the i4Q project

Industrial Data Services for Quality Control in Smart Manufacturing

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i4Q has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958205

The challenge

- Manufacturing companies are continuously facing the challenge of **redesigning** and **adjusting** their systems to produce goods **adapted to specific requirements** and produced **under the minimum required production rate**, **guaranteeing high quality** and **limiting the use of resources**.
- Therefore, **reducing waste**, **scraps** and **defects**, as well as production costs and lead times is **crucial to increase productivity**.
- In this context, the implementation of **zero defect strategies** plays a decisive role.
- During the last decades, several **manufacturing operations** and **manufactured products quality optimisation methodologies and tools**, such as
  - the use of sensors
  - automated processes
  - zero defect approaches
- …with the purpose of developing **solutions**

to improve **performance** of process control by

incorporating enhanced quality control solutions

The challenge

- Nevertheless, current solutions show three **major drawbacks** that have not been solved
  1. **Data management**: huge amount of data during the manufacturing process-> not possible to analyse the data generated in the process on a daily basis
  2. **Complexity of current solutions**: not accessible for SMEs; users are demanding access to insights from advanced analytics, without requiring them to have IT or data science advanced skills
  3. **Dynamic behaviour of the manufacturing factories:** Complex systems of diverse, connected, interdependent entities which need suitable modelling and simulation approaches and data fusion techniques to interpret the collected data

i4Q Project will provide a complete solution consisting of sustainable IoT-based Reliable Industrial Data Services (RIDS) able to manage the huge amount of industrial data coming from cost-effective, smart, and small size interconnected factory devices for supporting manufacturing online monitoring and control

The concept

- i4Q Project will develop **a set of Solutions** to improve the quality of manufactured products aiming at **zero-defect manufacturing**, therefore pushing forward the concept of a **smart, fully digitised factory**

- i4Q adopts a straightforward yet well-tested and effective approach which includes
  - a **needs** capturing part,
  - **a fundamental design phase** to produce a reference architecture and framework,
  - a **build phase** which delivers the actual tools and technologies used in the framework,
  - a **key evaluation phase** to ensure real-world applicability of the results and
  - **impact** generation activities centred around **disseminate and exploit** actions and tasks

The concept

- i4Q is a complete solution, the i4Q **RIDS** (Reliable Industrial Data Services), integrating a set of i4Q Solutions, targeting the manufacturing sector and aimed at **improving the digital manufacturing** through more **reliable** and **effective data**.
- It is founded on a unified yet modular **Framework**, rooted in a consistent **Reference Architecture**
- The Reference Architecture is based on current standards in manufacturing (e.g. IIRA, RAMI4.0, IDSA, and IMSA) and incorporates all fundamental ***viewpoints*** involved in the process: **business, usage, functional and implementation**.
- i4Q therefore aims to **support** the **complete flow of industrial data**, starting from **data collection** to **data analysis**, **simulation** and **prediction**.

The objectives

O1: i4Q Project Vision, establish the state of the art in terms of technologies for quality in manufacturing, and to set the requirements driving the creation of i4Q Solutions

O2: Design the i4Q Framework and deliver the Reference Architecture built on key digital models and ontologies for smart manufacturing and devised using multiple perspectives, related to business, usage, functional and implementation viewpoints

O3: Build the i4Q Manufacturing Data Quality, providing methodologies, tools and infrastructure to ensure the necessary data quality to enable operational intelligence

O4: Build the i4Q Manufacturing Data Analytics, a set of management tools for cloud/edge lifecycle of manufacturing related artificial intelligence models

O5: Build the i4Q Rapid Manufacturing Line Qualification and Reconfiguration, a set of new and improved strategies and methods for process qualification as well as process reconfiguration and optimisation

O6: Test and validate the i4Q Solutions in 6 use cases, covering different manufacturing perspectives and industrial sectors

O8: Facilitate technology uptake by the i4Q start-up company that is being created and long-term adoption of the i4Q Solutions by the industry

O7: Disseminate the i4Q Solutions, providing outreach of the project activity and results, offering benefits for final users

O9: Manage the project for guaranteeing that the project objectives are met by ensuring the successful completion of the project on-resource, on-quality and on time

The pilots

- 6 industrial scenarios for i4Q coupled with a high-level user expectation of impact across different industrial activities, sectors and domains.
- The goal is i4Q to demonstrate the applicability and the impact of the project and its results in the market environment under real-world conditions
- Industrial Sectors and activities:
- White Goods
  - Wood Equipment
  - Metal Machining
  - Ceramics Pressing
  - Plastic Injection
  - Metal Equipment

Wood Equipment (BIESSE)

Continuously monitor working conditions and process parameters. i4Q outputs will use readily available sensors, such as **vibration** or **temperature**, and will leverage the available PLCs, that are able to adapt the process to the recorded working conditions providing a way to correct process drifts

Metal Machining (FIDIA)

i4Q Solutions will combine advanced **vibration monitoring methods**, with **AI-driven prediction** of Quality indicators

White Goods (Whirlpool)

Reuse available data to continuously estimate the current product's quality, allowing the certification of product conformity at serial number level. Continuous process **qualification**, as compared to the earlier qualification based on **statistical verification** of early productions in external laboratories

Metal Equipment (FACTOR)

Factor will use the i4Q Digital Twin and the i4Q Data Repository for digitising its entire factory, through the use of sensors, cameras, and other data collection techniques, in order to be able to evaluate **production decisions** based upon data analytics and simulation, visualize products performing in their environments in real-time

Ceramics Pressing (RIASTONE)

Improve the **Production Efficiency**, through new and advanced processes that can measure the quality of the incoming Raw Matters inline, with a continuous and complete data driven incoming raw matter quality control

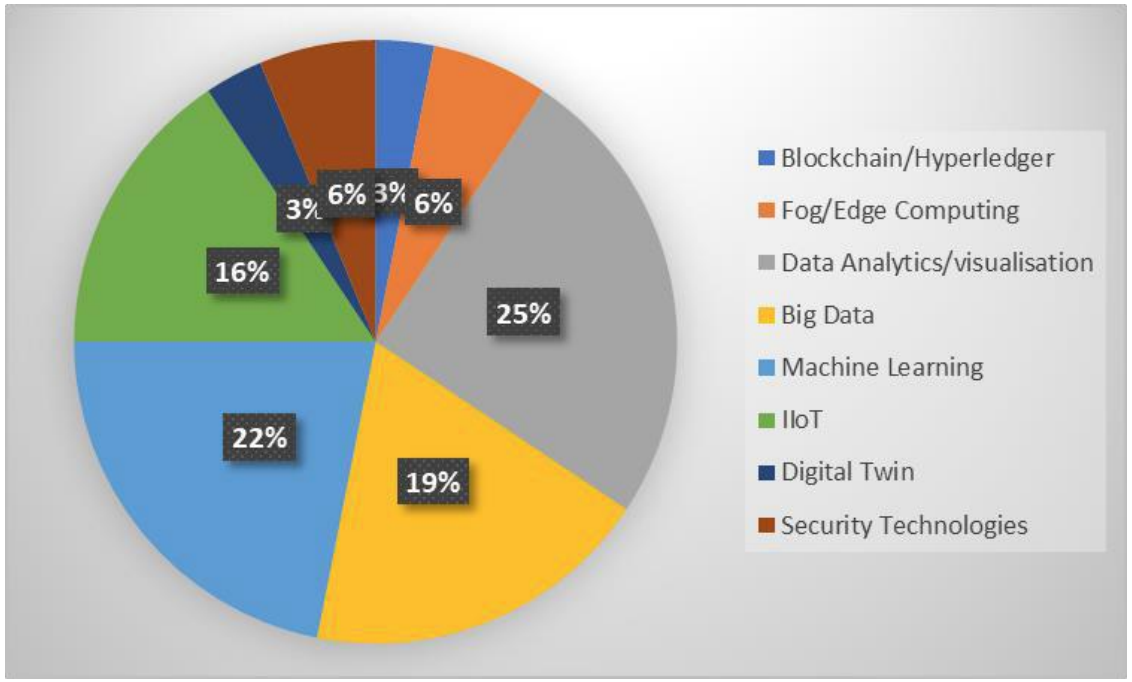
Plastic Injection (FARPLAS)

i4Q complements the plastic injection manufacturing process with an automatic advanced **inspection phase based on AI**, and collect data from all phases, perform the corresponding data analytics, and actuate over the different devices in order to optimize several processes.

Progress

- Benchmarking of Technologies for Quality in Manufacturing
- Use Case Scenarios and KPIs
- Requirements Analysis and Functional Specification (create solution diagrams)
- Data Management (regulations and internal rules)

✓ Questionnaires
✓ Meetings per pilot and solution providers
✓ Examples / demos of how to use tools

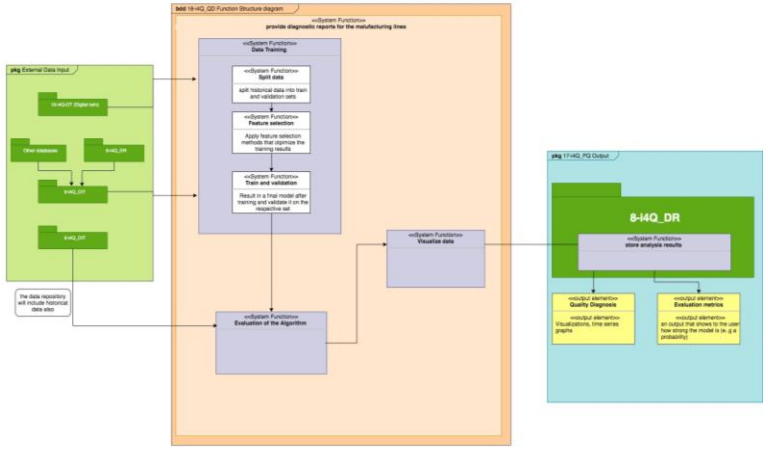


Percentage of the different technologies that will be used for the i4Q solutions development.

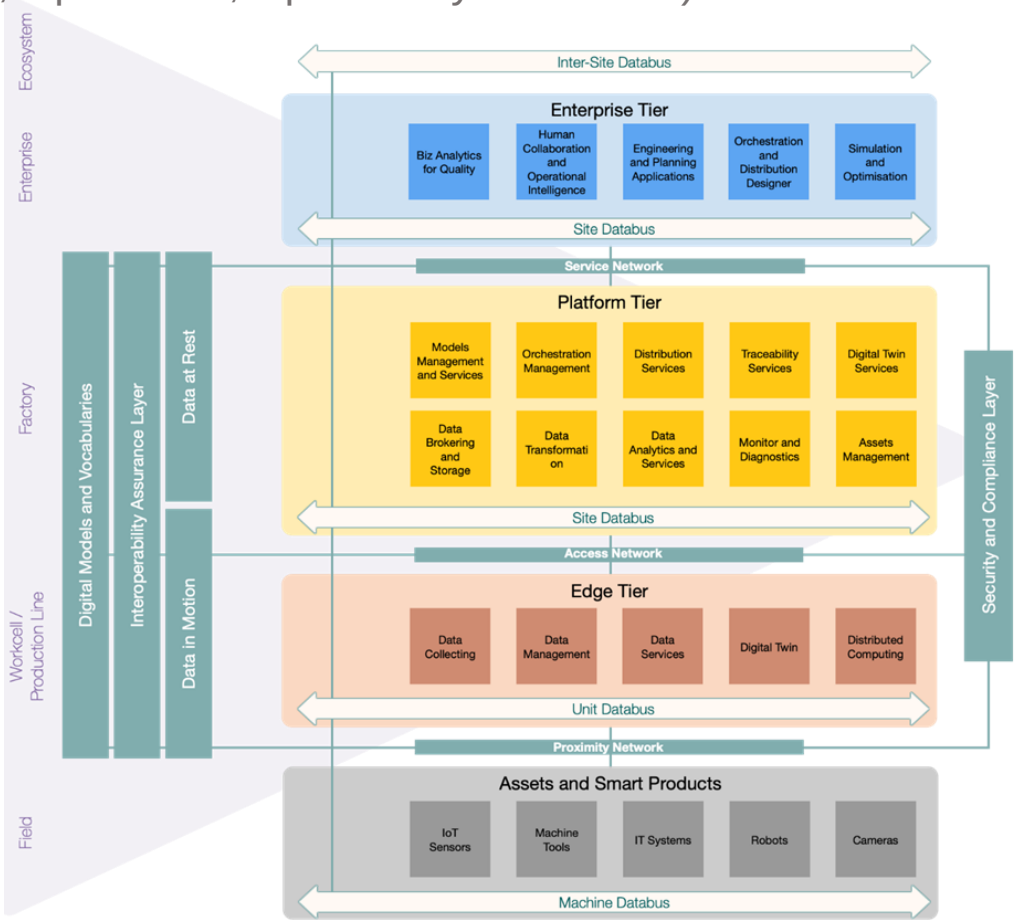
General progress

i4Q Framework and the Reference Architecture

- Reference Framework (surveys, previous projects, initiatives)
- Digital Models and Ontologies (Open Automation, Vertical Integration, Open Data, Open Analytics and AI)
- Business Viewpoint
- Usage Viewpoint
- Functional Viewpoint
- Implementation Viewpoint



i4Q_QD (Quality Diagnosis) SysML diagram



i4Q Reference Architecture

The results

i4Q Solution
i4Q Data Quality Guidelines / QualiExplore
i4Q Blockchain Traceability of Data
i4Q Trusted Networks with Wireless & Wired Industrial Interfaces
i4Q Cybersecurity Guidelines / IIoT Security Handler
i4Q Guidelines for Building Data Repositories for Industry 4.0 / i4Q Data Repository
i4Q Data Integration and Transformation Services
i4Q Services for Data Analytics / i4Q Big Data Analytics Suite /i4Q Analytics Dashboard
i4Q AI Models Distribution to the Edge
i4Q Edge Workloads Placement and Deployment
i4Q Infrastructure Monitoring
i4Q Digital Twin
i4Q Data-Driven Continuous Process Qualification
i4Q Rapid Quality Diagnosis
i4Q Prescriptive Analysis Tools
i4Q Manufacturing Line Reconfiguration Guidelines / i4Q Manufacturing Line Reconfiguration Toolkit
i4Q Manufacturing Line Data Certification Procedure

Impact

Expected Impacts from i4Q Pilots

- Improvement of **quality** (roughness from 2-3 Ra to 0.05-0.1 Ra) of **machined product** in finishing stage, through in-process suppression of vibration (smart sensors and actuators embedded in the smart flange + AVC algorithms)
- Quality **prediction effectiveness** (in order to be exploited the quality prediction needs to be reliable. Its accuracy needs to be higher than 90%)
- Improvement of **data quality, test cycles aimed to acquisition of quality data** (vibrations, currents, etc.) will be developed for each meaningful device (electro- spindle, axis, pistons, etc.)
- **Reduction** of **expenses** and capital by using a massive conformity test execution
- Through the use of the new i4Q Quality Control systems, the produce introduced in the **firing oven will present zero defects**
- **Significant increase in quality of manufactured products** leading to a **reduction of scrap**
- Reduction of the **production cycle time**
- **...**

Consortium

WHO The i4Q consortium is made up of **24 stakeholders** covering all the areas of expertise and demonstration necessary for a correct execution of the project.

- **Industrial partners (USER):** WHI (White goods manufacturer), BIES (Wood industrial equipment), FACT (Metal machining), RIAS (Ceramic pressing), FARP (Plastic injection), FIDIA (Metal industrial equipment)
- **Implementers (IMP):** TIAG (Industrial Communication Protocols and Standards), CESI (Machine tools, Advanced Materials, Micro-technology), AIMP (Thermoplastic and thermosetting plastic materials)
- **Technology providers (TECH):** IBM (Information Technologies Company), ENG (Software and Services Company), ITI (Information Technologies Institute), KBZ (Information Systems Company), EXOS (Operations Consulting Company)
- **Research & development (R&D):** IKER (Technological Centre), BIBA (Research Institute), UPV (Technical University), TUB (Technical University), UNI (Research Institute), CERTH (Research Institute)
- **Specialist Companies:** FBA (Dissemination and Exploitation), IVLAB (Dissemination and Exploitation), DIN (Standardisation), LIF (Legal)

ID	Participant organisation name	Acronym	Logo	Country	Size	Role
1	ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS	CERTH		Greece	RO	R&D
2	ENGINEERING - INGEGNERIA INFORMATICA SPA	ENG		Italy	LARGE	TECH
3	IBM ISRAEL - SCIENCE AND TECHNOLOGY LTD	IBM		Israel	LARGE	TECH
4	INSTITUTO TECNOLOGICO DE INFORMATICA	ITI		Spain	RO	TECH
5	KNOWLEDGEBIZ CONSULTING-SOCIEDADE DE CONSULTORIA EM GESTAO LDA	KBZ		Portugal	SME	TECH
6	EXOS SOLUTIONS SL	EXOS		Spain	SME	TECH
7	IKERLAN S. COOP	IKER		Spain	RO	R&D
8	BIBA - BREMER INSTITUT FUER PRODUKTION UND LOGISTIK GMBH	BIBA		Germany	HSEE	R&D
9	UNIVERSITAT POLITECNICA DE VALENCIA	UPV		Spain	HSEE	R&D
10	TECHNISCHE UNIVERSITAT BERLIN	TUB		Germany	HSEE	R&D
11	UNINOVA-INSTITUTO DE DESENVOLVIMENTO DE NOVAS TECNOLOGIAS-ASSOCIACAO	UNI		Portugal	RO	R&D
12	TTTECH INDUSTRIAL AUTOMATION AG	TIAG		Austria	LARGE	IMP
13	CE.S.I. CENTRO STUDI INDUSTRIALI SRL	CESI		Italy	SME	IMP
14	AIMPLAS - ASOCIACION DE INVESTIGACION DE MATERIALES PLASTICOS Y CONEXAS	AIMP		Spain	RO	IMP
15	FUNDINGBOX RESEARCH APS	FBR		Denmark	SME	SPEC
16	LABORATOIRE VIRTUEL EUROPEEN DANS LE DOMAINE DE L'INTEROPERABILITE DESENTREPRISES	IVLAB		Belgium	OTHER	SPEC
17	DIN DEUTSCHES INSTITUT FUER NORMUNG E.V.	DIN		Germany	OTHER	SPEC
18	PRAVO I INTERNET FOUNDATION	LIF		Bulgaria	OTHER	SPEC
19	WHIRLPOOL EMEA S.p.A.	WHI		Italy	LARGE	USER
20	BIESSE GROUP	BIES		Italy	LARGE	USER
21	FACTOR INGENIERIA Y DECOLETAJE S.L.	FACT		Spain	SME	USER
22	RIA STONE FABRICA DE LOUCA DE MESAEM GRES SA	RIAS		Portugal	SME	USER
23	FARPLAS OTOMOTIV ANONIM SIRKETI	FARP		Turkey	LARGE	USER
24	FIDIA SPA	FIDIA		Italy	LARGE	USER

Thank You!

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https://www.i4q-project.eu/

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