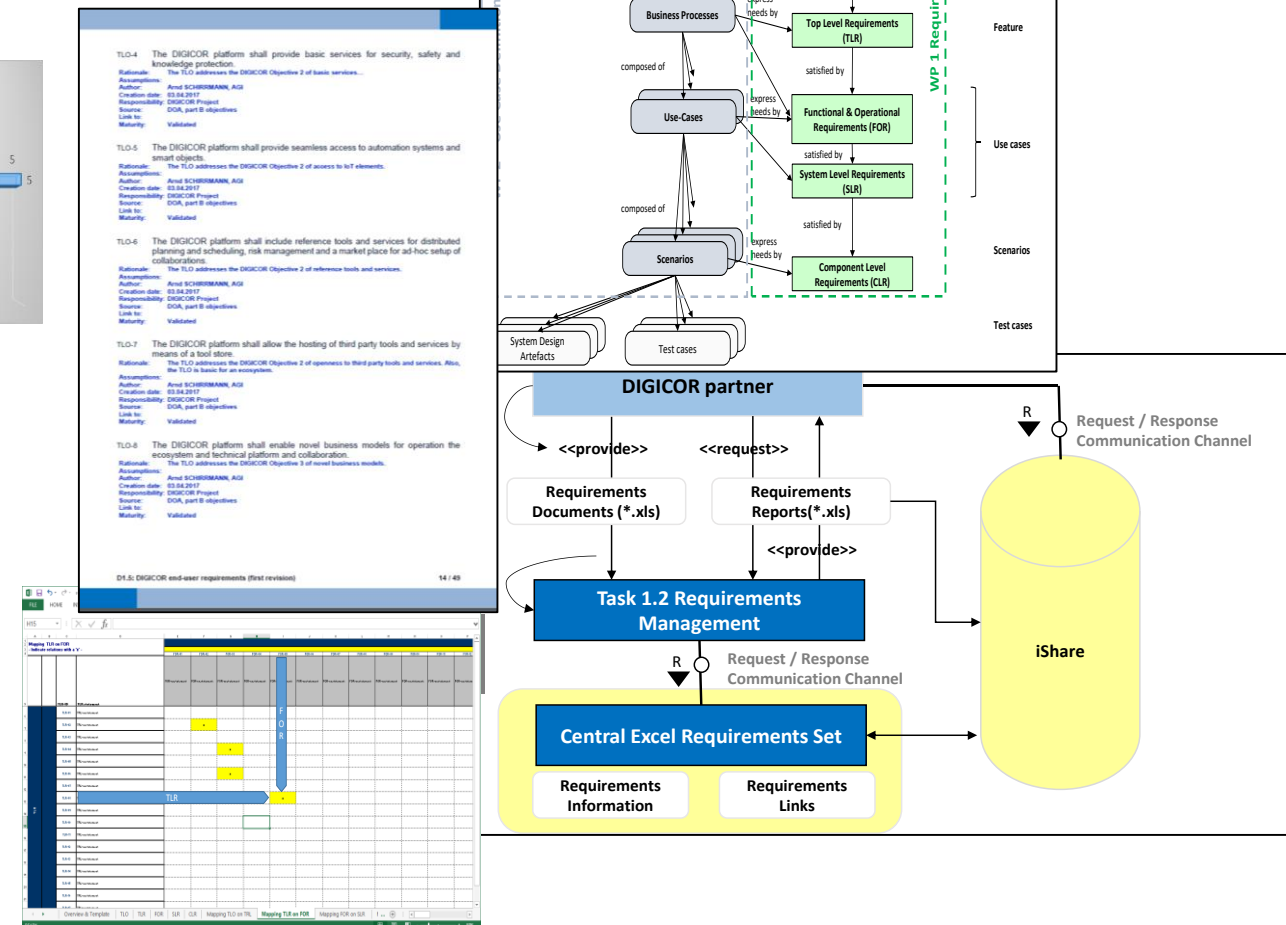


## Achievements

### GAP Analysis



### End-User Requirements Definition







# DIGICOR

Decentralised Agile Coordination Across Supply Chains



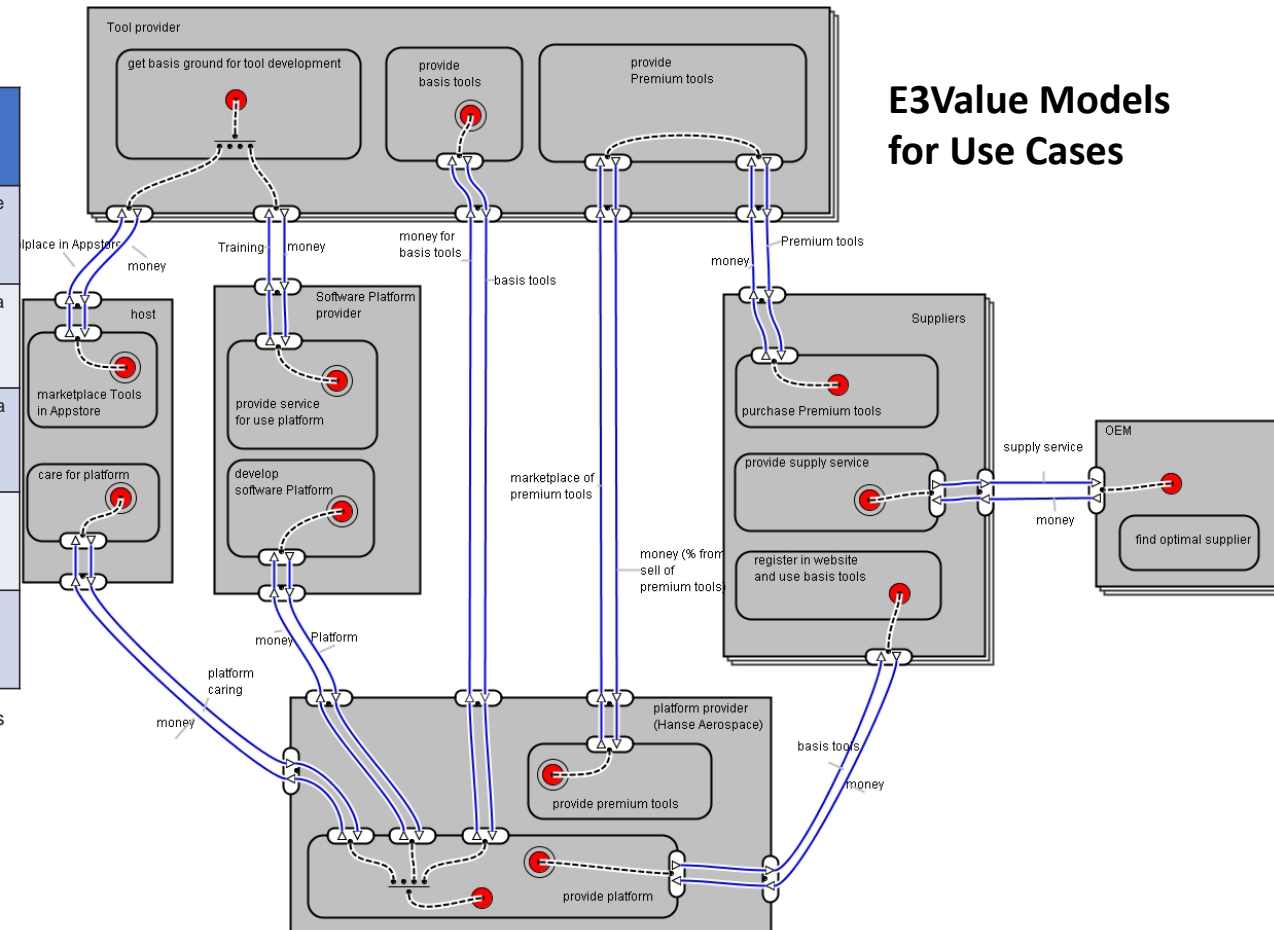
## Achievements

Morphological Box for Operation Models of the DIGICOR Platform

platform type	costs for access	use of tools	duration of access	number of connections to partners	number of participations in tenders	access to standardized documents	operator model
closed (only with registration)	fully paid	all tools are free	unlimited	unlimited	unlimited	unlimited	Infrastructure as a Service (IaaS)
partly open (only some parts with registration)	partly paid	only a couple of tools are free	limited to 1 year	contingent with fixed number	contingent with fixed number	permanent access for some documents	Platform as a Service (PaaS)
open (without registration)	fully free	pay per use	limited to 1 month	10	10	pay per use	Software as a Service (SaaS)
				5	5		combination
				1	1		

● Operation Concept 1: "Free limited access" 
 ● Operation Concept 3: "Fully paid access" 
 — Variants  
● Operation Concept 2: "Partly free access" 
 ● Operation Concept 4: "Pay-per-use access"

## Business Models for Use-cases



# DIGICOR

Decentralised Agile Coordination Across Supply Chains



## Achievements

App Name	Provider	Type	Subscription Models
Scheduler	Certicon AS	Planning/Scheduling	license fee, monthly subscription, pay per use
atRisk	Almende	Risk management	monthly subscription, pay per use
atMatch	Uni Manchester	Collaboration	license fee

© 2017 created by Airbus on behalf of EU funded DIGICOR Project

Machine	Working Hours	ElementDate	LatestAlarms
2213349	2018 [Hours] 6627 [Hours]	02/10/2017 10:46:54	2017-09-29 14:52:43.163 46377 - Severity 4-FAUSE Power Source 1 not ready for start riveting, waiting for SN[103] x True

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Order ID	Title	Duration (IM)	Mat Status	Station	StartDate	EndDate	Status
4712002	B737 eco pax seat (ER)	235	Missing Parts	FAL A	2017-10-17	2017-11-01	Delayed
4734002	B737 eco pax seat (AF)	210	In stock	FAL B	2017-10-15	2017-11-10	OPEN
4711001	B737 eco pax seat (LH)	185	Logistics	FAL A	2017-11-01	2017-11-28	PRINT

WO ID	Title	EndDate	Status
47110021	Seat structure assembly	2017-10-25	CLOSE

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# COMPOSITION

Ecosystem for Collaborative Manufacturing Processes



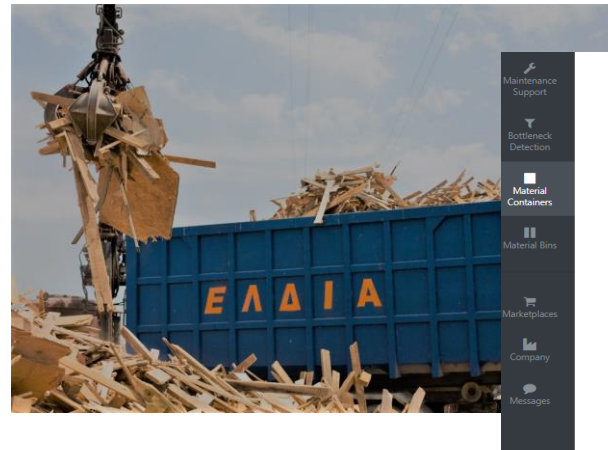
Integrated information management system to optimize production processes by connecting and sharing data & tools

## Use Cases

**Domain:** Management of recyclables of lift manufacturer

**Fill-level Notification:**  
Secured and customizable automatic transmission of data between supplier and customer for optimized service provision

**Scrap Metal Bidding:** Agent-based price negotiation over marketplace for cost optimization and new business opportunities



### Material Management Containers

<b>Container A</b>	<b>Container B</b>	<b>Container C</b>
Content: Metal burrs	Content: Scrap metal	Content: Scrap metal
Full in: 6 days	Full in: 1 days	Full in: 5 days
Current fill level: 52 %	Current fill level: 36 %	Current fill level: 20 %
Last emptied: 12 days ago	Last emptied: 2 days ago	Last emptied: 5 days ago
Price if sold today: 120 € / ton	Price if sold today: 140 € / ton	Price if sold today: 100 € / ton
Filling prediction: 6 days 5 hrs 30 min, 5.2 / 10 t, 52% filled	Filling prediction: 1 day 15 hrs 20 min, 5.4 / 15 t, 36% filled	Filling prediction: 5 days 10 hrs 20 min, 1.6 / 8 t, 20% filled

### Bidding Process Management

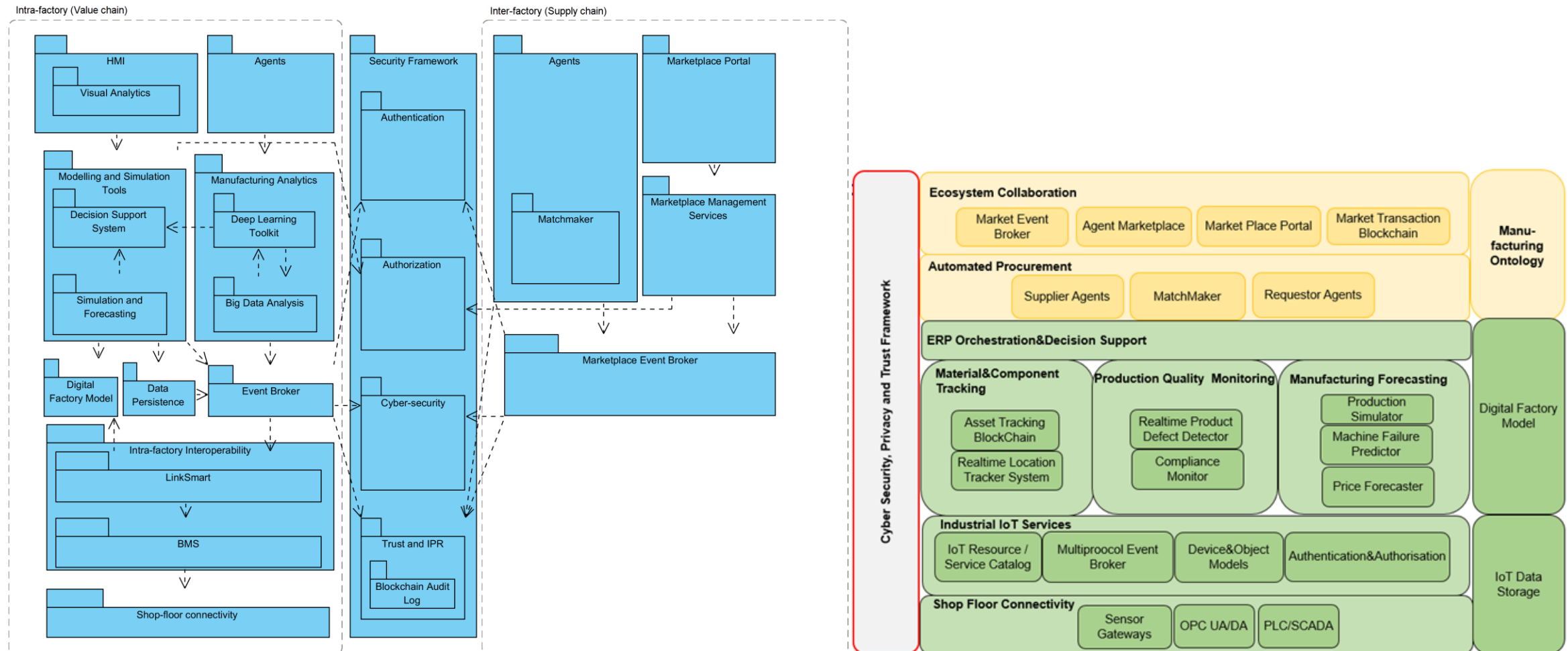
Status	Contractor	Quantity	Final offer	Participants	Marketplace	Action
Scrap metal: Bidding process initialized		120 q	75 EUR	5 companies		
Scrap metal: Waiting for selection	Eldia			2 companies		
Scrap metal: Bidding process initialized		120 q	75 EUR			
Scrap metal: Pickup Arranged		120 q	75 EUR			

# COMPOSITION

*Ecosystem for Collaborative Manufacturing Processes*



## Architecture



# COMPOSITION

*Ecosystem for Collaborative Manufacturing Processes*



## Technical Achievements



### **Agent-based Marketplace**

- FIPA ACL Dialect
- Semi-automatic Price and Supply Negotiation



### **Semantic Matchmaking**

- Apache Jena Ontology
- Establish new Business Contacts over Marketplace



### **Secure Access Control**

- Keycloak, EPICA, nginx
- Grant Dedicated External Entities Access to Specific Internal Data



### **Blockchain-based Immutable Logging**

- Multichain Implementation
- Trust Backbone of Collaborative Ecosystem



### **Big Data Analytics & Deep Learning**

- Recursive Neural Networks, leveraging on Keras on top of TensorFlow
- Predictive Maintenance, Price Forecast



### **Decision Support for Process Optimization**

- Data Visualization
- Tonnage-Route Calculation



# NIMBLE

*Federated, multi-sided, and cloud-based platform ecosystem supporting interoperability across all platform instances*



## Use cases

### Childcare Furniture Manufacturing supply chain:

- Catalogue publication
- Sourcing of materials and components
- Entrance to new markets regulated by particular laws and norms.

### Textile Manufacturing supply chain:

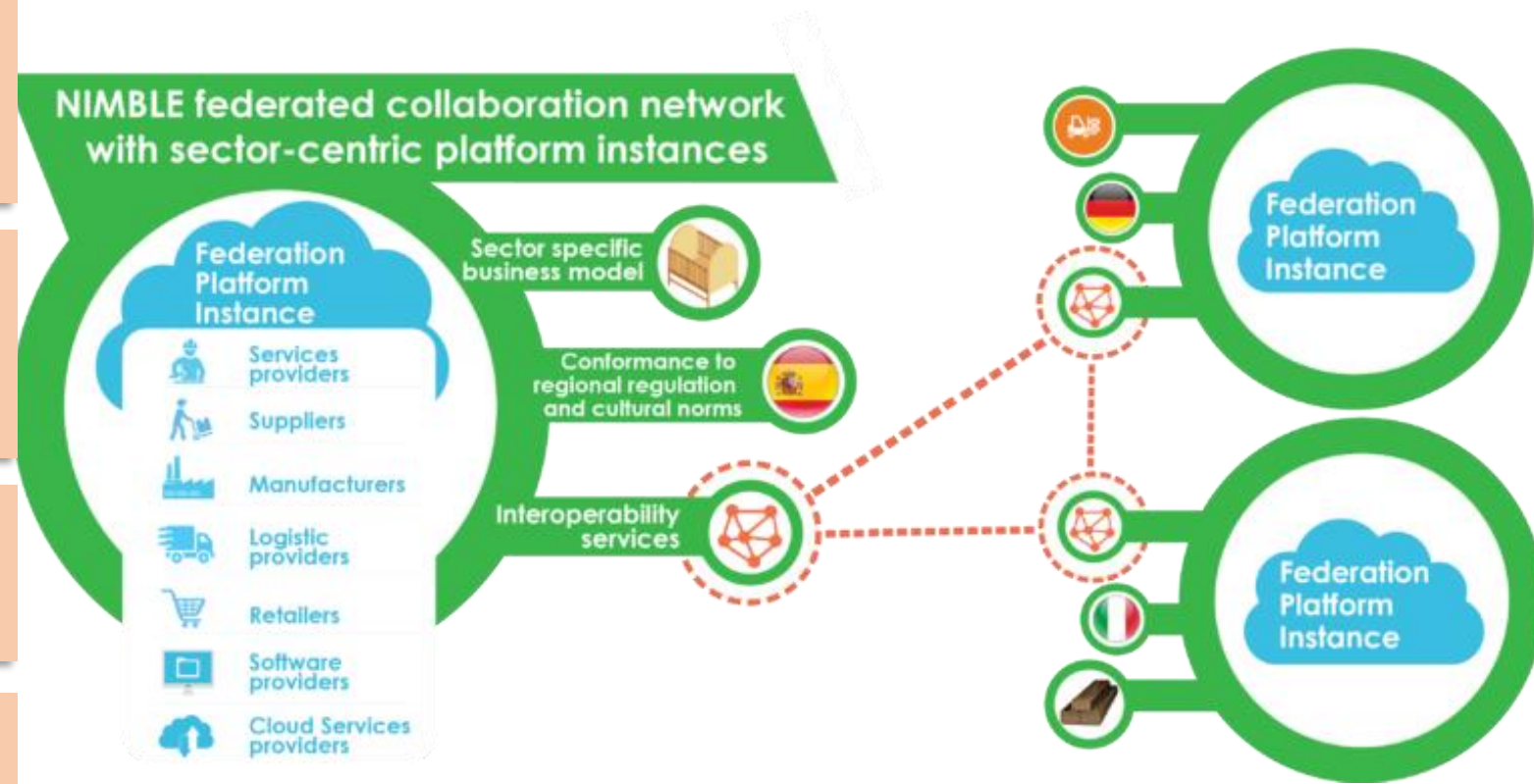
- Co-design,
- Preferential declaration of origin and traceability
- IoT based production data exchange

### Eco Houses Manufacturing supply chain:

- Configurable products e.g. bathroom units
- Integrating a 3D-configurator into the workflow

### White Goods Service supply chain:

- Maximize the user benefit while preserving data sensitivity and data consistency.





# NIMBLE

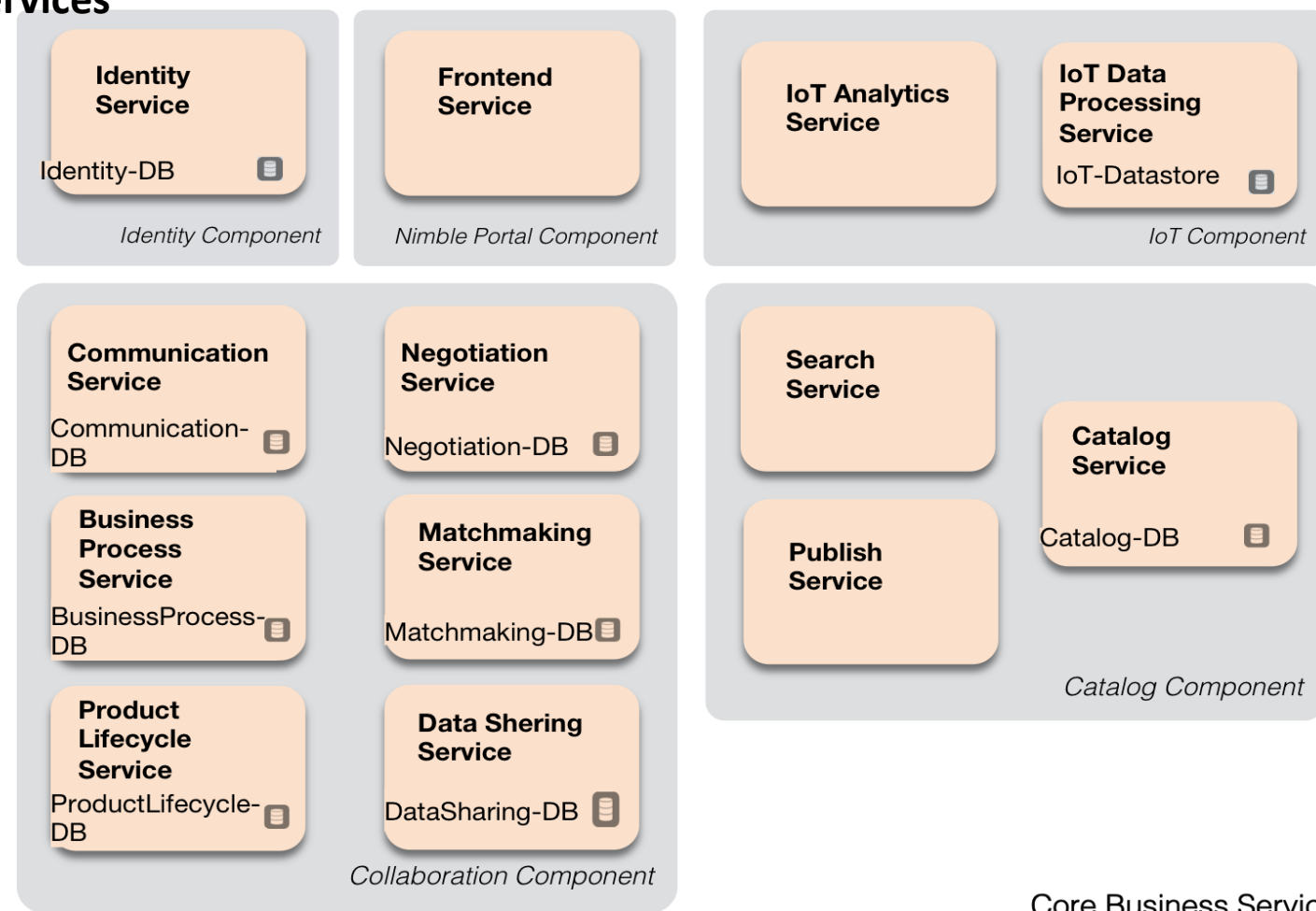
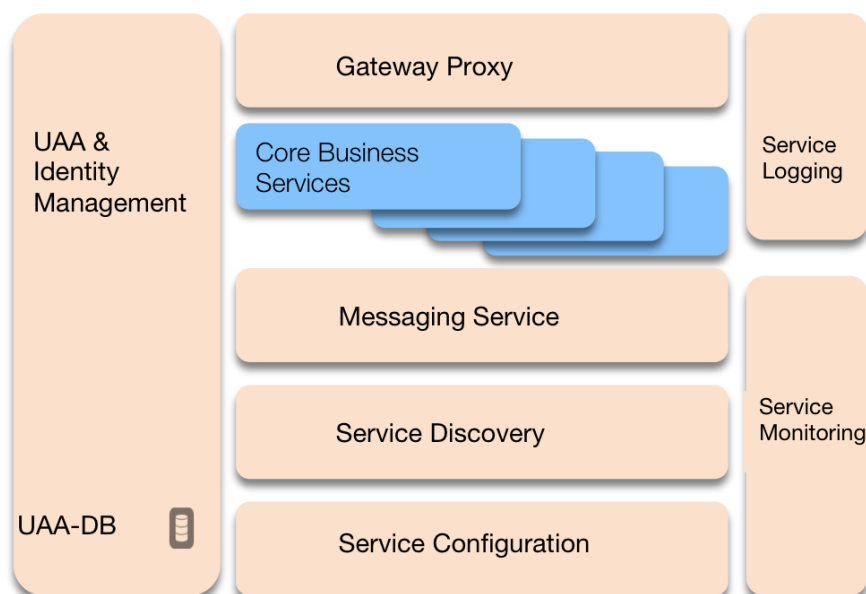
Federated, multi-sided, and cloud-based platform ecosystem supporting interoperability across all platform instances

## Technical Achievements

### Microservice architecture approach: Core services

Top level of the NIMBLE microservice architecture →

→ NIMBLE core business services



Core Business Services



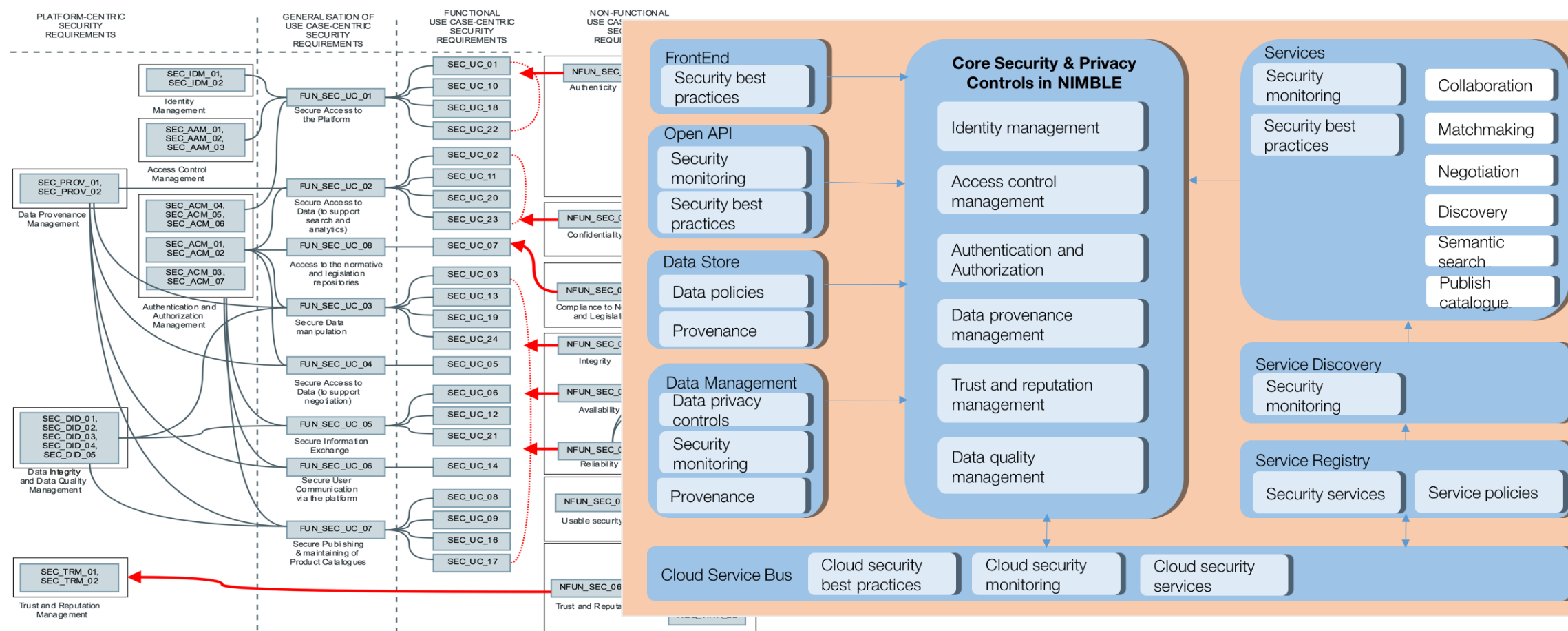
# NIMBLE

Federated, multi-sided, and cloud-based platform ecosystem supporting interoperability across all platform instances

## Microservice architecture approach: Security services

Mapping between various requirements: core platform-centric, use case-centric and security requirements

Core security & privacy controls in NIMBLE



# NIMBLE

Federated, multi-sided, and cloud-based platform ecosystem supporting interoperability across all platform instances



## Product Catalogue Upload and Preview

[Upload Single Product](#) [Upload Multiple Products](#)

[+ Select a product category](#) [Publish Product](#)



Product Identifier

Product Name

Product Description

Add Image [+](#)

[Switch to logistics view](#)

[Product Details](#) [Product Trading & Delivery Terms](#)

Dimensions

Add Dimension [+](#)

Certificates

Add Certificate [+](#)

Add custom property

Property Name

Property Value

Value type:

Text

[Add property](#)

### My Catalogue

[Delete Catalogue](#)

Category :

screw

All

Sort by:

Price:Low to High



#### Wood screw

15mm wood screws

5 Euro

[Edit](#)

[Delete](#)



#### Metal screw

15mm metal screw

7 Euro

[Edit](#)

[Delete](#)

[«](#) [«](#) [1](#) [»](#) [»](#)



# NIMBLE

Federated, multi-sided, and cloud-based platform ecosystem supporting interoperability across all platform instances

## Semantic Search

Your Semantic Query

"Varnish <hasProperty> Name <hasValue> Waterbased clear varnish <hasProperty> dryingTime <hasValue> 20"

Search Query

You are currently at: Varnish

Property Panel

Values Panel

Reference Panel

hasProperty

hasValue

hasReference

Name

Waterbased clear varnish

### Search

Search term

mdf



Showing results 1 - 3 of 3

<< < 1 > >>

item\_commodity\_classification

[MDFBoard \(3\)](#)  
[Drawable MDF \(2\)](#)  
[MDF laminated \(2\)](#)  
[Fireproof MDF \(1\)](#)

hasColour\_s

[White \(2\)](#)  
[Black \(1\)](#)  
[Blue \(1\)](#)  
[Yellow \(1\)](#)



**Fireproof MDF**

Greenwald Manufacturing

Fireproof MDF with special resin-based coating

10 EUR

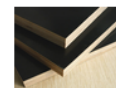


**MDF Board**

Greenwald Manufacturing

Laminated MDF Board

30 EUR



**MDF Board - Drawable**

Greenwald Manufacturing

Drawable board with markers

15 EUR





# NIMBLE

Federated, multi-sided, and cloud-based platform ecosystem supporting interoperability across all platform instances

## Management Dashboards

Discover

Visualize

Dashboard

Timeline

Dev Tools

Management

Collapse

Dashboard / Testing Dashboard

Full screen Share Clone Edit < Last 30 days >

Search... (e.g. status:200 AND extension:PHP)

Uses lucene query syntax

Add a filter +

Number of Logins

Messages per Service

Platform Services

Service Name	Last Success	Status
Eureka (CATALOG-SEARCH-SERVICE)	Never	BAD
Eureka (FRONTEND-SERVICE)	09/May/2018 13:50:21 (UTC)	GOOD
Eureka (BUSINESS-PROCESS-SERVICE)	09/May/2018 13:50:21 (UTC)	GOOD
Eureka (ERROR-NO-SERVICE (to show missing service))	Never	BAD
Eureka (CATALOGUE-SERVICE-SRDC)	09/May/2018 13:50:21 (UTC)	GOOD
Eureka (IDENTITY-SERVICE)	09/May/2018 13:50:21 (UTC)	GOOD
Eureka (GATEWAY-PROXY)	09/May/2018 13:50:21 (UTC)	GOOD
Data-Channels-Service	Never	BAD <a href="#">Restart</a>
ERROR-SERVICE (to show failure)	Never	BAD <a href="#">Restart</a>
Nimble Eureka	09/May/2018 13:50:21 (UTC)	GOOD
Messaging-Service	Never	BAD <a href="#">Restart</a>
Registration Service	09/May/2018 13:50:21 (UTC)	GOOD

Infrastructure Services

Service Name	Last Success	Status
Postgres-Database	09/May/2018 13:50:15 (UTC)	GOOD
Message Hub Nimble	09/May/2018 13:50:15 (UTC)	GOOD
Object Store Nimble	09/May/2018 13:50:15 (UTC)	GOOD

# NIMBLE



*Federated, multi-sided, and cloud-based platform ecosystem supporting interoperability across all platform instances*

Roadmap		1 <sup>st</sup> release	2 <sup>nd</sup> release	3 <sup>rd</sup> release
Component	Phase 1	Phase 2	Phase 3	
NIMBLE platform	<ul style="list-style-type: none"><li>Core functionality (registration of users and comp.; catalogue pub.;</li></ul>	<ul style="list-style-type: none"><li>All GUIs functioning</li></ul>	<ul style="list-style-type: none"><li>Support for different platform instances (federation services)</li></ul>	
Tools	<ul style="list-style-type: none"><li>Search functionality</li><li>Simple negotiation</li></ul>	<ul style="list-style-type: none"><li>Semantic search</li><li>Agent-based negotiation</li></ul>	<ul style="list-style-type: none"><li>Advanced negotiation</li><li>Customizable business workflows</li></ul>	
Security	<ul style="list-style-type: none"><li>User authentication, Role-based AC</li></ul>	<ul style="list-style-type: none"><li>Context-based AC; Sec. dashboard</li></ul>	<ul style="list-style-type: none"><li>Trust and reputation</li></ul>	
Industry connectivity	<ul style="list-style-type: none"><li>Data channels for remote monitoring</li></ul>	<ul style="list-style-type: none"><li>Support for additional standards, e.g. oneM2M</li></ul>		
Tool store	<ul style="list-style-type: none"><li>Third party APIs</li></ul>	<ul style="list-style-type: none"><li>Testing environment</li></ul>	<ul style="list-style-type: none"><li>Tool approval process</li></ul>	
Infrastructure	<ul style="list-style-type: none"><li>Infrastructure services running</li></ul>	<ul style="list-style-type: none"><li>Centralized logging and monitor.</li></ul>	<ul style="list-style-type: none"><li>Advanced infrastructure diagnostics</li></ul>	
Use cases Integration	<ul style="list-style-type: none"><li>Partial</li></ul>	<ul style="list-style-type: none"><li>Access from the 3rd party apps</li></ul>	<ul style="list-style-type: none"><li>Integration of extern. adopters</li></ul>	
Developers support	<ul style="list-style-type: none"><li>Basic documentation</li></ul>	<ul style="list-style-type: none"><li>More detailed documentation</li></ul>	<ul style="list-style-type: none"><li>Extensive documentation</li></ul>	
Community support	<ul style="list-style-type: none"><li>Early adopters programme for companies and platform providers</li></ul>	<ul style="list-style-type: none"><li>Access to testing version</li><li>Subscription to platform</li></ul>	<ul style="list-style-type: none"><li>Subscription to federated platforms</li></ul>	

# vf-OS

*An Operating System for Virtual Factories*



Cloud platform with services and multi-sided market ecosystem, enabling SMEs to develop and integrate better processes

## Use Cases

### Solar Panels Manufacturing:

Smart Apps to support the collaborative management of different stages of the supply chain.



### Construction Operations Management:

Smart Apps for project management and construction site supervision.



### Collaborative Product Manufacturing:

Smart Apps to increase collaboration between SMEs, providing their customers with a common decision support.



vf-OS provides a Virtual Factory System Kernel



A specific set of libraries and infrastructure for *vf-OS* applications to be built upon which interact with each other.

vf-OS provides Virtual Factory Device Drivers and Open APIs



A set of modules that virtualise a factory's real assets and connect them to their virtual images in the *vf-OS*.

vf-OS provides Virtual Factory Middleware and Databus



A set of modules for integrating data from arbitrary sources, including, but not limited to CPS, smart objects, RFID, and wireless sensor networks.

vf-OS provides an Open Application Development Kit



A complete and fully open Applications Development Kit addressed to the community with the aim of guarantee the growth of the specific applications

vf-OS provides Cloud Manufacturing Framework



A Cloud Platform allocating the core business functionalities of *vf-OS*, including the marketplace and monetisation means

vf-OS provides Virtual Factory Components



The individual technical components to build the functionalities of *vf-OS* are modular and provide open interfaces.

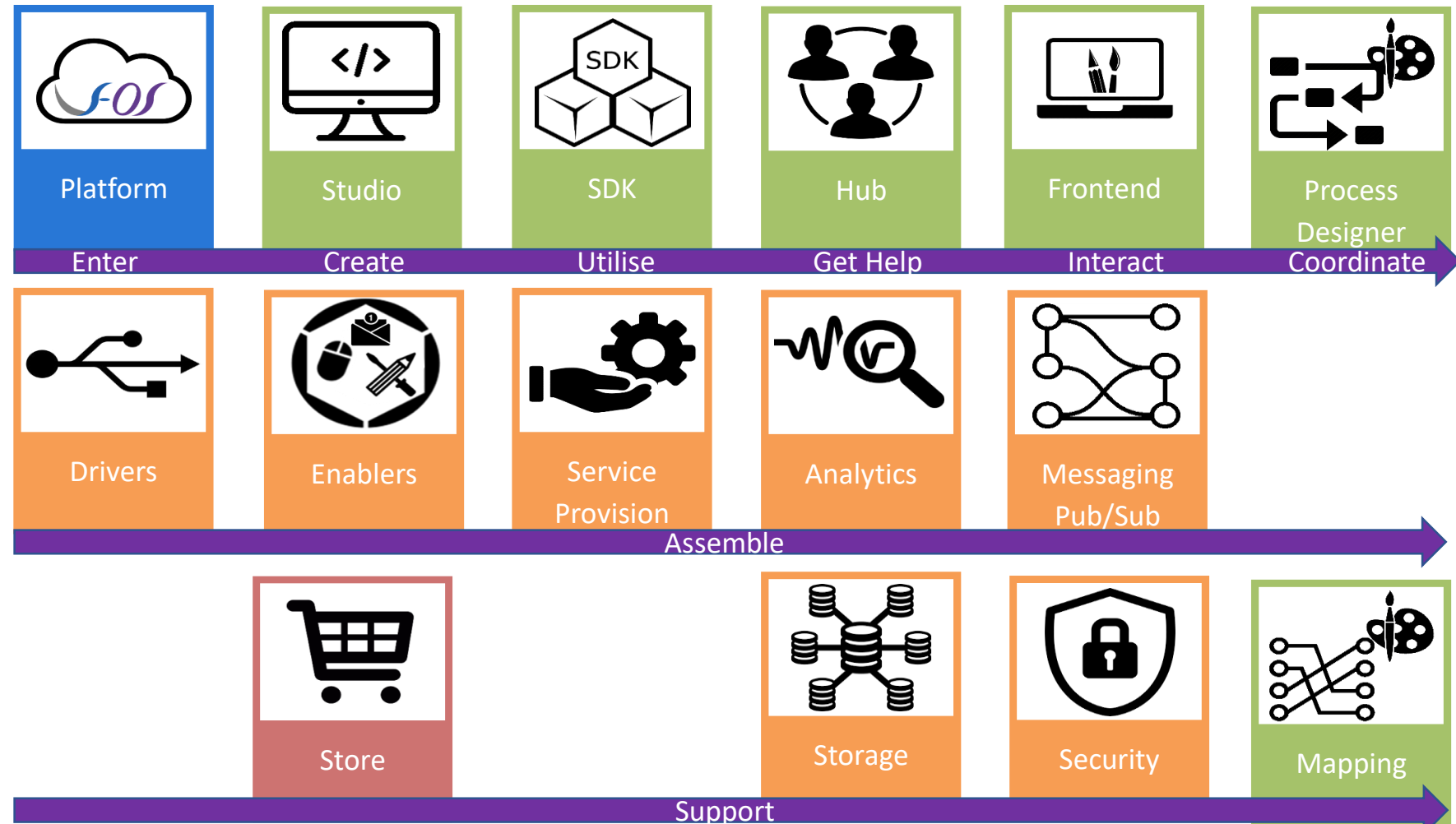
# vf-OS

*An Operating System for Virtual Factories*



Cloud platform with services and multi-sided market ecosystem, enabling SMEs to develop and integrate better processes

**What is  
needed to  
build a vApp?**



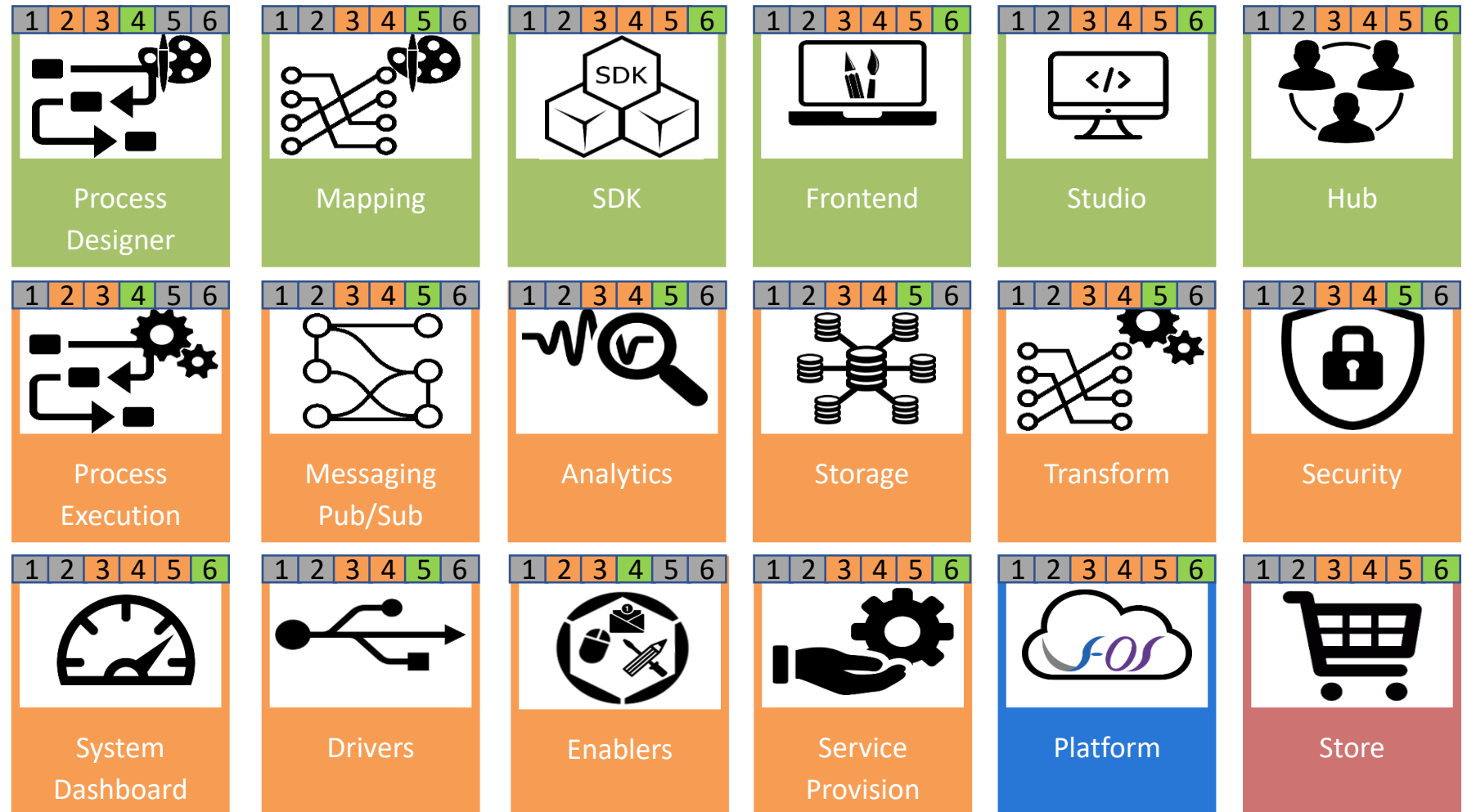
# vf-OS

*An Operating System for Virtual Factories*



Cloud platform with services and multi-sided market ecosystem, enabling SMEs to develop and integrate better processes

**Operational  
demonstrator  
(vApp) has been  
developed at  
M18**







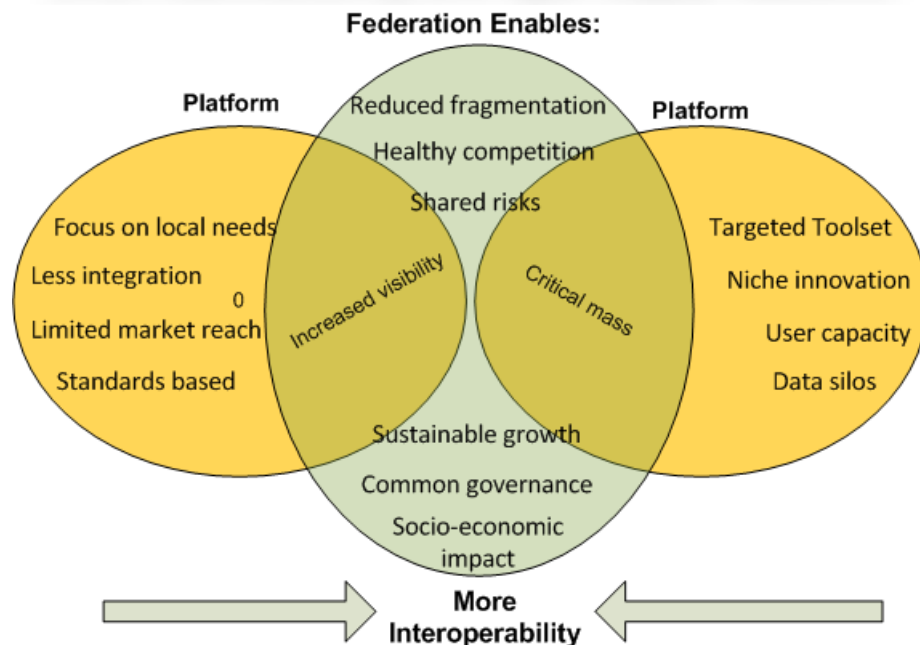
# Realisation of Hyperconnected Factories

*Challenges and Opportunities*

There remains challenges of interoperability and questions about the suitability of platforms to support agile collaborations

## European Ecosystem for Connected Smart Factories of the Future ?

Federation of many players can contribute to a sustainable, resilient digital infrastructure to support Smart Manufacturing and Agile Supply Networks

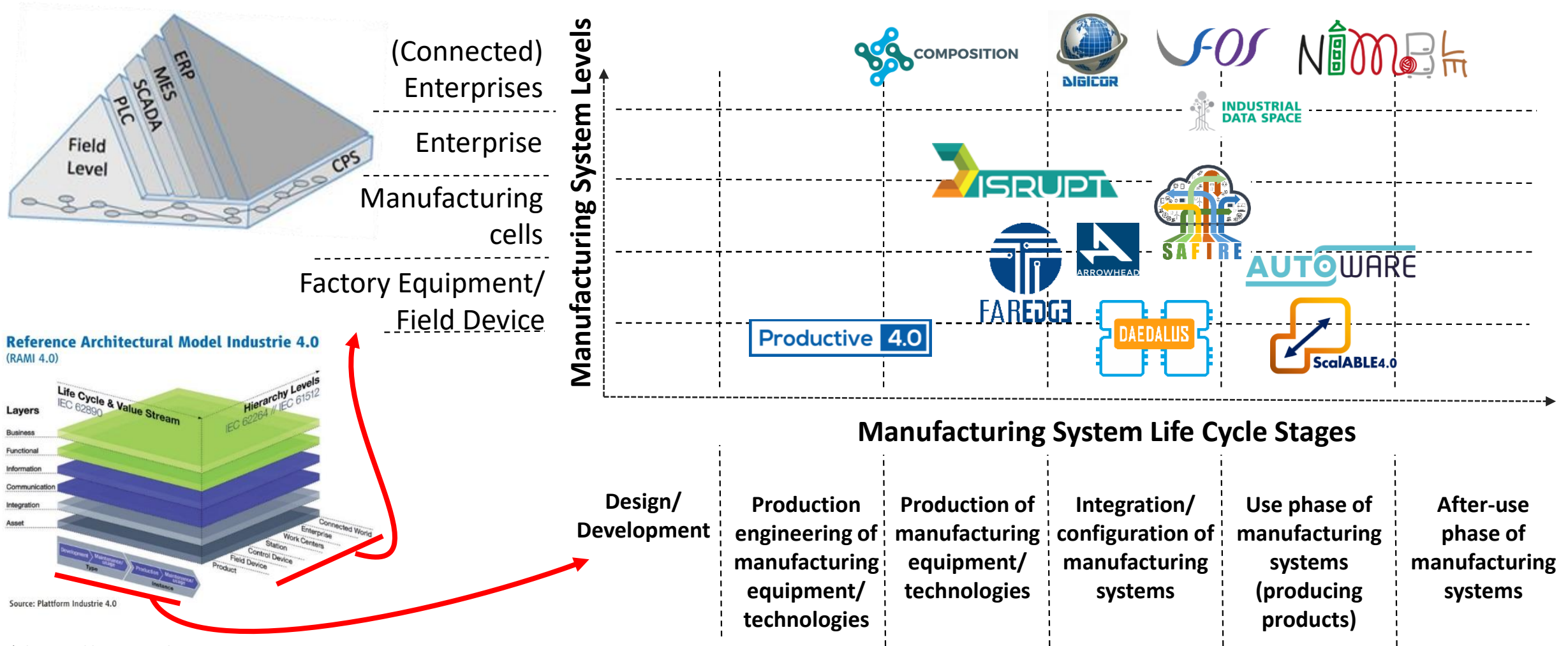


Business Functions	NIMBLE	COMPOSITION	DIGICOR	VF-OS
User registration	+	+	+	+
Company registration	+	+	+	+
Single Product Publishing	+	+	-	-
Product Catalogue Publishing	+	+	-	-
Manufacturing Capabilities Publishing	-	+	+	-
Semantic Search for products / capabilities	+	+	+	-
Distributed workflow and business process execution	+	-	-	+
Risk Management in the supply chain	-	-	+	-
Matchmaking for value networks on the basis of capability specifications	-	+	+	-
Distributed Production Planning	-	-	+	-
Agent based negotiation	+	+	-	-
Blockchain/Distributed Ledger Technology	(+)	+	-	-
Deep Learning Toolkit	-	+	-	-
Data Analytics	+	+	-	+
Shop-floor connectivity	+	+	+	+
Cross-company data channels for sharing	+	+	+	-
SDK for smart factory	-	-	-	+
Cloud-Dev-Ops dashboard	+	+	-	-
Security monitoring dashboard	+	-	-	-
Platform activity management dashboard	+	-	+	-

# Realisation of Hyperconnected Factories

*Recognition of Opportunities*

The interrelationships across selected 4 projects are also recognised in the Connected Factories mapping exercises



# Realisation of Hyperconnected Factories

*Realisation of Opportunities*

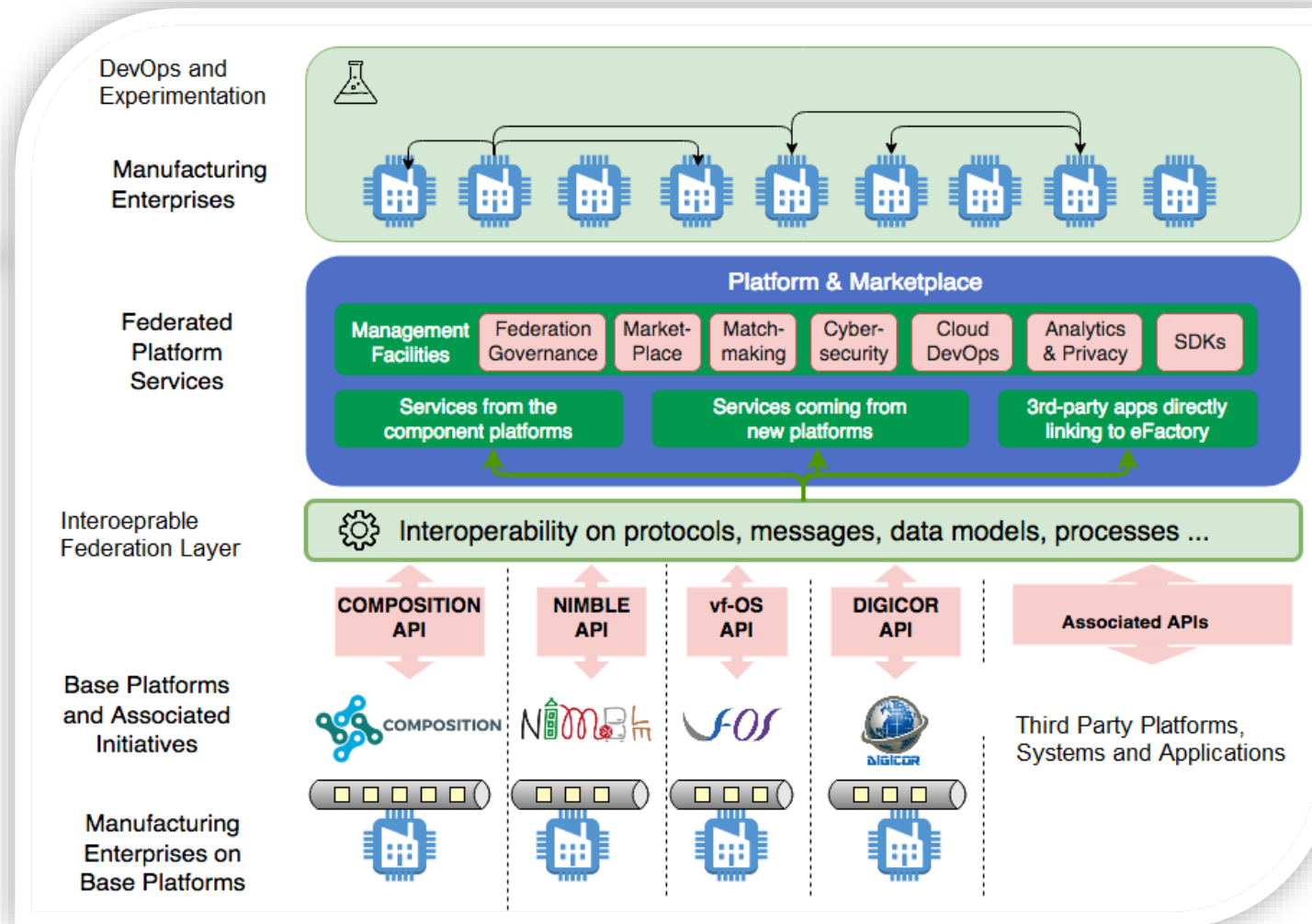
The federation model offers greater access, diversity and demand-led development in wide ranging industrial context

## From Vision to Realisation!

Interlinking existing platforms  
and user communities through a modular and  
flexible approach

### Focus Areas:

- ✓ Industry needs and pilot scenarios
- ✓ Interoperability and interoperations
- ✓ Technology alignment
- ✓ Marketplace ecosystem
- ✓ Sustainable co-creation
- ✓ Governance mechanisms
- ✓ Exploitation and business models



# Comments and Feedback



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