DIGITbrain

2nd Open Call

Short Technical Description

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1. Exec Summary

This document is part of the information package prepared for participants to the 2nd Open Call of the DIGITbrain project. It is intended to give an overview and insight to technical staff of the consortium proposing an application experiment to DIGITbrain.

It is important to note that the DIGITbrain Solution is being developed while experiments are run, i.e. different version of the DIGITbrain Solution will be available at different stages of the project. Thus, this document is structured into three main parts:

1. An introduction to DIGITbrain, its vision and important concepts and terminology.
2. A description of the current version of the DIGITbrain Solution which the experiments selected in the 2nd Open Call shall *integrate* with – we put integrate in italics here, because DIGITbrain as a platform strives for a minimum of integration effort, thus, experiments are rather publishing their tools then integrating them. In the publishing process the tools are described with Metadata and an automated deployment and execution mechanism is provided to minimize the integration and interaction effort with the underlying infrastructure – technical experiment partners hardly/not need to implement "against" a specific API.
3. An Outlook to the envisaged benefits for different experiment participants of the final DIGITbrain Solution.

2. Introduction: vision, concepts, and terminology

2.1. The DIGITbrain Vision

Enabling customised **Industrial Products** and facilitating cost-effective distributed and localised production for manufacturing SMEs, by means of leveraging edge-, cloud- and HPC-based modelling, simulation, optimisation, analytics, and machine learning tools and by means of expanding the concept of **Digital Twin** with a memorising capacity towards:

a) recording the provenance and boosting the cognition of the Industrial Product over its full lifecycle, and
b) empowering the network of DIHs to implement the smart business model "Manufacturing as a Service" (hereafter MaaS).

2.2. Concepts and terminology

Given the above vision, some key concepts and respective terminology are of paramount importance for experiments within DIGITbrain:

- Industrial Products,
- Digital Twins and,
- Product Life Cycle (hereafter PLC)

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Application experiments shall help manufacturing SMEs that produce or use **Industrial Products**, i.e. products that support the production of other products – consumer products are not in the scope of DIGITbrain experiments. Industrial Products are considered being mechatronic systems that can communicate over the Internet and can send and receive data by their own means or by means of attached networked devices (e.g. IIoT devices); such networked mechatronic systems are also referred to as Cyber-Physical Production Systems (hereafter CPPS). CPPS contain sensing, actuating, and controlling capabilities.

Application experiments shall do so by developing, using, exploiting **Digital Twins**. In DIGITbrain Digital Twins are conceived being formal digital representations of some asset, process or system that captures attributes and behaviours of that entity, and suitable for communication, storage, interpretation or processing within a certain context. The Digital Twin information includes, but is not limited to, combinations of the following categories:

- Physics-based model and data,
- Analytical models and data,
- Time-series data and historians,
- Transactional data, master data, visual data and
- Computations performed by executing implementations of algorithms which evaluate models.

According to our interpretation, one Digital Twin of an instance of an Industrial Product comprises all purposes described by the attribute and behaviour information. Different views on a Digital Twins identify individual purposes. One purpose is represented by a tuple referencing **Data, Model and Algorithm**. Each Industrial Product Instance relates to just one valid Digital Twin for any point in time. However, there can be many invalid Digital Twins at the currently considered point in time. Digital Twins are represented in a semantic network by the **Digital Product Brain**.

The DIGITbrain project aims to extend the traditional Digital Twin concept towards the **Digital Product Brain** (hereafter DPB): it is a coordinating entity that guides the behaviour and performance of the industrial product by coalescing its physical and digital dimensions and by memorising the occurred (physical and digital) events over a significant part of its lifecycle. The DPB is intended to be created as early as possible during the lifecycle of the industrial product (ideally during the conceptual design phase) and to accompany the downstream lifecycle phases. From the point of creation onwards, the DPB starts memorising events and its **Assets** (**Data**, **Models**, **Algorithms**, **Resources**) start evolving.

Data or Data resources are considered a main element in Digital Twins (see also definition of DTs above). Data Assets are characterised by the following aspects:

- type of content, e.g. engineering, material, production, distributions, sensor, customer, environmental impact data
- type of appearance, e.g. files, streams, databases
- format and structure of the data source

Data in the context of DIGITbrain are actual data sources acting as inputs for Models and Algorithms.

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A **Model** is considered to be a description of a certain behaviour of/for an Industrial Product according to the given characteristics and operation conditions. Evaluating a Model serves one or more purposes, e.g. detect critical deformations implied by forces. A Model can be shared across Industrial Product Instances, as long as they share the same configuration and characteristics. The creation of a model requires domain knowledge related to the Industrial Product. The creation of a model could be accomplished by either:

1. manually editing a description (editing a file / interacting with a GUI) resulting – for instance – in a YAML/XML/proprietary file; or
2. processing / analysing data / simulation results to generate / derive / deduct a behaviour description, e.g. AI-trained model, reduced-ordered model, design-of-experiment model.

Model Assets are characterised by the following aspects:

- type, e.g. material, functional and behavioural, semantic and/or analytical models form, e.g. files, containing for instance SysML, Ansys input decks, etc.

Models shall be created as independent as possible from Microservices so that different Microservices may be used to evaluate a Model of the same type – for an experiment, it is sufficient to provide one Microservices that evaluates the respective Model.

An **Algorithm** consists of one or more Microservices. Microservices may evaluate Models, map data from data sources, e.g. sensors, into Models, etc. The Microservices that constitute the Algorithm, can be deployed into different compute resources (e.g. edge, cloud, HPC) for execution. Compute resources are chosen depending on the resource needs of the Algorithm's Microservices either being Cloud resources provided via EGI or accessible local ones residing in the production sites of the respective manufacturing SME.

A **Microservice** "encapsulates" an executable procedure in a containerised form, e.g. in a Docker container. DIGITbrain offers automatic deployment which requires Microservices to be containerized and provided as Docker containers. Experiment partners may need to containerize their Microservices. In some cases, modularization of existing software may be required to facilitate the execution of some functionality on a remote compute resource (Cloud) and some other modules locally.

Microservices may deal with some of the following types of functionalities, e.g.:

- Evaluate a Model (with the associated Data)
- Connect to a Data resource
- Filter and aggregate Data
- Communicate with other services

Since Model evaluation is key in the context of Digital Twins, below we further elaborate on examples for kinds of Microservices that evaluate different types of Models, e.g.:

- Microservices for solving partial differential equations (PDEs) and / or differential algebraic equations (DAEs) and / or for discrete event simulation (DES)
- Machine Learning Microservices and Scientific Machine Learning Microservices, e.g. generating/evaluating reduced-order models (ROMs)
- Life-cycle assessment Microservices

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Microservices may be able of evaluating different types of Models. Models of the same type may be evaluated by different Microservices. Microservice are agnostic w.r.t. instances of Industrial Products (e.g. their application field or the context in which a Model is being used). Microservices can be deployed into different resources (e.g. edge, cloud, HPC) to be executed.

Six stages in the PLC have been identified to which **DIGITbrain relates to**:

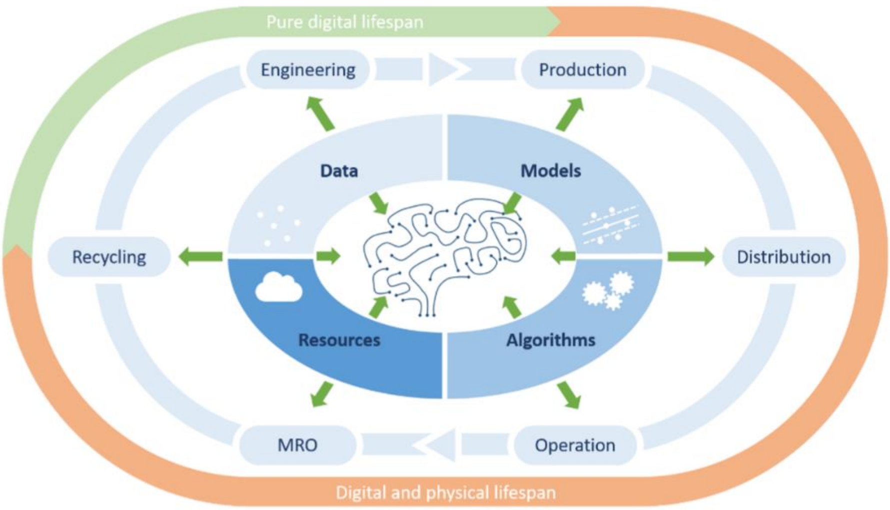

Figure 1: High-level architecture of the initial DIGITbrain Testbed

1. **Engineering covering**
    a. Design
        i. Design a new Industrial Product (IP)
        ii. Adapt it based on insights derived from the DIGITbrain
        iii. Re-design and evolve an IP to a next-gen version
    b. Engineering
        i. virtual testing/simulating
        ii. physical testing/simulating

2. **Production covering**
    a. Production engineering / Production planning
    b. Producing and monitoring
    c. Quality assurance

3. **Distribution**

    This relates to the "distribution" of production capacity.

4. **Operation**

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This is the operation of an Industrial Product in/on a manufacturing facility. The manufacturing facility can be a factory building, plant, even a farmer's field where IPs are used to harvest natural goods.

Improvements in the operation phase aim for faster adaptation of operation to changing requirements. The idea is to use knowledge represented in DIGITbrain and the Digital Twins to facilitate changing faster and easing the virtual testing phase before applying the change on an IP.

5. **Maintain, repair, overhaul (hereafter MRO)**

   Provided the corresponding Digital Twins, DIGITbrain can help to identify maintenance needs and be used for predictive maintenance measures. Digital Twins may help to prevent damages to IPs.

6. **Recycling**

   The Life-Cycle Assessment (LCA) activities and models within DIGITbrain are addressing recycling and support to evolution of ever more environment-friendly IP design and operation of IPs.

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3. The DIGITbrain Solution for experiments of the 2nd Open Call

The development in DIGITbrain started with a testbed infrastructure. Currently, the first version for the experiments of the 1st Open Call is under implementation – second wave of experiments. This version will be further matured when the experiments of the 2nd Open Call will enter the project. The versions of the DIGITbrain Solution are constantly extended with new components and functionality from core partners and by assets and tools from experiment partners (Third Parties) as they become available during the lifetime of the project. The final version of the DIGITbrain Solution populated with results from the experiments is expected to be in close-to-production quality ready for commercialisation and wider exploitation.

The DIGITbrain Solution comprises a platform with platform components and an associated Digital Marketplace, the Digital Agora.

This section introduces the high-level design of the DIGITbrain Solution (short: Db Solution). The high-level architecture is provided in Figure 2 and integrates five facets:

1. Stakeholders (user roles) and involved asset types
2. The process of publishing assets and generating Digital Twins
3. Major components of the Db Platform architecture and their interaction
4. The process of deploying, executing and monitoring DMA Tuples constituting Digital Twins
5. Involved resources "outside" the Db Platform, mainly resources of/from the production sites (e.g. a manufacturing facility) and remote compute resources (e.g. Cloud resources, HPC facilities)

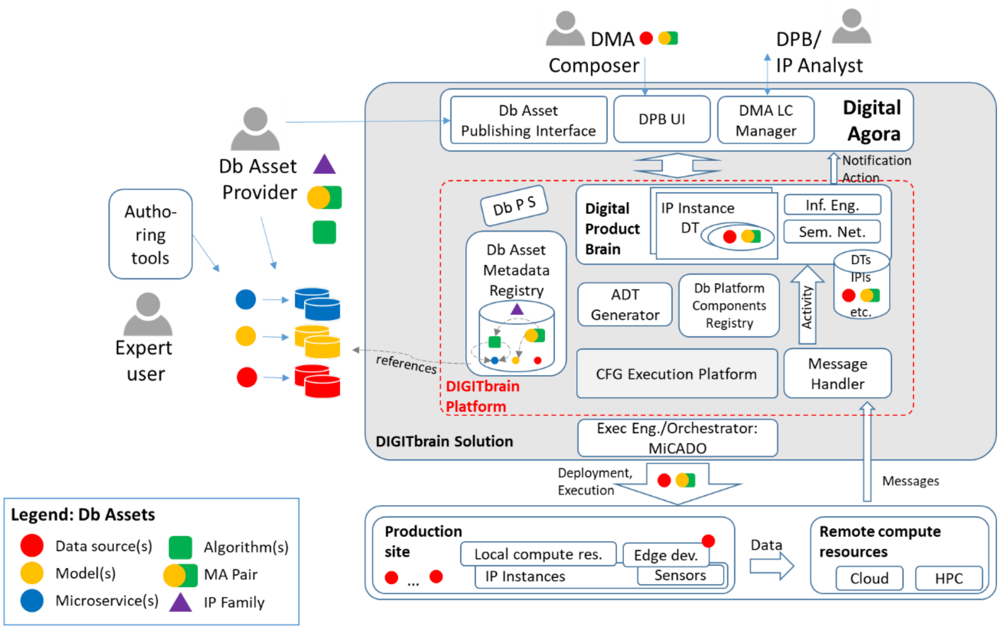

Figure 2: High-level design of the Db Solution

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In the following, we describe each of the five facets in the relevant context.

One of the **guiding concepts** in the Platform conceptual design and architecture is the strive for **separation between Data, Model and Algorithm**. Treating them as distinct concepts aims

- to **maximise potential re-use** of actual instances of these three kinds of concepts, as well as
- to **enable monetisation of all three** independently via a Digital Agora, in the future.

As explained above, Data, Model and Algorithm are three key building blocks for Digital Twins. The motivation behind the separation is to allow for faster creation of Digital Twins by combining individual Models with new Data sources while keeping the actual Algorithm that evaluates a Model also flexible to the largest extent technically possible. Thus, this separation shall constitute one of the contributions to the openness of the platform to not bind all the assets from the beginning (publishing a DT as one monolith) but to allow for re-combination and re-use at the latest possible stage. Making use of existing assets also has the potential to speed up the creation of Digital Twins. For this end, the assets have to be described to be found for being re-used in new combinations. All assets are described by metadata to allow users in different working with the Db Platform to retrieve assets from a metadata registry, thus, that the assets can be re-used for different IP instances or IP families – individual assets may be re-usable across IP families or even instances depending on content and universality.

Experiments are expected to follow the principle of separation between Data, Model and Algorithm to allow for deploying Algorithms on different compute infrastructures to evaluate different Models and feed Models with Data from different Industrial Products. A goal which seems obvious but not always supported in Cloud Computing and with Digital Twin technology.

3.1. Authoring Tools and Authoring by Expert Users

On the very left of the high-level architecture diagram (Figure 2) we have depicted Expert Users using Authoring Tools to create digital assets. While the types of asset Data and Microservice are seldomly authored, authoring is relevant for Models, especially for physics-based models since ML-based models are “trained” not authored by an expert. Since Models shall represent a behaviour of an Industrial Product, typically a domain expert is required to generate (“author”) the Model: the expert user.

Different kinds of assets are created with different kinds of Authoring Tools. Authoring Tools can range from text editors to interactive applications. For instance, Authoring Tools for models typically store it in one or many files and usually they also provide functionality to test/check whether a model behaves as expected, within reasonable bounds/tolerances/ approximation thresholds and/or runtime, depending on the purpose of the model.

In some cases, Authoring Tools are modular: they provide one module (with a user interface) to create a model, a distinct back end to evaluate a model, and possibly another module with UI to visualise and explore the results generated by evaluating the model.

In any case, the Db Platform is designed to leverage Authoring Tools in two ways:

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- as Microservices as a whole or potentially derived from modules of the Authoring Tools by the Microservice / Algorithm Provider.
- as properties within the Digital Agora so that Expert Users can use them as enablers for the digital transformation of manufacturing SMEs for more affordable creation of Digital Twins.

Experiments are expected to bring their own Authoring Tools for further populate the offers of Db.

Some Authoring tools already exists within DIGITbrain that can be used for realising experiments, however new Authoring tools are welcome in order to enrich the power of the DIGITbrain Solution and become part of the Digital Agora at the end of the experiment. Current DIGITbrain authoring tools include:

- Into-CPS App: an Authoring tool to compose co-simulation scenarios out of FMUs (provided by Aarhus University) – NB: the FMUs have to be provided by the experiment from Third party tools

- DDS Solution: an Authoring Tool for discrete event simulation of manufacturing lines (by Technology Transfer System)

- CAELLA: an Authoring Tool to create reduced-order models (ROMs) (by ITAINNOVA)

- PreSTRA: an Authoring Tool to create finite element models for structural analyses for the RISTRA solver (by Fraunhofer)

If an application experiment wants to make use of any of those Authoring tools, we highly encourage to get in touch with the respective experts and discuss the possibilities and limitations of these tools to be sure they deliver what the experiment requires in case of getting selected.

3.2. Asset Providers, Assets and Publishing

As stated before, in Db **integration** is largely done be providing digital assets in certain forms, i.e. **publishing** them to the Db Solution to make them known to Db. Publishing here refers to providing a reference to the respective location and specifying the metadata describing the Asset.

This is done for different types of Assets by users acting in the role of Asset Providers, namely Model Provider, Microservice Provider, etc., using the Asset Metadata Publishing Interface of Db:

- a Data Provider publishes one or many Data resources,
- a Microservice Provider publishes one or many Microservices and
- a Model Provider publishes one or many Models.

Other types of Assets are created via the Db Asset Metadata Publishing Interface in a slightly different form, e.g.:

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- an Algorithm is created by instantiating and filling the respective metadata referencing the Microservices the Algorithm.

Data is not required to be uploaded (published) to a central repository, instead the platform is designed to support distributed data and access to different repository technologies, databases or data sources (also located within the production sites, e.g. sensors) through dedicated Microservices. The Data resources need to be described by metadata, publishing Data tickles down to describing the characteristics of the Data source in the Db Metadata scheme. Access to data sources is realised by existing and to-be-published Microservices which can be re-used to access respective, compatible Data sources. Microservices realising access to certain types of Data sources shall become part of the offering of the Digital Agora – as all other Micoservices – contributing to monetarise the results of the experiment and generating revenue for the Microservice provider.

3.3. DMA Composing and Publishing

Out of the Assets being published by the Asset Providers, a user in the role of a DMA Composer - where D, M and A stand for Data, Model and Algorithm - is becoming active next. Out of all the Assets already published, the DMA Composer creates a tuple of Assets (D, M and A), a DMA Tuple, instantiating the behaviour described in a Model for an instance of an IP (e.g. an instance of a manufacturing machine).

As – in general - individual instances of manufacturing machines have their individual sensors (Data sources), this instantiation "binds" an individual Data source to a pair of MA Assets allowing for capturing/monitoring the individual behaviour of this particular IP Instance.

To perform the above task, the DMA Composer will use the Digital Product Brain User Interface (DPB UI). The DPB UI will interact with the Digital Product Brain. The DPB has its independent data storage and management subsystem where – amongst other things - metadata related to IP Instances and DMA Tuples is stored.

The separation between the two Db Platform Components, *Asset Metadata Registry* and *Digital Product Brain* with respect to metadata takes into account future deployment scenarios and data sovereignty. This way an Asset Metadata Registry can be deployed centrally whereas "local" Digital Product Brains can be supported; local with respect to the boundaries of the future clients from the manufacturing sector respecting their data sovereignty needs and requirements, thus, contributing to security and acceptance of the Db Platform in commercial settings.

3.4. Deployment and Execution

Before a DMA Tuple can be deployed and executed, the compute infrastructure has to be selected, i.e. the local or Cloud resources to be used to execute the Algorithm, evaluate the Model and process the Data. The DMA Composer may select from available resources based on requirements, costs of different providers, etc. The selections become part of the metadata.

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The Db Platform supports automated deployment of the composed DMA Tuples on the targeted and specified computing infrastructures. For this end, the Db Platform Component called *ADT Generator* (Application Description Template Generator) extracts metadata via the APIs of the *Asset Metadata Registry* and the *Digital Product Brain*. It compiles an ADT file, so that the Execution Engine / Orchestrator, MiCADO [1], can deploy all containerised Microservices belonging to the Algorithm to the respective compute resources and serve them with information about the Model and Data sources to be used.

3.5. Monitoring and Massaging

Currently under design is a concept to monitor the execution of DMA tuples in a homogeneous manner, i.e. not just monitor if the Microservices are still running but more importantly provide a mechanism with which intermediate or final results of the Model under evaluation can be checked against described conditions and messages being send if those conditions apply.

These concepts are planned to be tested with experiments of the 2nd Open Call. So, experiments partners will be introduced to the details of describing Conditions and linking their Microservices to the unified concept at experiment begin. The experiments will benefit from the eased handling of condition monitoring and the information being automatically memorised in the Digital Product Brain going to be implemented in this mechanism by technical core partners:

- While a DMA Tuple is executing / running - it can be as long as the corresponding IP Instance is operating – the Algorithm can contain the Condition Evaluator to send Messages to the Message Handler that will belong to the Db Platform.

- Algorithms are supposed to integrate and interface with the Condition Evaluator (CE) sending Messages to the Message Handler based on Conditions, more specifically, if unexpected symptoms appear. For instance, if a Machine Learning Model (ML Model) detects an abnormal signal in sensor data being processed, the Algorithm (Microservice) evaluating the ML Model sends information to the CE which unifies interaction with the Message Handler and sends a message. Another example: when a simulation Model predicts a heat-induced deformation (heat/temperature data comes from sensors, deformation is simulated) that exceeds a tolerable threshold and that may lead to unacceptable wear and tear or can even lead to damage / break-down of the machine, the CE integrated into the Algorithm evaluating the Model sends a Message.

3.6. Memorising Events in the Digital Product Brain

The above Messages will be interpreted as Activities by the Message Handler, worth memorising in the event-centric semantic network of the DPB and yield Notification Actions to the user of the Digital Agora. The Db Platform foresees to send a signal directly to the machine operator or even to the IP Instance, e.g. to slow down operation or eventually stop operation.

[1] For further information go to: https://micado-scale.eu/

3.7. Events, Activities, Actions and the role of DPB / IP Analyst

The last indicated role in Figure 2 that we have not yet detailed, is the one of the DPB / IP Analyst. The DPB / IP Analyst is using the DMA LC Manager (DMA Lifecycle Manager) to interact with DMAs and DTs belonging to IP Instances.

The management tasks comprise but are not limited to:

- setting DTs as valid/invalid for an IP Instance. (NB: Since we handle history and provenance in DPB, a DT can have a certain lifespan for which it is representative for the given IP Instance. The IP Instance may undergo some changes, e.g. maintenance, which may render a DT obsolete and be replaced by another DT capturing the behaviour of the maintained IP Instance),
- managing DMA Tuples and their dependencies within a DT,
- running analysis / inference over (parts of) the DPB content, e.g. trying to identify cohorts of IP Instances and outliers and trying to learn what caused a subset of IP Instances to become outliers.

4. Final Db Solution and expected benefits for stakeholder

In this chapter, we sketch out the purpose of the Digital (Product) Brain – already mentioned in chapter 2. The Digital (Product) Brain (DPB) functionality is under development. It is meant to provide various benefits to different stakeholders in different use scenarios along the product's life cycle in the final DIGITbrain Solution.

As mentioned in the introduction (chapter 1 of this document), the **Digital Product Brain** is a coordinating entity that shall guide the behaviour and performance of an Industrial Product by coalescing its physical and digital dimensions. The physical dimension being the instance of an Industrial Product – the machine – itself, whereas the digital dimension being represented by a Digital Twin. The Digital Product Brain will memorise the occurred (physical and digital) events and all Assets related to the Digital Twin and Industrial Product (instance), respectively. For example, changes made to a Digital Twin, e.g. improvements made to Models, insights created from Model execution, are considered events that are memorised. The Digital Product Brain is intended to be created as early as possible during the lifecycle of an Industrial Product and to accompany the downstream lifecycle phases.

The final DIGITbrain Solution will have a user interface to the Digital Product Brain, where persons acting in the role of an Analyst of Industrial Products can configure Digital Twins, perform analysis based on rules triggered as well as navigate the provenance and evolution of IP published to the DIGITbrain Solution over their product's lifecycle. Provenance may be even available beyond the lifecycle of one IP comprising the impact of insights gained by analysis on improved versions and new generations of IPs.

The tables below summarize the envisaged benefits of the final DIGITbrain Solution for stakeholders such as:

a) Manufacturers of Industrial Products (manufacturing machinery, CPS)

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b) Manufacturing companies (users of Industrial Products)
c) Algorithm Providers/Suppliers (ISV / VAR)
d) Model Providers/Developers (ISV / VAR/ Consultants)

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a) **Manufacturers of Industrial Products (manufacturing machinery, CPS)**

Manufactures of Industrial Products have clients that use their IP Instances to produce goods – the latter are manufacturing companies using Industrial Products.

Who?	Manufacturers of Industrial Products (manufacturing machinery, CPS)
Which benefit?	DIGITbrain Solution as a central point of access to information on virtual IP Instances and families of Industrial Products • Easier and faster creation of Digital Twins • Flexible execution on different resources • Documentation of evolution across engineering domains, data involved (consumed and generated) • Comprehensible decision-making
How?	Manage and maintain information (Assets) related to virtual IP Instances and families of Industrial Products: • Manage the Assets • Create Digital Twins • Evaluate Models and execute Algorithm on local and remote resources to perform virtual simulations • Use simulation results to refine digital models • Document and track the provenance of evolution
Where/when in PLC?	Engineering
Which benefit?	DIGITbrain Solution as a central point of access to information on physical Industrial Product Instances (hereafter IPIs) manufactured
How?	Document each IPI produced in DIGITbrain Solution: • Its configuration • QA results • the client • etc.
Where/when in PLC?	Production

Which benefit?	DIGITbrain Solution as a central point of access to information from Industrial Product Instances (IPIs) “working in the field”, i.e. the ones delivered to customers in order to:
	• Optimize settings for IPIs
	  ○ Maximize output
	  ○ Reduce energy consumption
	  ○ Reduce wear and tear
	• Minimize break-down times in a MaaS setting
	• Learn from the data/insights to improve next product generation
	• Improve customer experience (customer = IPI Operator)

How?	Collect and analyze information provided by IPIs (sold and/or rented ones - MaaS) • monitor their status • run simulations / evaluate models with data from the field (real conditions) • create insight from data & results • feedback insight to product development (Engineering stage) • inform clients

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	○ how to optimize settings for IPI for their conditions ○ to update the "firmware" ○ etc. Analysis can be done across the multitude of IP instances independent from their location and the IPI Operator. Behavior of individual IP instances can be compared with Digital Twins a family of IPs, e.g. • to identify outliers, • find cohorts (clusters) of IPs experiencing similar conditions, • adjust Models for a family of IPs.
Where/when in PLC?	Operation
Which benefit?	DIGITbrain Solution as a central point of access to information from Industrial Product Instances (IPIs) "working in the field", i.e. the ones delivered to customers in order to: • schedule maintenance events minimizing negative impact on production • minimize maintenance duration / down-times • postpone or avoid repair by adjusting IPI to actual load case / use scenario (cmp.: drive slower to burn less energy)
How?	Similar to the Operation phase above, but with different Models / Data.
Where/when in PLC?	Benefits in MRO

NB: the benefits depend on the Models published to DIGITbrain Solution.

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b) Manufacturing companies (users of Industrial Products)

Manufacturing companies, i.e. the operators of IP Instances, use instances of Industrial products to produce goods. The main product lifecycle stage they benefit in, thus, is operation.

However, they may also:

- pursue activities in the planning phase (production planning) how to best use the available IP Instance for their production – this is considered operation planning in the table below,
- plan how to distribute and deploy the IPIs for producing, esp. when the IPIs are mobile,
- run their own MRO activities as some actually do or
- even consider re-purposing (parts of) the IPIs and recycle others.

Who?	Manufacturing companies (users of Industrial Products)

Which benefit?	Especially in case of mobile IP Instances:
	• better planning of how and where to deploy the IPI to
	    o maximize occupancy rate of IP Instances (maximizing through- and output)
	    o faster react to changing conditions

How?	• Knowing demands and run production/operation planning simulations to optimize "distribution" of production capabilities represented by the (mobile) IP Instances
Where/when in PLC?	**Distribution**
Which benefit?	Manufacturing companies uses the Assets within DIGITbrain Solution (its installation – likely to differ to quite an extent from the one of the IP Manufacturer) to • better plan their production of goods • maximize occupancy rate of IPI (maximizing through- and output) • gain agility in re-planning-faster re-planning • detect issues quicker • detect issues earlier • explore alternatives solutions • find optimal settings faster – optimizing IPIs to operation conditions • improve quality of production
How?	Exploit information referenced, managed by DIGITbrain Solution as a central inventory of IP Instances and data/results provided by them to: • monitor operation status and conditions • get warnings if rules trigger • analyze data, not just single sources but in conjunction • exploit the Digital Twins of the IP Instances, ideally provided by the IP Manufacturer and accessible via DIGITbrain • re-use, re-purpose, extend DTs • create and integrate additional Digital Twins in DIGITbrain – easier/faster development of Digital Twins using the authoring tools

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	and search and browse functionality for Assets of DIGITbrain and DIGITbrain for deployment • run and re-run Digital Twins - easy use and deployment of Digital Twins • gain insights from data analytics and simulation results • inform workers to change settings of IP Instance
Where/when in PLC?	**Operation**
Which benefit?	• Minimize maintenance work and efforts • Predict maintenance necessities • Minimize and schedule repair efforts • Minimize wear and tear • Better plan overhauling
How?	See IP Manufacturer
Where/when in PLC?	MRO

NB: the benefits depend on the Models published to DIGITbrain Solution

c) Algorithm Provider/Supplier (ISV / VAR)

An Algorithm Provider may be able to expand the use of its Algorithm and generate additional revenue, e.g. based on pay-per-use models whenever the Algorithm is run as a part of a Digital Twin.

The Algorithm Provider is expected to present its profile and Algorithm also via the Digital Agora, part of the DIGITbrain Solution. The Digital Agora provides an additional marketing channel for the Algorithm provider to become better known in the manufacturing market sector on a European scale.

d) Model Provider/Developers (ISV / VAR/ Consultants)

A Model Provider may be able to expand the use of its Model and generate additional revenue, e.g. based on pay-per-use models whenever the Model is evaluated by an Algorithm run from a Digital Twin.

The Model Provider is expected to present its profile and Models also via the Digital Agora, part of the DIGITbrain Solution. The Digital Agora provides an additional marketing channel for the Model Provider to become better known in the manufacturing market sector on a European scale.

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5. What technical developments do technical experiment partners have to do?

There are two categories of technical activities for experiment partners to be performed:

a) Technical developments within the respective experiment according to the technical concepts and design principled described above
b) Technical provisioning (Assets and Metadata) to the DIGITbrain Solution

Regarding a)

Technical development within an experiment typically comprises:

- Design, develop, apply, verify Digital Twins for instances of Industrial Products and selected behaviour.
- Provide / adapt corresponding software tools: simulation, optimisation, analytics, machine learning, etc.
- Leverage edge-, cloud- and HPC-based computing.
- Provide Assets: Model, Data, Algorithm, on repositories.
- Provide connectors to factory data sources if experiment requires.
- Provide Apps for visualizing results of Model evaluation and human computer interaction
- Showcase benefits for:
    - Customisation of Industrial Products / Production Processes,
    - Cost-effective distributed and localised production,
    - Evolution and improvement of next generation Industrial Products

  by applying Digital Twins:
    - on one instance of Industrial Products.
    - on many instances of Industrial Products (cohort analysis).

Regarding b)

Technical provisioning of Assets and Metadata to DIGITbrain Solution comprises (mandatory):

- Containerization of software tool(s) aka Microservices:
    - Docker and Linux preferred, deployment is automatic
    - Data connectors are considered Microservices and need to be developed/provided by the experiment
- Optional: modularization of existing software tool(s)
- Publishing Algorithm, Model and Data to the DIGITbrain Solution via DIGITbrain Asset Publishing Interface
- Defining Conditions and actions to be triggered via the Digital Product Brain (Conditions act on output of evaluated Models).
- Providing Metadata for Assets according to existing Db Metadata scheme

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- Optional: providing visualisation app with specific functionality, e.g. acting on data generated by the Digital Twin
- Registering Assets with the Digital Agora
- Publish profile in Digital Agora

NB: There are some other non-technical tasks expected to be done by experiment consortia – please refer to the Proposal Template for more details.

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