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D5.1 Technical report on ReconCell model for business intelligence, part 1

Executive Summary

This report contains deliverable D5.1 Technical report on ReconCell model of business intelligence, part 1 as outcome of progress made within Work Pakage 5 (WP5) Business Intelligence (BI). It describes the concept of Reconcell BI system.

WP 5 is concerned with planning and implementing a business intelligence solution to support ReconCell business model. ReconCell business model consists of two layers; ReconCell ltd and ReconCell Systems. ReconCell System is a robot based reconfigurable autonomous assembly system and ReconCell Ltd a company providing these cells and supporting their life-cycle and providing related services. This document describes the business model and the business intelligence solution that supports it. It provides the background and motivation for used approaches and selected tools as synthesis of the workshops held with ReconCell business team, industrial partners and collaborative partners. Also integration issues with other Work Packages and ReconCell as whole are discussed and solution approaches presented. This report provides the first Business Intelligence system(BI) intention description, and the first concepts that support chosen two layer product service system business model of ReconCell Inc and related ReconCell system implementations over their life-cycle.

The task is carried out by HERMIA and supported by all partners of this task.

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Used Terminology

ADOxx.	Development platform, metamodelling development platform for implementing modelling tools
ADONIS	Commercial Business Process Management and Notation (PBMN) toolkit.
AIF	ATHENA Interoperability Framework
ASOA	Advanced Service-Oriented Architecture
ATHENA	Advanced Technologies for Heterogeneous Enterprise Networks and their Applications
BI	Business Intelligence; Business Intelligence is a set of methodologies, processes, architectures, and technologies that transform raw data into meaningful and useful information used to enable more effective strategic, tactical, and operational insights and decision-making. Business Intelligence tools use Business Process Modelling and Analysis to produce process knowledge.
BIF	Business Interoperability Framework
BM	Business Model (BM); BM has two parts: “Part one (organizing) includes all the activities associated with making something: designing it, purchasing raw materials, manufacturing, and so on. Part two (functional) includes all the activities associated with selling something: finding and reaching customers, transacting a sale, distributing the product, or delivering the service.
BM Canvas	Business Model Canvas is an organized way to lay out your assumptions about not only the key resources and key activities of your value chain, but also your value proposition, customer relationships, channels, customer segments, cost structures, and revenue streams.
BMI	Business Modelling and Integration. BMI provides standard integrated models to support management of an enterprise. It is developed within OMG (http://bmi.omg.org/)
BPM	Business Process Management (BPM) is a discipline within management system involving any combination of modeling, automation, execution, control, measurement and optimization of business activity flows, in support of enterprise goals, spanning systems, employees, customers and partners within and beyond the enterprise boundaries. It is part of Business Intelligence”
BPMN	Business Process Model and Notation (BPMNN) will provide businesses with the capability of understanding their internal business procedures in a graphical notation and will give organizations the ability to communicate these procedures in a standard manner. Furthermore, the graphical notation will facilitate the understanding of the performance collaborations and business transactions between the organizations. This will ensure that businesses will understand themselves and participants in their business and will enable organizations to adjust to new internal and B2B business circumstances quickly. (OMG definition)
BPML	Business Process Modelling Language is a XML-based language for business process modeling and enrich UML with process notation. It is supported by OMG.
EIF	European Interoperability Framework
Eclipse	Eclipse Foundation is an open source community, whose projects are focused on building an open development platform.
eBAM	Eclipse extended Business Activity Monitoring platform for the monitoring of heterogeneous services and applications (infrastructures, processes, components) and the historical analysis of data. Integrates with SpagoBI suite
FEI	Framework for Enterprise Interoperability
FRISCO	Framework of Information System Concepts
GD3	Good Discussion, Good Design, Good Dissection; Cyclic system design procedure of TQM (Total Quality Management) and ISO 9000.
HERMxx	Higher-order entity-relationship modelling development platform
ICT	Information and Communication Technology

KMP	Knowledge Management Process; representation, acquisition, search & retrieval and maintenance of domain knowledge. (used by IBM Watson Analytics and ADONIS)
macroxx	Macro level in BI refers to general framework for business process associated with strategic business environment.(ReconCell ltd)
microxx	Micro level in BI refers business entity level and business operations
OMG	The Object Management Group® (OMG®) is an international, open membership, not-for-profit technology standards consortium, founded in 1989. OMG standards are driven by vendors, end-users, academic institutions and government agencies. OMG also managed the Industrial Internet Consortium.
OSI	Open System Interconnection
OMiLAB	Open Models (OMi) Laboratory, environment for modelling method engineering
PSS	Product Service System (PSS) a business model that consist of tangible products and intangible services designed and combined for jointly fulfilling specific customer needs.
RAMI	Reference Architechture Model for Industrie 4.0 (https://www.plattform-i40.de/)
SMEs	Small and Medium-sized Enterprises
SpagoBI	SpagoBI is an Open Source Business Intelligence suite. (https://www.spagobi.org)
SOA	Service-Oriented Architecture
SCM	Supply Chain Management
TQM	Total Quality Management, Transformation management based management philosophy that concentrates on constant improvement of quality of business, product and production processes after sales service, quality of management, the company itself and the human life.

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WP5 Business Intelligence

Introduction

State- of- the- art robotic automation is considered economically infeasible especially for many SMEs due to markets growing demand of shorter product life-cycles, small batch sizes, fast delivery, high quality standards and even one -of-kind production and coping with fluctuating demand. This is causing planning, set-up, ramp-up and maintenance complexity that exceeds their capabilities, takes too long and rises the costs excessively. [1] [2] [3] [11][12].

According to the [International Federation of Robotics] IFR World Robotics 2009 the cost of deploying an automation system can be split into 20 % to 25 % for the robot, 20 % to 30 % auxiliary hardware, and 45 % to 60 % systems integration [4]. This fact was noted also in discussions with ReconCell case companies.

Therefore ReconCell projects sets to develop an easy to (re-)configure and (re-)program workcell for assembly and a supporting service platform making ReonCell robot solutions economically viable in current business environment even for manufacturing SMEs. It will reduce integration cost and time as well as improve process quality and efficiency and costs of the hardware by efficient modularization, process base knowledge sharing and benchmarking with reuse and sharing of resources. This is achieved by reducing set-up, ramp-up and life-cycle maintenance effort substantially achieving very short, self-adaptable and affordable changeovers under the conditions demanded and based on end-user needs. This will be achieved with the minimum need of additional resources over the system's lifetime leading to reduced costs of ownership.

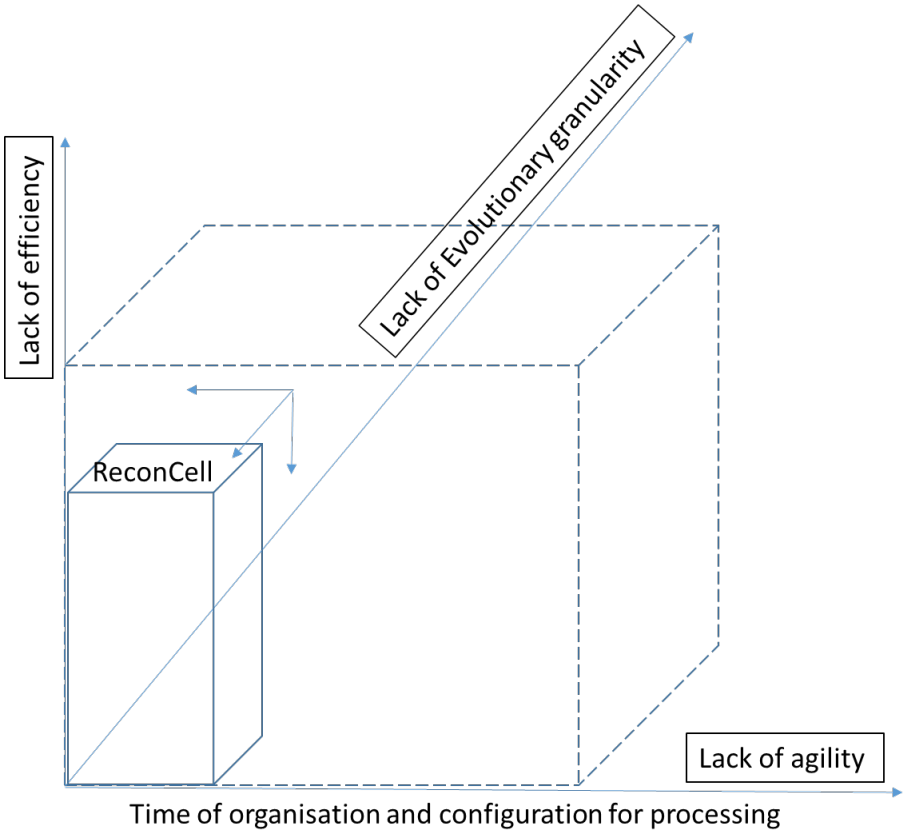


Figure 1: ReconCell Product Service System (PSS) Business Model increase agility, evolutionary granularity and efficiency of processes [7]

ReconCell business model is required to be:

- efficient (low cost per minimum amount of transaction in the operational stage),
- agile (low lag in setting up new or modified processes), and
- able to evolve their process space based on new ideas, low lead costs for setting up new or modified processes by virtual development and accessing networks assets.

ReconCell project has chosen to use Product Service System (PSS) [8] approach to Business Model (BM) developement. BM has two parts: Part one (organizing) includes all the activities associated with making something: designing it, purchasing raw materials, manufacturing, and so on. Part two (functional) includes all the activities associated with selling something: finding and reaching customers, transacting a sale, distributing the product, or delivering the service. ReconCell PSS is a layered concept where the service layer maintained by ReconCell ltd identify potential target groups based on synthesis of own and market possibilities. Selected groups are contacted and together with customers begin with building functional case intention against suitable concept variants by modelling and analyzing for the assembly case needs both for technical and business requirements. The work is supported by the process based knowledge elements that allow simulation [5]. Business intelligence and analysis module provides for process analysis against decisive Key Performance Indicators (KPIs) based on carefully defined Objectives and Key Results (OKR). On approval, the system design (organizational) for implementation of the ReconCell System solution takes place with efficient virtual and real tests and constant improvement with re-configuration on the need is supported over its life-cycle.

Within the project the demonstration of the capabilities of the layered ReconCell approach is done on three real use cases provided by the industry partners (SMEs) of our consortium and later with two more use cases, established through an open call.

Business team

ReconCell Business Model and supporting environment is developed by an internal “business team” consisting of experts from Hermia, MMI, JSI and BOR. This “business team” is responsible for defining and developing an integrated system for envisioned Product Service System (PSS) [8]. It´s primary task is to support decision making by providing analysis of economic and technical viability of the planned actions. The envisioned support system consisting of Business Assessment (BAT), Business Intellligence (BI) and VEROSIM modules is intended to support decision making in marketing, sales, implementation, use and services phases. The integrated approach consists of:

- pre-sales marketing and sales process and management supported by business assement developed by BOR,
- ReconCell intention building configuration, virtual verification and implementation planning supported by business Intelligence and system design management,
- organisation of implementation, intelligent use, control and re-configuration support during life-cycle supported by verified business and technical processes as knowledge elements.

Relevant processes are described and supported by integrated tool environment consisting of:

- Business Assessment System (BAT) developed by BOR. BAT is a system that connects a ReconCell Solution with its potential customer base at an early stage. It helps a business developer (sales person) with the initial customer communication.
- VEROSIM developed by supported by MMI (WP4). VEROSIM is a system for (re-) configuration and (re-) programming using a comprehensive, functional 3D virtual model of the system, which support simulation, automated simulation-based optimization as well as simulation-based control of the assembly cell.

- ReconCell BI (Business Intelligence) a collaborative platform that integrates business process management PBM (Business Process Management), business process modelling and Notation PBMN (Business Process Modelling and Notation) and business process analytics to a comprehensive decision support and process based knowledge management system.

WP 5 Tasks, approaches and results

WP5 Business Intelligence is a collaborative effort of ReconCell "Business team"; Hermia, MMI, BOR and JSI and industrial cases LDT, ELVEZ, and PRZM. It`s main responsibility is to develop business model and integrated platform that can support it. The adaptation of ReconCell is done using three steps synthesis (intention building), analysis (implementation concept building) and intelligent use (continuous improvement by reconfiguration and knowledge building). The support platform consists of business assessment developed by BOR, business process management developed by Hermia and system design management developed by MMI and JSI to allow efficient set up of ReconCell network and allow constant improvement in efficiency, agility and evolution of both Reconcell ltd and implemented ReconCell systems. It is envisioned to use state-of-the-art established standards and solutions. ReconCell Business team has established also a collaboration platform using Sharepoint.

ReconCell WP5 Business Intelligence (BI) consists of four tasks:

5.1 Business requirements synthesis, (Intention-based Business Model): details about the strategic and operative demands derived from real industrial cases.

5.2 Business model implementation (Concept-based Business Process Modelling): alternative basic paradigms, agile and lean, supports fast configuration of four interacting strategic resources: capabilities, competences, collaboration, and knowledge.

5.3 Intelligent use of business model (Implementation and Use): this task concentrates on the application of the developed system and on setting-up a knowledge model to support fast order changeovers and prediction-based order management.

5.4 Standards and state of the art benchmarking (Development): this task ensures efficient use of the most current standards.

Business model

Business Model describes the business logic of ReconCell Inc and it is described in D7.2 (3.1) using BM Canvas approach (D7.2) for organized way to lay out assumptions about the key resources and key activities of ReconCell value chain and value proposition, customer relationships, channels, customer segments, cost structures, and revenue streams. ReconCell project has decided to use Product Service System (PSS) [8] approach as basis for business model development. The PSS business model (BM) concept has three interacting processes and two layers that are supported by BI. The three processes are system design that includes all the activities associated with making and maintaining a re-configurable assembly cell: designing it, manufacturing that includes all activities associated with purchasing raw materials, manufacturing and all related processes and customer service that includes all the activities associated with selling and maintaining customer base: finding and reaching customers, transacting a sale, distributing the product and delivering the service. The two interacting business layers are ReconCell Ltd layer and the layer of implemented ReconCell systems at customer's business processes. The management of this complex system is envisioned to be designed on TQM (Total Quality Management) [9] [14] principles that are embedded also within current ISO 9000, ISO 14 000 and other relevant ISO standards. The base in TQM is in quality systems that are embedded in constantly improving processes as shared knowledge base. Cyclic process based development

is governed by systematic scientific GD3 (Good Discussion, Good Design, Good Dissection) process. TQM and BPM both involve in management of business processes. TQM explicitly looks at ensuring ongoing customer satisfaction (along with other internal business drivers) through better planning, improvement and control of business processes enabled by organization. BPM focus in dynamic processes, e.g. agility and flexibility enabled by technology.

Business Intelligence solution on ReconCell approach is built to serve basic business processes that accommodate the needed knowledge to run the selected Business Model. The special requirement of ReconCell BM is that BI solution must support complex dynamic evolving business environment. The basic business architecture consists of a network of synergic autonomous entities that can be seen as a network of VSM (Viable System Modules) [10] with the core "DNA" allowing system entities reproducing themselves. This makes possible knowledge sharing and learning.

Business levels supported by BI [6]:

n+2	ReconCell System tactics (organizational, how) controlling configuration,
n+1	ReconCell System strategy (functional, what) designing of new concepts,
n	Business model directing business model based value chain development,
n-1	ReconCell ltd Business network ontology (applied and regional) allowing role based tactical network configuration and re-configuration. (functional, what)
n-2	ReconCell ltd Business level Ontology i.e its operations as processes (formal and general) organized as domain ontologies allowing strategic customer adaptation by product and service level adaptation. (organizational, how)

Business models are developed at the base level (n). Possible strategy choices are founded on selected business model, and tactics is founded on chosen strategy [6]. Underlying is ReconCell enterprise ontology, which defines ReconCell ltd as a system consisting of a composition, business and design flows, business structure, business environment and business processes. Ontological system (n -1, n-2) is needed for construction and operation of dynamic ReconCell while it's Business Model provides functional perspective characterized by products and services (n, n+1, n+2).

Figure 2: Enterprise ontology [14]

The assumptions made in an enterprise ontology are envisioned to be explained at the level of general ontology, which specifies the ingredients of reality and their relations. All levels are emergent with respect to the lower ones. The ReconCell PSS Business Model modeling is planned to be done within integrated ADOxx (functional) and VEROSIM (organizational) environment.

From a design perspective, a generic business model must as a minimum specify the what, how, and for whom, of production. It must at its essential core identify content, structure, and governance.

ReconCell PSS business model allows ReconCell partners and customers to create new sources of added value and competitiveness, since they can;

- seek to exceed client needs in an integrated and customized way using shared modular system and knowledge base and collaboration platform,
- allow clients to concentrate on their core activities and also learn to support them,
- can build unique win-win relationships with clients based on shared capabilities, competences, knowledge and collaboration network,
- innovate faster by following constantly development in needs and possibilities and sharing processed knowledge and best practices among network,
- both service and production layer has shared interest in minimizing life-cycle costs,
- need fulfilment system takes final consumer needs (rather than the product fulfilling the need) as a starting point, allowing freedom to design and configurate improvements on point of need.

Business Intelligence

Business Intelligence is a set of methodologies, processes, architectures, and technologies that transform raw data into meaningful and useful information used to enable more effective strategic, tactical, and operational insights and decision-making. ReconCell BI uses processes as knowledge entities and Business Intelligence tools that use Business Process Modelling and Analysis to produce these process knowledge entities [5]. From the business process management point of view knowledge management activities are part of business processes and all knowledge elements valuable assets. ReconCell Business Intelligence (BI) module for ReconCell PSS is planned to form an integrated platform with business assessment (BAT) and VEROSIM to support both ReconCell Inc. and its customer's business processes. Efficient knowledge modeling and re-use of knowledge enable more effective strategic, tactical, and operational insights for business related decision-making.

BI module provides for an information system capable of serving management of processes of ReconCell domains (marketing, sales, design, logistics, production and services) trough needed analysis of data gathered from domain processes. It is intended to support also predictive modeling, forecasting, what-if analysis, and other future-facing decision-support needs. It could also include complex event processing for real-time analytics of implemented systems. Standard Business Process Modelling and Notation (BPMN) tools are used to describe the relevant business processes in standardized way as reusable knowledge elements and to allow integrated data gathering also from other BI systems (customers).

Business Intelligence (BI) is planned to be used in ReconCell to support the following tasks:

1. Intention forming and creating a hierarchy of relevant Objectives and Key Results (OKR) with related sets of corresponding performance metrics (Key Performance Indicators) and organize measurement and other relevant data gathering.

2. Concept selection and implementation planning processes using statistical and predictive analytics.
3. Intelligent use of ReconCell systems by providing data visualization and supporting life-cycle collaboration of different parts of ReconCell Inc. by sharing data, information and knowledge between BAT, BI and VEROSIM tools.
4. Knowledge Management Process (KMP) [5] for learning and process based knowledge creation, sharing and re-use.

It is thus central for collaboration and interaction between three service processes; organization of resources, configuration of systems and quality-based management and control of systems in use.

The basic requirement for ReconCell as a whole is that it can provide for cost-efficient agile configuration and re-configuration based on efficient organization of needed resources; capabilities, competences, collaboration and knowledge and fast reconfiguration of technologies, processes, ICT and networks reducing costs of ownership and improving resource reuse.

Business Process Management and Notation (BPMN)

Standard Business Process Management and Notation (BPMN) (http://www.bpmn.org/) was selected to be used in ReconCell BI to provide the basis capabilities for process description in a graphical notation and give organizations the ability to communicate these procedures in a standard manner. In ReconCell PSS context Business Process descriptions are done for two interacting levels; firstly the ReconCell Inc. level that is responsible for delivery and support of systems and system modules and secondly, the ReconCell system level responsible for integrating the delivered workcell seamlessly into the company's business processes. Business Process Models of interacting PSS layers need to be described in parallel with delivery using pre-defined and tested process elements.

ReconCell as dynamic network of business processes

ReconCell challenge from business process point of view is its dynamic complex network. ReconCell aims at creating a complex dynamic system of ReconCell Ltd that is capable of planning, delivery and maintenance of an autonomous robot based collaborative re-configurable ReconCell System modules for assembly processes. The delivered ReconCell Systems consists of organization of role based easy and rapid re-configurable system modules and components like grippers, fixtures, tools, vision system, materials handling etc. provided for by ReconCell Ltd network partners. The delivered assembly system is envisioned to be constantly adapted upon changes in its role or requirements of process or in quality related to new or current products, processes and/or their variants supported by ReconCell Ltd. Thus the configuration of each delivery is in constant change and the system modules (assets) are circulated.

To cope with response and resiliency requirements ReconCell Ltd needs an agile adaptation platform that is collaborating with each delivered system. The requirements for this platform are the capability of discussing on functional business process level on changes requiring re-configuration with customer base and translated these requests quickly to corresponding organizational process that deliver corresponding constructional re-configurations and implement and ramp them up quickly. To achieve that a large pool of capabilities, competences, and knowledge from collaboration network is needed. Also every implemented cases need to be stored as variant for potential reuse.

ReconCell Inc. is from business point of view an agile integrated problem solving network that provides a product and service portfolio for rapid collaborative configuration and reconfiguration of delivered assembly cell. It works as open networked system joining needed resources on point of need for solving a problem as service by providing system components, knowledge and support services like simulations, concept planning, implementation support, maintenance and training.

The basic business processes providing these services are to be seen as process knowledge planned modeled and tested for efficient reuse to guarantee agile resilient service within constantly changing dynamic network of partners.

ReconCell business processes management (PBM)

The business process management (BPM) approach for complex ReconCell PSS environment is the based on Business Intelligence (BI) solution capable of providing quick analytics for decision making. The main idea is that adaptation process uses standardized business model entities and they are selected and activated by BI in collaboration with BPM. Within ReconCell process oriented quality based approach BPM is an integral part of TQM (Total Quality Management) system. All tested and accepted processes and their variants and the processes for creating and maintaining them form the basis of process based quality system. ReconCell process based BPM consists of three interacting levels; strategic, tactical and operative and related three interactive process flows; management flow, configuration flow and information flow each consisting of standardized business processes. Basic need is to standardize interplay between business, design and implementation processes on common quality base.

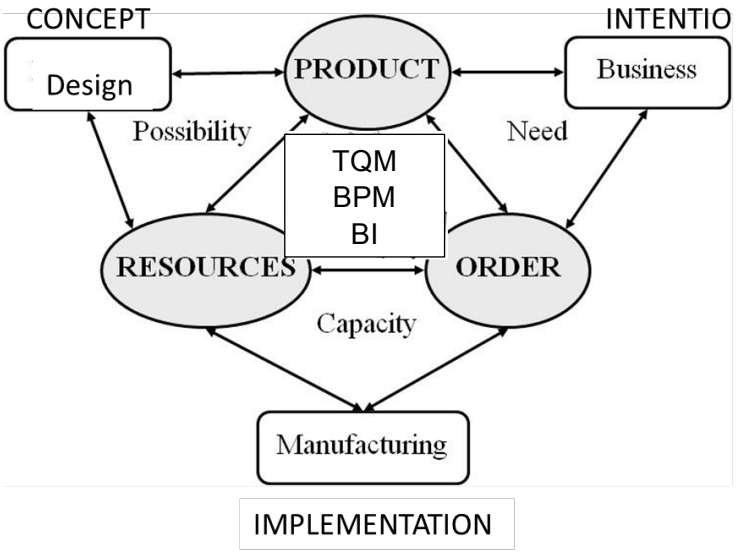


Figure 3: TQM-based Business Process Management (BPM) framework in ReconCell [11]

Modern BI tools that integrate BPM tools and provide analysis for decision support can provide for an advanced cloud based platforms that can be shared by ReconCell network. This allows also a shared meta-modelling environment. ReconCell decided to test ADOxx as modelling platform because there is a good selection of needed tools available built on top of it. (OmiLab omilab.org; http://book.omilab.org/psm/book_content). There is also established commercial BI tools made on it like ADONIS, ADOSCORE, ADOIT etc. that are used by Hermia. Besides ADOxx the project tests also SpagoBI (https://www.spagobi.org/) Open Source Business Intelligence suite and Sygnavio that is used by Logicdata.

ReconCell PSS requires the following basic functionalities and approaches and development of corresponding processes to integrate business process, product and service design process, delivery process and quality based management process;

1. Collaboration with markets and customer base (integration of BI/BPM with Business Assessment Tool (BAT)) to identify and contact the customer base and form the basis for business model

2. Intention building combining functional business based needs with configuration possibilities (request, promise, concept and acceptance) for strategic decision making for management. (Strategic, function based)
3. Integration of product and service concept design with business process design; agile organization of resources and fast system design and configuration upon customer need (intention-based concepts and organization of resources for implementation), (Tactical, organizational)
4. Implementation and intelligent use; Configuration and reconfiguration upon process needs (implementation for use) and constant quality control and data gathering. (Operative)
5. Process knowledge creation and sharing; process control and simulations, analysis and knowledge creation. (Strategic)

ReconCell system modules internal and ReconCell Inc. external-level management collaboration should enable efficient and agile system adaptation according to specific business goals expressed by internal and external OKR (Operative Key Results) and related KPI (Key Process Indicators).

The discussions with partners are then in the next phases elaborated further for design of ReconCell BPM/BI approaches and testbed:

- ReconCell BMI (Business Modelling and Integration) solution, strategic framework for integrated business decision making and process knowledge creation for collaboration within BI, BAT and VEROSIM framework.
- ReconCell BPM, Business Process modelling based Management; frameworks for organizing processes, coordination, configuration and control of operations.(Support of TQM and ISO 9000 based management)
- ReconCell BI, Business Intelligence module; provides for process intelligence and analysis for decision making, knowledge reuse and sharing within selected domain processes.

The aim of these modules is to support agile continuous decision making and learning for agile adaptation (configuration, organization and correction) within ReconCell system in a changing business environment.

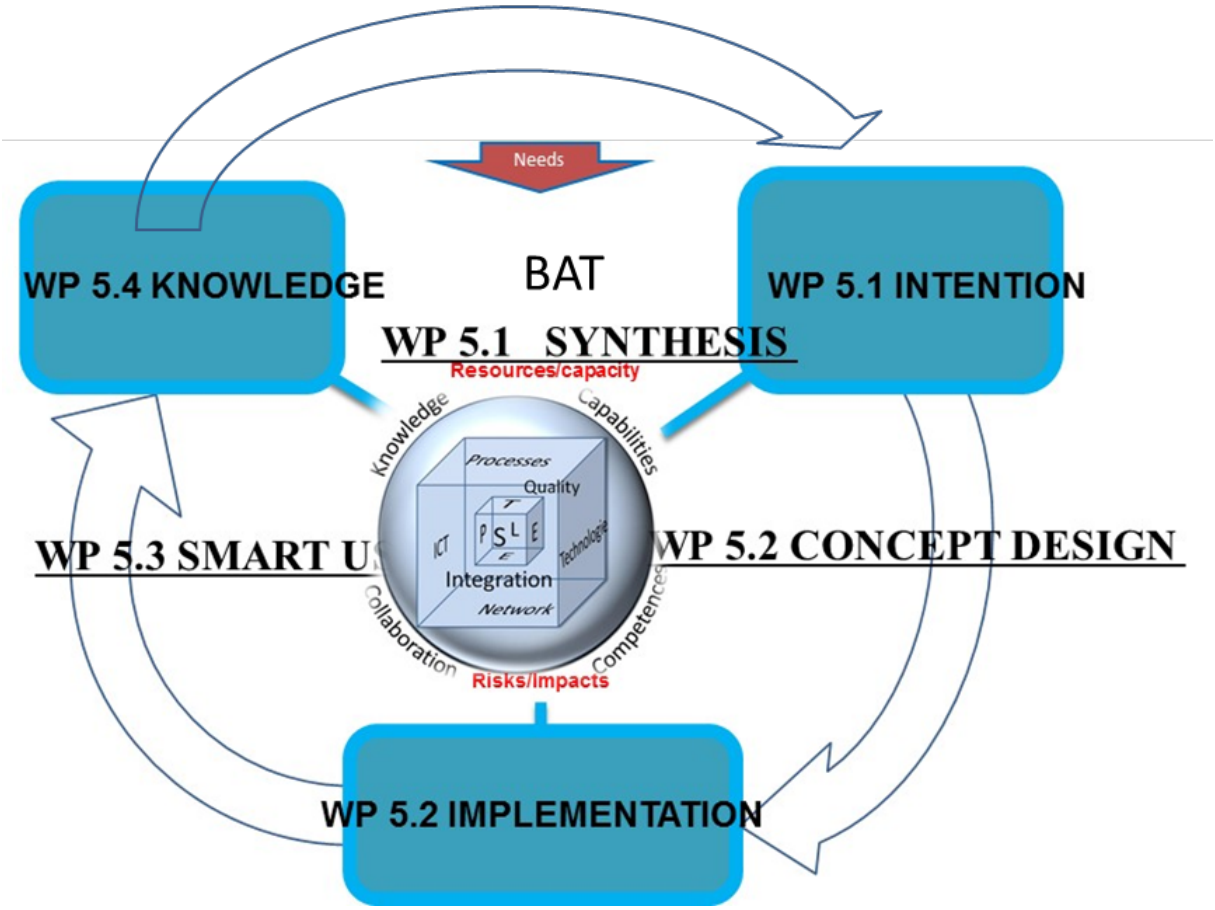


Figure 4: ReconCell cyclic business framework [11] [12]

ReconCell WP5 is divided into four interconnected tasks and collaboration with other WPs. WP5.1 concentrates on Intention process connecting business functional needs with concept design (Request- Promise, Concept- Acceptance). The envisioned Intention process provides for synthesis on needs and possibilities using process knowledge. This requires interaction with Business Assessment Tool (BAT) for creation of customer and service based functional knowledge from chosen market segment and integration of VEROSIM and BPM for providing process knowledge for business intelligence (BI) for decision support.

The first tasks of WP5.1 are collection and synthesis of the needs, ideas, possibilities and knowledge from participating organizations and at the same time the development of Intention platform for ReconCell. These were discussed with BOR for business assessment to provide a general market oriented solution. This task was performed in parallel with technical requirement analysis made by JSI. Used approach integrates functional requirements with organizational possibilities and contrasted against market view.

Functional requirements

Functional (de) composition of the system that forms the business view must be studied against macro-economic STEEPL (Socio-Technical, Economic-Environmental and Political-Legislative) framework that gives the requirement context for system planning for High Value Adding (HAV) production and production systems [18]. Process level BPM integrates quality control (management according to functional requirements), information flow and processing (organization of production) and manufacturing process and network (organization of configuration) processes on shared quality system (based on Joseph Juran Quality Triangle) [16]. Resulting

capability, competence, collaboration and knowledge system is the base of agile platform and form the key competitive element and the basis of economic viability of ReconCell business model.

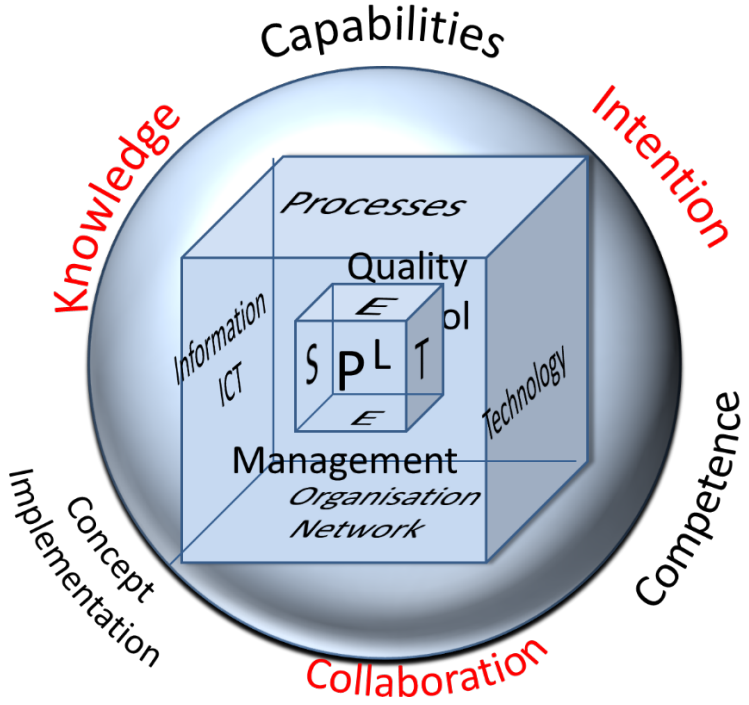


Figure 5: The layered macro/micro level system for BPM from strategic macro level STEEPL to micro-level operative business processes; Information flow, Management flow and Process configuration flow system (quality triangle) for creating competitive Capabilities, Competences, Collaboration, and Knowledge for agile Implementation.[12][18]

BI with Business Analytics; Efficiency and Effectiveness

Business Process Modelling and Notation forms the basis for business process standardization and reuse for simulations and analytics. For agile re-configuration ReconCell integrates three basic interconnected process models; Business process, Design process and Manufacturing process. Business Assessment and concept design, implementation and use control are based on the same semantics and ontology. The efficiency and effectiveness is defined within all three process models using a shared set of Objectives and Key Results (OKRs) and related Key Process Indicators (KPIs). Agility, resiliency, efficiency, and effectiveness of the ReconCell solution is measured by the quality of these processes and transformation ability in terms of meeting the set of well-defined OKRs and KPIs.

The basic approach for setting OKRs and KPIs is to use Action Learning with Goal Question Metrics (GQM) [17]. Corresponding data gathering, analysis and improvements follows TQM constant improvement (Kaizen) and Statistical Quality Control (SQC) principles. They are set for ReconCell Ltd and for customer cases.. The process separates and models value adding (Q =processing) and non-value adding (q+L = configuration + Loads) processes and measures the

efficiency E = Q / (q+L). Effectiveness is measured by qualitative metrics. The procedure use simulated and real data comparison for learning based process improvement.

Figure 6: ReconCell TQM based BI framework [27] [32]

WP 5.1 Business requirements synthesis

ReconCell WP5 Business requirements synthesis is done in several workshops with ReconCell organisation. By the business of ReconCell ltd it is understood the function perspective of the platform. It is characterized by the products and services that are envisioned to be delivered to the business environment. ReconCell Business Model has two parts; Business layer with functional (de) composition describing needed functions and functional behavior of the planned Product Service Support system and the organization layer with which is understood the construction perspective that is characterized by the processes in which the products and services are brought about.

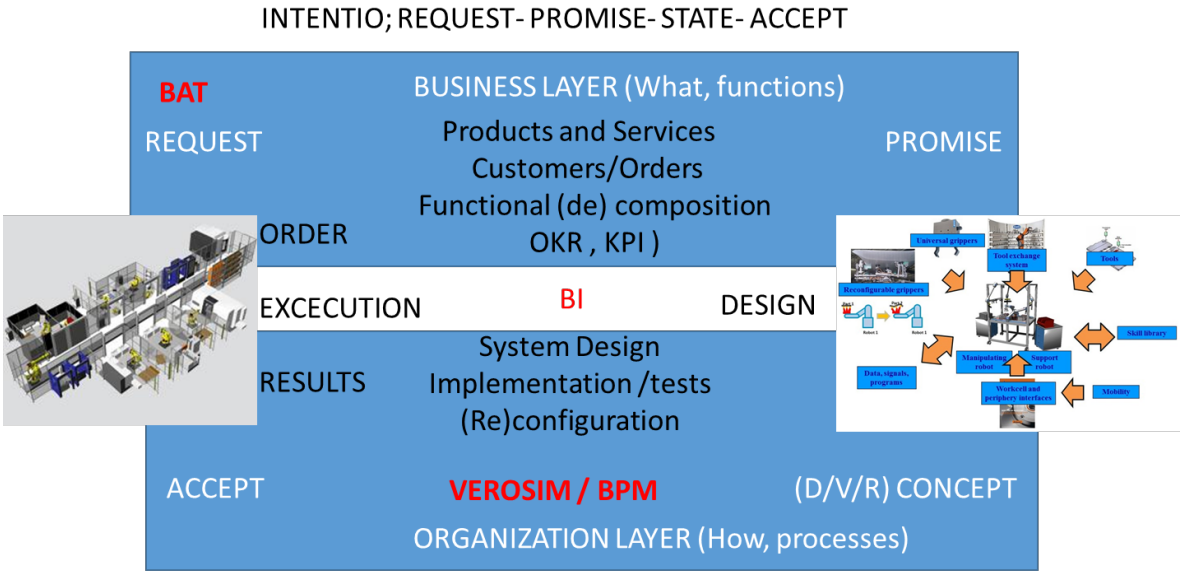


Figure 7: Integrated workshop approach; business /organization [15] [12]

The goal for the case- workshops is on the other hand to develop agile Product Service System by integrating various customer orders, their excecution and results evaluation needs with system design. This requires efficient integration of functional requirements with the organizational process knowledge. System intention is thus the synthesis of changing needs and requirements with constantly developing possibilities and can be used to constantly improve the value proposition.

Experiences from workshops are used for development of ReconCell PSS BM and ReconCell System modules and concepts accordingly. They will help also planning of integration of BI and PBM with Business Assessment Tool (BAT) and VEROSIM environment. User requirements of various identified user groups and development ideas and system needs are collected first together with participating industrial use case companies Logicdata, ELVEZ, and Precizika Metal and developing partners BOR, MMI and JSI. Later there will be additional case-companies. System development is also based on previous research projects and supported by thorough literature review, benchmarking and collaboration with other similar EU projects. Possibilities are also discussed with tools and systems providers (like BOC group and IBM), similar projects, and standardization bodies like OMG and ISO.

Workshops with project platform partners:

Hermia Group,	Five internal workshops
Logicdata:	Two workshops at site (Deutschlandsberg)
ELVEZ:	Two workshops at site (Višnja Gora)
Precizika Metal.:	One workshop at site (Vilnius)
BOR:	Two workshops at site (Odense)+ BAT and WP7 definitions.
JSI:	Two workshops at site (Ljubljana)+ business and organisation
MMI:	One workshop at site (Aachen)+ integration training with VEROSIM

The intention developing methodology and agenda of workshops was planned and organized together with JSI, HERMIA, BOR and MMI. Our approach is based on action research and

extensive use of integrated synthesis methods. Within these workshops we outlined the interactions between System Design approach developed by JSI, BOR Business Assessment Tool (BAT), HERMIA BPM BI and MMI VEROSIM tools and discussed on shared modelling basis and ontology.

It was decided that the Business, Product and Process modelling tools interact primarily using Intelligent Action Blocks developed by MMI. The same entity and activity descriptions (ontology and semantics) are used and Business Processes are modelled using standard languages. With JSI it was agreed on to form an integrated team that run the workshops with case companies using integrated bottom –up System Design and configuration in parallel with top-down strategic functional design process supported by process based Business Intelligence, Business Assessment and VEROSIM. Also activity-based approach using ABC (Activity based Costing) to support analytics was agreed.

Agile adaptation is within ReconCell supported on market level by Business Assessment Tool (BAT), on network level by business modelling and analysis (BI) platform and on system level by product and production modelling within VEROSIM simulation platform. Therefore MMI, BOR and Hermia allocated resources for the VEROSIM integration with BI and BAT tools. The ReconCell Inc. PSS business model development is going on until final demonstration.

The first analyzed industry case using integrated approach was done in Deutschlansberg within the Logicdata (LDT) case. It served also as first testbed for integrative approach for parallel system and business modelling. It was done by team consisting of JSI, HERMIA and LDT experts. The workshop took place at Logicdata within two sessions, each lasting two days. This was the first test of parallel top-down strategic business and bottom-up organizational system design approach. Thus the goals and means were discussed and developed in parallel manner. However lack of models at this stage of the project prevented the use of virtual tools and simulations.

For testing and development of the approach, the team chose one typical product case from LDT production and created a business scenario and a corresponding system scenario, intention and concept variations.

In LDT case current business and product design processes are done in house and well integrated but manufacturing is outsourced and therefore this process is not modelled and integrated with planning systems. Therefore the manufacturing is not known in detail and the manufacturing processes could not be modelled. Moreover, although LDT uses Sygnavio BPM system for Business Process Modelling, it was not used over subcontractor network and the applied modelling logic was not as such compatible with envisioned PSS logic. Therefore it was decided that JSI/HERMIA will create alternative concepts and models using ReconCell PSS system independent of the current processes. Experiments and test results of LDT assembly case within JSI can be evaluated against virtual LDT process using VEROSIM and BI prior to integration within production. It was also agreed that besides virtual analysis also a corresponding roadmap for the transformation process towards integration of ReconCell PSS with LDT should be provided for. LDT considers also to build a production test platform of ReconCell in house for its own testing for integration of both functional and organizational parts of PSS. Planning of this is underway.

With the ELVEZ case, the same approach was applied. Similar top-down functional and bottom-up organizational approach and project team and likewise a representative product were chosen. As ELVEZ does not yet use neither BPM nor process simulation, the team decided to proceed same way as within LDT and create a virtual reference concepts and business models for case analysis. It was agreed to prepare also a roadmap for ELVEZ with steps for introduction of ReconCell PSS platform and to provide for presentation and training of possible BI tools like SpagoBI and Adonis. MMI provides for the training of VEROSIM. It was also agreed to organize benchmarking visits to a

similar company that already uses BI systems and process simulations. At this stage ELVEZ use ReconCell PSS platform for analysis of three cases with different difficulty level; simple, complex and chaotic production process. Since ELVEZ cannot yet provide process data for BI, HERMIA will prepare an option using Excel sheet for data gathering for demonstration purposes. ELVEZ sees extensive use of agile ReconCell PSS as competitive advantage especially for collaboration with OEMs from automobile industry.

Additional questions ELVEZ addressed for ReconCell developement;

1. Is ReconCell PSS a general way for integration with all OEMs systems
2. Which possibilities offered by ReconCell PSS are “low hanging fruits”.
3. What kind of support there is for ELVEZ from ReconCell Inc. after the project

With Precizika Metal use case, a similar project team and approach were used. In this case there was no specific product portfolio or typical repeating orders as their business model is based on strategic specialized resources for agile one-of-kind manufacturing or small batch sizes of non-repeating orders of precision parts. Besides their own production also the business case as part of ReconCell Ltd. as system module and component provider and system integrator was discussed. In ReconCell Ltd. case, PRZM can assume roles both as end-user and as manufacturing site for ReconCell Ltd. PRZM could provide for besides whole systems also modules like special tooling and fixtures and related parts. It was agreed that an evaluation and integration planning will be done for both roles. A collaboration workshop was held also with BI tool provider BOC ltd that represents tool family ADONIS, ADOSCORE and ADOIT built on ADOxx modelling platform. The ReconCell project can use ADOxx development platform as modelling platform and was granted also support from BOC.Collaboration with other ADOxx users was also envisioned.

Business Intelligence (BI) analytics

The basic assumption is that modern, large and medium size companies have their processes described within their quality system and usually modelled using standard business modelling language like BPEL. This is seldom true with manufacturing SMEs. Therefore ReconCell Ltd was planned to provide for cloud base resources as services for efficient use of PSS approach. Analysis of needed capabilities and the way to integrate them with any SME that currently has no such capabilities was found to be necessary. Details about the strategic and operative demands derived from real industrial use cases for suitable cloud based BI tool were discussed within the workshops. It was decided that Hermia provides to SMEs access into the ReconCell test platform and helps with integration using simple data gathering methods like excel sheets.

The use of BI tools within ReconCell:

Company	BPMN	Modelling	BI	Quality System
LDT	Sygnavio	-	-	ISO 9000
ELVEZ	-	-	-	ISO 9000
PRZM,	-	-	-	ISO 9000
BOR	-	-	-	ISO 9000
JSI	-	-	-	ISO 9000
Hermia	ADONIS	ADOxx	IBM SpagoBI ADOSCORE	TQM ISO 9000

As the companies within ReconCell are SMEs and not used to neither BPM/BI tools nor simulation or TQM approach it was decided to use Hermia platform as the reference system and run the ReconCell PSS as a cloud based service as a test bed for the cases. Moreover it was decided to use general tool-independent standards, languages and approaches.

Information gathering from other EU projects

Similar integrated business and organization layer integration cases are also within ongoing FoF projects that share the same modelling platform ADOxx. Collaboration with them is planned. Collaboration with I4MS project HORSE has also been started.

Collaboration with BPM/BI tool developers:

ADONIS /ADOxx	One workshop at JSI
IBM (Watson Analytics)	One workshop at Hermia

Workshop results summary:

The workshops concluded that ReconCell case SMEs do not generally have their own Business Process Management systems nor Business Intelligence tools in use. Therefore they have also no experience of them. A cloud-based BPM/BI service is therefore planned to be provided by the ReconCell Ltd. as a system module. Extensive study of platforms and tools that could provide a needed set of functionalities and organize a corresponding set of integrating tools for such cloud-based extensive next generation development platform solution led to collaboration with Open Models (OMi) Laboratory and its development platform ADOxx. It proved to be able to provide the needed BI suite for ReconCell Ltd.

The BI tools selected for the ReconCell PSS test platform to integrate with BAT and VEROSIM are:

1. ADOxx development platform for modelling
2. ADONIS BPMN tool
3. Sygnavio BPMN tool used by Logicdata
4. ADOSCORE analytics tool
5. PGA Process-Goal Alignment modeling and analysis technique tool.
6. IBM Watson Analytics
7. SpagoBI Open Source Business Intelligence suite.
8. Eclipse eBAM (extended Business Activity Monitoring) with SpagoBI suite

The ReconCell Ltd. integrated platform idea will provide support for agile process adaptation and decision making for fast intention, concept, and implementation planning support and data gathering during test use and related process knowledge creation.

A list of challenges of ReconCell case companies :

- Need to improve ability for agile re-configuration in terms of coping volatility, variations, batch size, customization, speed, volumes and prices.
- Meeting strict quality requirements (process, qualifications, accuracy, cleanness, yield etc.),(Time to quality)
- Coping with hazards in terms of environment or product-specific causes like temperature, sharp edges, hazardous substances etc.
- Coping with process challenges in terms of required ramp-up time, configuration and monitoring with improved planning, introducing new technology and setting norms for system modules and components (grippers, tools, fixtures, sensory systems, etc.).

- Coping with developing norms and standards related to workplace organization and labor use.
- Providing education, teaching and learning systems and access to competences and reducing time to achieve adequate capabilities and competences.
- Quickly changing business model and production system role in the value chain, for example a change from subcontracting to system deliveries.
- Strengthening scaling and localization ability by cloning the processes reusing models and process knowledge and a quick reaction with OEMs process location changes.
- Easy access to new capabilities, competences, networks and knowledge.

The adaptation goals (OKR) and the related system Key Performance Indicators (KPI) were decided to be grouped along QCDF and SR (Quality, Cost, Delivery, Flexibility, Sustainability and Resiliency) framework for providing easier reference data of system performance evaluation for planning, implementation and use [16][19].

BI, BPMN and VEROSIM simulation systematic:

The selected use cases require different set-up of assembly processes, therefore a specific configuration, and monitoring solution is needed to meet their specific needs. The core agile PSS should provide for a generic rapid re- configuration for specific solution using standard components. Integration of BAT, BI and VEROSIM system and large collaboration network with easy access to wide spectrum of capabilities, competences and knowledge is planned to meet this requirement.

Generic framework for agile adaptation to business process

Solving the technical difficulties arising in automated robot assembly is only one part of the intended integrated services ReconCell PSS solution. Improving efficiency, agility and providing new possibilities is the core of any resilient manufacturing system. The competitive edge of ReconCell is intended to be derived from shared use of capabilities, competences and knowledge from large collaborative network and rapid re-configuration. This is achieved by creating a collaborative business environment using Business Assessment to identify suitable partners and customers and integrate them with business network. Rapid intention management is done within business layer and rapid configuration on organisation layer using constantly growing process knowledge. Standardized intention process I($\boldsymbol{\sigma}$) (intention) that integrates business and organization layers provides for the core of the system.

I($\boldsymbol{\sigma}$) := I(φ) -> I(ψ), and φ,ψ ∈ I($\boldsymbol{\sigma}$),

- I($\boldsymbol{\sigma}$) = Intention (digital model, presented in natural language and target values, BI)
- I(φ) = Intention based system concept (virtual model, VEROSIM)
- I(ψ) = Intention concept based implementation (real system that includes also the countermeasures against loads, real ReconCell System)
  I(ψ) is seen also as an real intention consequence whenever I(φ) is an corresponding virtual intention consequence

As seen in the representation virtual model is not a perfect match of desired reality and real implementation within real system is again far from perfect match of virtual representation. Therefore a constant improving of system towards better match with requirements in terms of meeting business and technical process requirements is needed. This is achieved by concentrating both on value adding and non-value adding processes simultaneously.

The system's value adding gains that the end-user is looking for are related to multiple aspects of Business Process integration that need to be addressed within the concept design. The

undesirable side-effects and environment related factors require countermeasures in real implementation and need to be addressed simultaneously with implementation and use.

The ReconCell BI aim was defined to support achieving agile, intelligent, business-oriented system design, implementation and use and pave the way towards agile intelligent self-organization, self-configuration and self-correcting abilities and continuous learning-based improvement in order to achieve agile adaptation, φ ≡ ψ. One key process is creation of re-usable process knowledge entities and easy access to capabilities, competences and collaboration.

Agile adaptation was defined to require three problem-solving approaches:

- selecting from the pre-designed variants,
- introducing an agile systematics for creation of new variants by simulation-based modelling and planning against existing resources,
- Introducing systematics for developing new variants by introducing new technology, new components, new norms, and/or new standards.

This calls for three interacting steps requiring different level of capabilities. These three steps requiring standardized processes are: cyclic strategic planning step, concept planning step and intelligent use step.

The systematic integrated business and organization layer management should address three interacting business flows and integration with corresponding company systems and analytics environments:

- business information flow ψ (Organization flow)
- process configuration flow φ (Configuration flow)
- quality management flow **σ** (Control flow)

These flows form a cyclic evolutionary learning system that manage the needed competitive capabilities, competences, collaboration and knowledge for efficient business system behavior.

Integration with VEROSIM and BAT

The BI and its BPM system integration will be done with VEROSIM and BAT to ensure the integration of ReconCell PSS Business Model. It has three processes based on three models:

- Business Model describes the interaction with customers and network, (management),
- System Model describes the System Design environment ,(configuration)
- Process Model described the process design environment. (organization)

Each of these models describe one design aspect and their integration can be done using shared ontology and semantics. This integration will take place in collaboration with Hermia and MMI using VEROSIM and ADOxx modelling platforms.

ReconCell BI and BPM; Intention creation

The first activity of WP5 was to make a thorough requirement synthesis for integrating ReconCell BI business layer (required functionalities) with organization layer (construction planning).

The basic assumption that the case companies already have their business processes described within their quality system using standardized notation (BPMN) for linking them to ReconCell BI environment or at least have equivalent data in their ISO 9000 based quality system hand books proved to be optimistic. Thus a new strategy was developed to provide for a cloud-based shared environment for needed modelling of case processes and their integration with ReconCell BI. This approach means that business and organization layers are maintained using only ReconCell Ltd tools BI, VEROSIM and BAT and the ontologies and semantics. Using standard languages and approaches will help future integration with companies that have their own equivalent environments.

Business requirements synthesis was done using Hermia tools as a BI module example. Synthesis focused on collecting the necessary requirements and data for modelling and analysis. With this approach we developed the integration approach of tools and systems for collecting and organizing the strategic and operative demands of companies use cases. The developed approach integrates top-down modelling of business cases and bottom-up ReconCell System design as a team effort. The main idea is to integrate both business, product and process development in one agile effort. The proposed approach is developed and tested on real ReconCell use cases provided by LDT, ELVEZ, and PRZM. In collaboration between HERMIA, BOR, MMI, JSI and ADOxx teams, the integration of BPMN, VEROSIM and BAT for the ReconCell platform will be further elaborated to improve the development platform and the proposed platform.

Synthesis approach is going to be developed and tested by company site visits as a joint effort led by HERMIA. So far held workshops:

1. LDT, two days
2. ELVEZ, two days
3. PRZM, one day
4. BOR, two days
5. MMI, two days
6. JSI, ten days

The idea, approach and integration issues needed to be described as intelligent process elements are continuously discussed with JSI, BOR and MMI in close collaboration and evolved further.

ReconCell Business Intelligence (BI) platform tests

Testing of ReconCell as a complete system needs thorough pre planning, integration and testing. A three-step strategy was used for planning data gathering and testing of Business Intelligence solution against needs and possibilities:

- First step: Event and action level description, modelling of processes and adapting analysis.
- Second Step: Functional system modelling for analysis
- Third step: Environment and workflow description for contextual system analysis.

The analysis environment for these processes elements uses IBM Watson Analytics, ADOSCORE and SpagoBI with eBAM (extended Business Activity Monitoring). Maximum four KPIs are set for each OKR and they are used for acceptance of alternative ReconCell functional concepts for basis of configuration planning. Each case is evaluated against efficiency and effectiveness requirements added possibilities and against amount of new ideas. The results give guidelines for implementation planning within VEROSIM and improvements in PSS approach.

ReconCell Inc. BI needs

ReconCell Inc. is here seen as an autonomous business network entity providing for PSS platform supporting the ReconCell system sales, design, implementation, and constant re-configuration. It links the network of service and component providers, system integrators and end-users to a joint PSS platform. Business Intelligence module serves decision making by providing process knowledge embedded in best practice process entities that are used for describing alternative agile self-organization, self-configuration, and self-correction system configurations for planning and developing customers ReconCell System assembly system.

Business Intelligence entities are planned to be created as assets according to RAMI (Reference Architecture Model for Industry 4.0, https://www.plattform-i40.de) reference architecture for connecting ReconCell to the novel Industry 4.0 manufacturing business system paradigm [20] .

ReconCell Ltd. BI simulation

ReconCell Ltd reuse and share process knowledge entities in order to support both predictive and real-time planning using efficiently reference processes. Modelling and simulation of business processes support the rapid decision making for system configuration upon change in business, product design and process domains. It support also product design and production planning, factory operations planning, and shop floor planning during ReconCell System implementation planning and implementation.

The main purpose of a general BI system (e.g. managing Business process knowledge for integrated strategic, tactical and operational decision making) is in use of enriched cross-domain knowledge. By using process based knowledge elements support agile re-configuration as various alternative processes can be analyzed against each other by simulation.

Further needs

ReconCell BI system should be later deployable on several system levels and devices like tablets, smart phones, PCs, workstations, cloud, high performance computer clusters and other industry-driven application scenarios.

ReconCell BPMN/BI platform design and implementation challenges

ReconCell Business Modelling and Notation for BI (BPM/BI) platform consists of three interconnected levels; strategic planning level, concept development level and operative implementation and execution level. The platform is used to produce processed knowledge entities. The cyclic evolutionary approach allows learning based support of eventual self-configuration, self-organization and self-correction towards changing business requirements. The levels integrate as follows:

1. Planning level support consists of creating analyzing and improving process knowledge entities embedding functional features to be linked with constructional process alternatives produced by VEROSIM.

2. Concept level analytics are used for developing and improving concepts consisting of sets of functional business process alternatives capable of meeting the intention requirements.
3. Execution level analytics compares the functional requirements to actual system organization and performance analysis, monitors the achieved quality against metrics and supports the learning for developing knowledge within functional business process entities

The ReconCell BI platform will be in the first phase be a stand-alone solution integrated with ReconCell testbed and later it is planned to be a cloud based system and integrated at first only with Recon Cell demonstration environments and validated with all three industrial cases; Logicdata, Elvez, and Precizika Metal.

ReconCell Planning level system

The planning level of ReconCell Ltd BI system describes the PSS Business Model (BM) and derives the development objects and key performance indicators for system design and adaptation performance (efficiency and effectiveness) from service requirements of its network. The key requirement is to meet the demands of customer base. This is studied by using a concept of intelligent configuration or re –configuration order of a ReconCell System. From business perspectives requirement consists of functionalities, ramp-up requirements, cost limits, quality requirements, quantities and delivery time etc.to meet adaptation demand and resiliency requirements. This business reality makes flexibility and robustness increasingly important attributes to PSS solution. Therefore systems need to be transformable, high-performing, robust, cost efficient, and consisting sufficient amount of resources (knowledge, capabilities, competences and collaboration network) [18].

In addition to the redesign of the production structure (adapting to changes in Business environment) the introduction of autonomous assembly systems like ReconCell gives the possibility of rethinking of the processes. ReconCelln uses CS3 (Compact Simple Slim and Speedy) as a potential reference model. Agile Compact Simple Slim and Speedy (CS3) concept (developed by Toyota and Denso) (https://www.denso.com) uses Lean principles enhanced by CPS (Cyber Physical Systems).

CS3 (Compact, Simple, Slim, Speed):

- Compact: A compact collaborative robot assisted production system that still preserves the Simple, Slim and Speed aspects of the CS3 concept.
- Simple: System construction that is simple (min. functionalities) and adaptable, yet realizes high quality.
- Slim: Net processing ratio that produces high added value and no waste (E=max Q/min L).
- Speed: Swift preparation and production using only the required functionalities and resources for each product.
    - Rapid introduction of new assets for processing and assembly equipment and apply new possibilities quickly to customers production lines.
- Supply and transport equipment will also be targeted, with attention given to reducing equipment costs by simplifying the flow of goods and components right from the process design stage.

Specific CS3 initiatives:

- Clarify which points to emphasize regarding the flow, and thoroughly eliminate hidden inefficiencies
- Use a variety of approaches to create production lines that either minimize or avoid the need for transport and supply work altogether.

- eliminate work-piece direction change and dramatically condense the length of workpiece travel within the production line
- reduce the amount of transport equipment used and develop simple component parts supply devices, transport robots and other low-cost transport and supply equipment
- avoid waste in every process with respect to time, space, movement, energy, material, etc.
- provide resiliency towards changes with re-configurability.

- Develop rapid self-organization, self-configuration and self-correction based on cognitive network of intelligent autonomous production resources.

Standards and state-of-the-art system benchmarking

Standards and state-of-the-art system benchmarking ensures efficient use of the latest existing standards and integration of novel results for development of BI.

Relevant standards are from ISO, Japan and US:

1. **ISO 22400-2:2014 Automation systems and integration**: Key performance indicators (KPIs) for manufacturing operations management
2. **MRED: The Multi-Relationship Evaluation Design (MRED) Framework**: Producing Evaluation Blueprints to Test Emerging, Advanced, and Intelligent Systems
3. **RAMI: Industry 4.0 reference architecture** is a good framework for autonomous elements agile adaptation. It addresses parallel efficiency improvement of LC & value Stream, adding fast new possibilities upon need and implementing effectively new ideas from all levels.

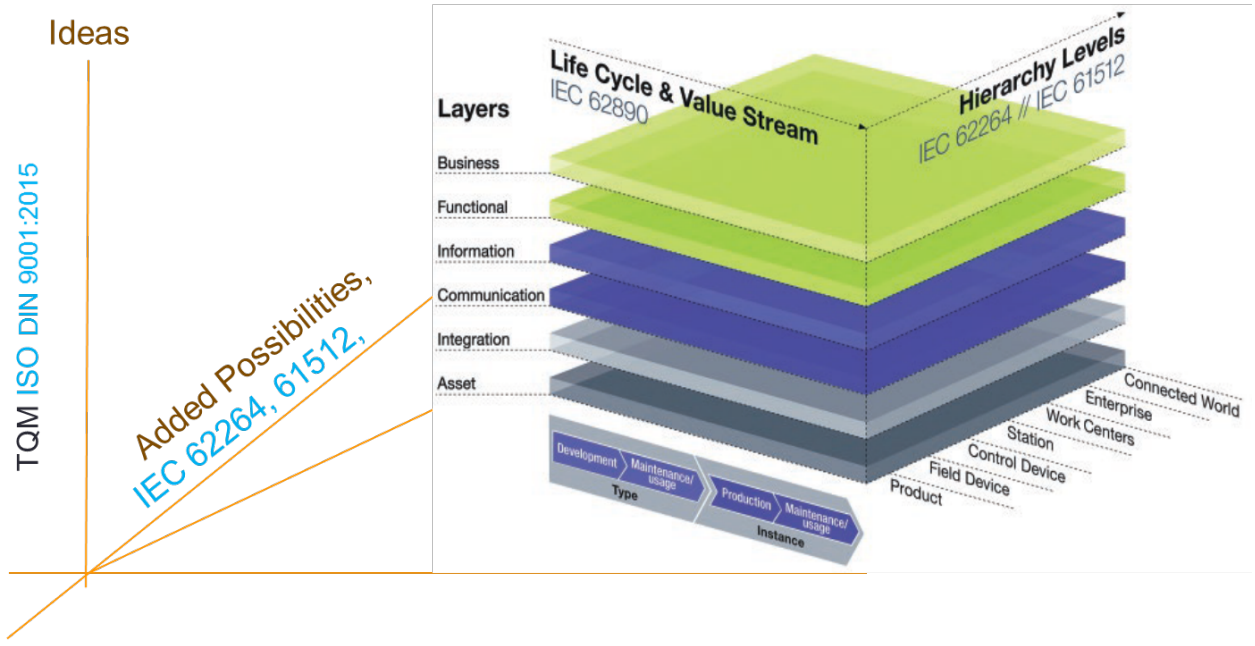
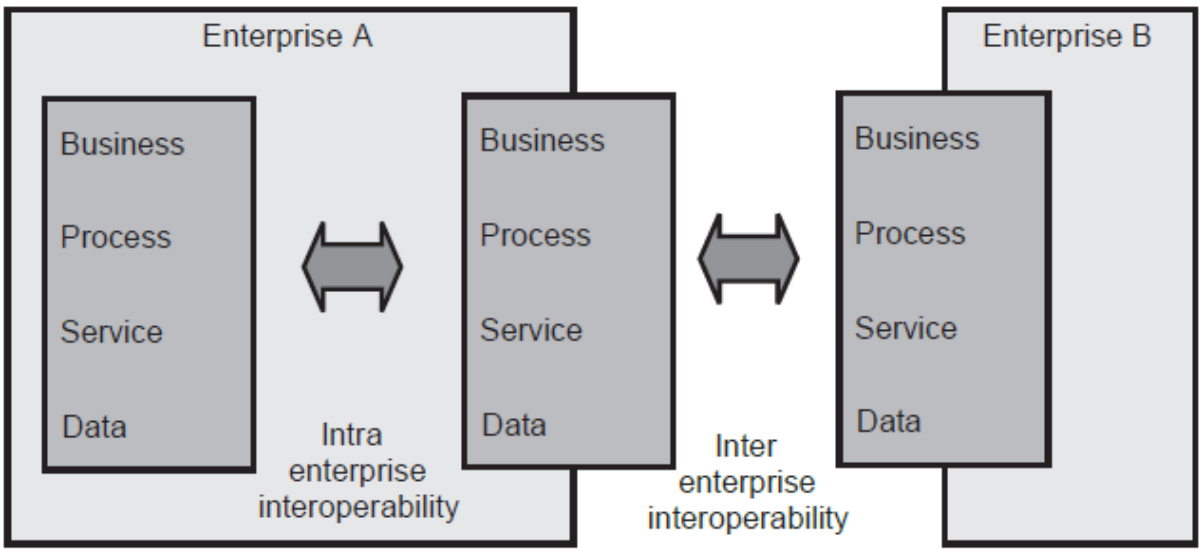


Figure 8: Industry 4.0 RAMI reference architechture [20]



Source: ATHENA[11].

*Figure 9: C*ategories of interoperability (ATHENA) (http://athena.modelbased.net/index.htm)

The interoperability concern viewpoint is used within BI system development. It describes the categories of concerns that are relevant for ReconCell Inc. platforms interoperability. Although the descriptions are primarily related here to ICT-based applications, they can apply to non-computerized business processes as well.

State of the art in BPM/BI tools

State-of-the-art in BPM/BI is studied by several relevant development groups using latest platforms:

1. Collaborative Platform for industrial Business Models. https://www.adoxx.org/live/web/nmbp-collaborative-platform/space
2. The Open Models (OMi) Laboratory, http://www.omilab.org/. OMi is a research and experimentation space for the conceptualization, development, and deployment of modelling methods and has a group developing Business modelling platforms designed with them.
3. Lapa J. Bernardino J, Almeida A, 2015, Commercial Business Intelligence Suites Comparison, at New Contributions in Information Systems and Technologies Volume 353 of the series Advances in Intelligent Systems and Computing pp 237-246 Springer

Lists of most relevant commercial BI tools and platforms with evaluation:

1. http://www.predictiveanalyticstoday.com/category/business-intelligence/
2. https://www.g2crowd.com/categories/business-intelligence
3. http://uk.pcmag.com/cloud-services/74173/guide/the-best-self-service-business-intelligence-bi-tools-of-2016

Summary of state-of-the art

First generation Business Intelligence and Analysis (BI&A 1.0) tools are from the 70`s and 80`s when companies' internal data were structured, collected through various legacy systems, and stored in local relational database management systems (RDBMIS).

Current state of the art web based BI&A 2.0 tools adds to BI&A 1.0 the possibility to take advantage of ReconCell Ltd type business networks and create web based intelligence, web analytics, and use the user-generated content. The present systems and tools used by Hermia (SpagoBI, IBM Watson Analytics and ADOSCORE) allow text and web analytics also for unstructured web contents.

The ongoing evolution towards BI&A 3.0 is taken into account in Hermia that is together with IBM in a collaborative project making use of new possibilities of Web 3.0 (mobile and sensor-based) era of distributed mobile analytics and location and context-aware techniques for collecting, processing, analyzing and visualizing large-scale and fluid mobile and sensor data. BI&A 3.0 is an open complex system requiring equivalent system approach.

Current tools selected for ReconCell BI platform (SpagoBI https://www.spagobi.org/ , IBM Watson Analytics https://www.ibm.com/analytics/watson-analytics/us-en/ and BOC ADOScore https://uk.boc-group.com/adoscore/ tools position as most advanced and easily customized ones. They allow BI&A 2.0 applications based on Web 2.0 distributed platforms and emerging BI&A 3.0 on smart IoT based dynamic platforms. Important is also that they take on account integration with large variation of commercial state of the art BI platforms by major IT vendors and freeware providers including;

- Microsoft (https://powerbi.microsoft.com/en-us/),
- IBM, (http://www.ibm.com/analytics/us/en/technology/business-intelligence/)
- Oracle (https://www.oracle.com/solutions/business-analytics/business-intelligence/index.html),
- and SAP http://go.sap.com/solution/platform-technology/analytics/business-intelligence-bi.html .
- Freeware and Opensource BI (http://www.predictiveanalyticstoday.com/open-source-free-business-intelligence-solutions/)

Data management and warehousing under legacy systems is the foundation of most companies using first generation BI&A 1.0; reporting, dashboards, ad hoc query, search-based BI, OLAP, interactive visualization, scorecards, predictive modeling, and data mining.

ReconCell takes into account the possibilities of Web 2.0 applications that are designed to address the use of company, industry, product, and customer information gathered from the web and organized and visualized through various text and web mining techniques. ReconCell Inc. can make available also an abundance of user-generated content from specific online groups, web blogs, social networking, social multimedia (for photos and videos), and even shared virtual worlds and learning/teaching games making it possible to act and gather a large volume of timely feedback from a diverse sources for different types of needs offering the opportunity for users to treat the business network as a "conversation" platform for decision making.

As BI&A 1.0 technologies that are already integrated into most commercial enterprise IT systems, BI&A 2.0 systems can be created on top by integration of mature and scalable techniques (e.g., information extraction, topic identification, opinion mining, question-answering), web mining, social network analysis, and spatial-temporal analysis with existing DBMIS-based BI&A 1.0 systems.

ReconCell takes into account also the developments in Bi&A 3.0. New smart system platforms developed for instance by SAP and IBM are supporting Industry 4.0 RAMI architecture [that add

definition of assets and standard communication layer. They include mobile and sensor-based content with location-aware analysis, node and asset-centered analysis, context-relevant analysis and mobile visualization & HCI, simulation and gamification.

The potential business network for ReconCell Ltd that are in connection with Hermia use large variation of commercial BI&A tools for instance Yellowfin BI, Oracle Hyperion System, MS SharePoint, Dundas BI, IBM Cognos Business Intelligence, SAP Business Objects, BI360 Suite and BOC ADOxx family. This forms a good basis for benchmarking compatibility of ReconCell BI across applications. Especially for SMEs suitable tools are for instance SpagoBI, QlikView personal, IBM Watson Analytics, MS Power BI, Tableau Public, A Reporting Tool, Widestage, Rapidminer, and Jedox.

Benchmarking concentrates extensively to similar applications and projects using same tools ; Open Models (OMi) Laboratory, SpagoBI, and Eclipse eBAM (extended Business Activity Monitoring), ADOxx and IBM Watson Analytics, do to their use of advanced semantic layer that is well suited for VEROSIM integration and both analytical and behavioral models offering also the possibility for location ware spatial-temporal analysis. IBM Watson Analytics users are benchmarked especially do to its desktop and mobile readiness allowing study of those applications.

Summary

The first period of RerconCell WP 5 concentrated on business requirements synthesis and studying corresponding Business Models. It concentrated to outline details about the strategic and operative demands derived from real industrial cases of the ReconCell. The method used is Action Research based AL (Action Learning) using Deming PDCA (Plan, Do, Check, Act) cycle with GQM (Goal Question Metrics) tables [25][26][17]. The workshops covering functional business oriented requirements were gathered by Hermia parallel with system design oriented organizational requirements gathering by JSI.

The results were discussed with the consortia and it was decided to form a special “business team” within ReconCell for testing the planned approaches for creation of integrated PSS solution capable to support both envisioned ReconCell Ltd and its network of customers and service providers:

1. Product Service System (PSS) approach. [8][4]
2. PSS business model integration approach of BI top-down function oriented business layer and VEROSIM bottom-up construction oriented organization layer. [15] [7] [5]
3. Process knowledge embedded within business processes and design processes for efficient knowledge based configuration support. Efficient knowledge reuse for rapid re-configuration and learning from implemented cases to support continuous cost reduction and strategic agile scaling with BI and VEROSIM [5]
4. VEROSIM Action Blocks approach is planned to be tested by MMI and Hermia to assist integrated autonomous re-configuration by describing business requirements by desired functionalities using “Function Blocks [FB]” that embed process intelligence for specification planning and “Organization Blocks [OB]” that embed process intelligence for construction and implementation of actual product and service.[7][23] [25][15]
5. Case data Integration with BI; Excel tables are decided to be used for information retrieval from ELVEZ business processes and with LDT Sygnavio based process models. JSI, Hermia and MMI are using ADONIS and ADOxx platform with IBM Watson Analytics. Hermia will also run SpagoBI in parallel for reference.

6. Analysis of business cases and roles for ReconCell BI development; ELVEZ case serve as model for a typical manufacturing SME, Logicdata case represents manufacturing subcontracting company developing responsiveness of its network, PRZM acts as provider of ReconCell and its modules and BOR as PSS process owner. Hermia, JSI, and MMI are potential service providers.

The first phase of WP5 reached its goal to outline a suitable platform for BI development and form a mutually shared basis idea for the use of BI within next phase of project. Main challenge is to reach maturity for the integration with real company processes.

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