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D3.1 Lean Operational Model for cMDFs' Federations

TRENTINO SVILUPPO

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Author(s)/ Organisation(s)	Luca Capra (Trentino Sviluppo), Francesca Azzolini (Trentino Sviluppo), Silvio Antonioni and Andrea Guarise (Hub Innovazione Trentino)
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Abstract	iPRODUCE Deliverable D3.1 describes the Lean Operational Model developed in the project, which can lead the transformation of both Local cMDFs and their Federation, made up of 6 national hubs. The document outlines the Value Stream Map of the Federation as is and gives rise to an Implementation Roadmap, focused on the application of the main principles of Lean Models to the holistic vision of the Federation.

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Executive Summary

T3.1 promotes the establishment of a network of local contributors that will cooperate together as part of local cMDFs' (collective Manufacturing Demonstration Facilities) network, working under an operating model compliant to the Kaizen and Lean principles, that will fit into the Open Platform (OpIS) deployed in the second and third year of the project iPRODUCE.

This Deliverable reports the outputs of a series of structured Kaizen workshops involving representatives of the six cMDFs and other partners of the project and aimed at defining the operation of the Federation co-creation activities.

After an introduction on Lean and Kaizen methodologies and their main tools, described just as much as it is necessary for the understanding of the activities performed in the Task T3.1, the Deliverable reports the methodology adopted to organise the Kaizen activities, the design principles adopted in the activities carried out and the description of the work done.

It takes into exam the Value Stream Map of the Federation as it currently is and then it illustrates the future Value Stream Map, together with a suitable lean operational model compliant with it.

The final part of the Deliverable concerns the definition of a roadmap for the development of the Federation (from the project Federation to the future Federation) and a set of guidelines useful for its implementation.

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List of Abbreviations & Definitions

Abbreviation	Definition
AR / VR	Augmented Reality / Virtual Reality
BPMN	Business Process Model and Notation
cMDF	collaborative Manufacturing Demonstration Facility
COSME	Competitiveness of Enterprises and Small and Medium-sized Enterprises
CPI	Cost Performance Indicator
CRM	Customer Relationship Management
DIY	Do It Yourself
DoW	Description of Work
EU	European Union
FPY	First Pass Yield
IPR	Intellectual Property Rights
IT	Information Technology
KPI	Key Performance Indicator
LT	Lead Time
MMC	Maker, Manufacturer, Consumer
NGO	Non-Governmental Organization
ODT	On-Time Delivery
OEE	Overall Equipment Effectiveness
OpIS	Open Innovation Space
PM	Project Manager
PDCA	Plan-Do-Check-Act (Deming Cycle)
PT	Process Time
SDCA	Standardise-Do-Check-Act
SEO	Search Engine Optimization
SME	Small and Medium Enterprise
SMED	Single-Minute Exchange of Die
SMS	Social Manufacturing Space
TOC	Theory of Constraints
TPM	Total Productive Maintenance
TPS	Toyota Production System
TQM	Total Quality Management
UC	Use Case
UML	Unified Modelling Language
UX	User Experience
VSM	Value Stream Map
WCM	World Class Manufacturing

WBS	Work Breakdown Structure
WP	Work Package

1. Introduction

WP3, Establishment of local Collaborative Manufacturing Demonstration Facilities (cMDFs), addresses how the cMDFs will work both individually and in a federated way. First of all, it proposes the development of a Lean Operational Model to transform a constellation of local heterogeneous facilities into iPRODUCE cMDFs and prepare them for the transition to a Federated entity.

WP3 also has the objective of mapping the existing manufacturing capacities, skills, services of the nodes of the Federation in order to reinforce the local cMDFs' capacities. Moreover, this work package and T3.1 promote the establishment of a network of local contributors/stakeholders that, even if differently featured one from each other, will cooperate together as federated nodes/sub nodes of local cMDFs´ network, working under a lean operational model that will fit into the Open Platform deployed during the project.

Being developed within task T3.1, D3.1 maps and examines the current configuration of the network - ex ante analysis - and, through Kaizen, lean analysis and design activities carried out by the members of the iPRODUCE consortium within the T3.1 project activities, devises a Lean Operational Model of the Federation as a whole and an implementation roadmap.

1.1. Purpose and Scope

The objective of this deliverable is to define a Lean Operational Model - and guidelines for its application - for the **future cMDF Federation**, starting from the current status (a set of nodes partially cooperating, with different services and competences/skills) and designing the most efficient and feasible model for the future.

Integration of complementary partners in the cMDFs, valorisation of differences and limitation of the overlapping, getting the interest of current and potential stakeholders and clients, creating an iPRODUCE value chain are some of the main cornerstones that will drive the elaboration of a Lean Operational model and related guidelines to implement it in iPRODUCE.

1.2. Relation to other iPRODUCE Work Packages and Tasks

This deliverable is the main outcome of Task 3.1 "Lean Operational Models for Local cMDFs and their Federation". This task is linked to the rest of WP3 tasks and mainly to:

- T3.2, that identifies the cMDFs' basic capabilities (in terms of machines, skill, etc.) and "gaps";
- T3.3, whose objective is marking the actual set up status of the cMDFs once their main requirements have been satisfied: the definition of a local network (community), the incorporation of complementary partners in the core group of the cMDFs to adequately develop the use cases and the definition of an initial plan of activities.

WP2 ("Business Challenge Definition for Social Manufacturing in Consumer Goods Sectors"), is relevant to T3.1: this WP provides the initial definition of cMDFs, use cases and their KPI metrics, the "voice of customers" (that is, the profiles of cMDFs and stakeholders), governance guidelines. They are all interesting inputs to outline the current status of iPRODUCE network.

WP6 ("Social Media-Enriched Engagement Strategies for Makers and Consumer Communities") and specifically T6.1 ("Ecosystem Establishment and Engagement") provide the mapping of the cMDF ecosystems (communities) in the targeted areas as well as methodologies for stimulating and managing the engagement of makers and consumers, that will contribute to the participatory

processes in the local networks. Furthermore, T6.1 provides an analysis of the current and potential stakeholders of IPRODUCE.

WP7 (“iPRODUCE Sharing Economy Business Models and Execution Tools”) provides a few insights about business models, useful for Operational Model definition.

Being Kaizen methodology based on the human factor, the link with the above-mentioned WPs and tasks has been not only based on the sharing of documents, but also on the participation of members not directly involved in T3.1 to the Kaizen workshops, in order to efficiently share views, ideas, opinions working together.

This deliverable will be input also to WP7 (definition of business models will be very depending on the type of community and processes developed), D3.5 (follow up of D3.4) and WP9 (the evaluation framework to test the iPRODUCE solution, not only in the local cMDFs, but also in the Federated network).

1.3. Structure of the Document

Besides this introduction and the final section about conclusions, the document is structured into seven main chapters. The second section introduces the concepts of Lean and Kaizen methodologies: a methodological framework, useful for the reader to understand the basis of the following chapters.

Section three and four detail the Lean Transformation Model implemented and the Kaizen Activities performed in T3.1: this sections’ contents would have been probably different in a non-pandemic scenario; difficulties encountered by the team and risk mitigation activities performed to overcome the pandemic obstacles to the task are here explained, together with the activities carried out.

The fifth and sixth sections describe the output of the kaizen-lean work performed in the task and define the future Value Stream Map. Section seven describes the Lean Operational Model of the future iPRODUCE Federation. Section eight contains the roadmap for the development of the iPRODUCE Federation and a set of implementation guidelines.

Finally, “Annex 1 - Canvas”, “

Annex 2 - Most Used Tools for Process Description” and “Annex 3 - Visual management tools” report details about a few of the Kaizen tools dealt with in the previous sections.

2. Introduction to Kaizen Principles and Lean Methodology

2.1. Introduction to Kaizen and Lean

The history of Kaizen began after World War II when Toyota first implemented quality circles in its production process and developed the Toyota Production System (TPS). American business and quality management teachers who visited the country back then partly influenced such implementation.

"Kaizen" is a Japanese word and literally means "Change for the better" (KAI: Change, ZEN: Good). Kaizen[1] is a very general approach to improvement based on common sense, self-discipline, order, and economy. It means continuous improvement in personal life, home life, social life, and working life. When applied to the organization of the activities and the workplace, it means continuous improvement involving everyone – managers and workers, everywhere and every day.

While Kaizen is a general approach to improvement, Lean[2] is a methodology with a background in manufacturing that focuses on a very specific type of metrics. Lean Production was born with the aim to exploit the advantages of artisanal production and mass production - that are the high variety of products and the high production volumes - while at the same time avoiding the disadvantages of the two systems: high production costs, characteristic of an artisanal production, and the high rigidity typical of mass production. The Lean methodology has evolved over the years and its main focus has remained the same: eliminating waste in order to free up time and to increase value to the customer. This is possible by eliminating all the activities that are not essential for satisfying the needs expressed by the customers.

Kaizen and Lean methodologies are nowadays applied in a variety of sectors all over the world. When applied to production, the two terms are often used as synonyms.

2.2. Kaizen and Lean principles

There are five Kaizen Fundamental Principles that are embedded in every tool and in every behaviour. They are graphically shown in Figure 1:

- Know your Customer: to create value for the customers and enhance their experience, it's important to identify their interests.
- Let it Flow: everyone inside the organization should aim to create value and eliminate Muda (Japanese word that means "wastefulness").
- Go to Gemba: value is created where things happen, therefore you need to go to "Gemba" ("the real place").
- Empower People: set the same goals for the teams, organize them by providing systems and tools to reach the goals.
- Be Transparent: performance and improvements should be tangible, visible and measurable with real data.

[1] With the book "Kaizen: The Key to Japan's Competitive Success" published in 1986, Masaaki Imai introduced Kaizen to the western world.
[2] The term Lean first appeared in 1990 in the book "The machine that changed the world" written by Womack J.P., Jones T.D. and Ross D.

Figure 1. The five Fundamental Principles of Kaizen (source: Kaizen Institute)

The implementation of those 5 principles in any organization is fundamentally important for a successful Continuous Improvement culture and to mark a turning point in the progression of quality, productivity, and labour-management relations.

The 5 fundamental principles of Lean Thinking are:

- defining the value;
- identifying the flow of value;
- letting the flow of value flow;
- implementing a pull system;
- striving for perfection.

The main pillars on which the Lean Production model is based are: a continuous focus on increasing company efficiency, which allows to create the products desired by the customer in the shortest time and with the lowest possible costs, and the complete satisfaction of customer's requests.

Hereafter, in the following sections, the main principles are shortly described.

2.2.1. Continuous Improvement

There are two different approaches to business improvement: innovative improvement (or innovation) and incremental improvement (or Kaizen). Their intrinsic features are shown in Figure 2.

Innovative improvement is characteristic of great scientific discoveries: a very high improvement is obtained compared to the previous situation, but this requires long development times and a huge investment of both human and monetary resources.

The Lean philosophy, on the other hand, favours a more conservative but not less effective type of change: Kaizen or continuous improvement. This type of improvement fosters the exploitation of the knowledge of the subjects involved or of what you already have, thus requiring zero or very low investments. Standardization is fundamental for continuous improvement, i.e., making the change that has been introduced known and known, so that the positive effect obtained is not lost over time:

ideally, this phase can be compared to the construction of the horizontal component of a step to avoid the loss of the increase in altitude gained thanks to the vertical component of the same (the improvement).

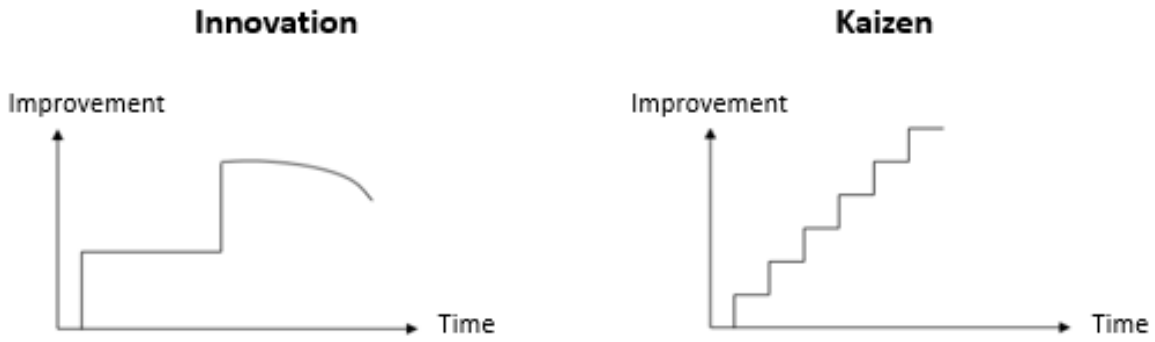


Figure 2. Innovation vs. Continuous Improvement

In particular, the Kaizen methodology follows the rules that are described below.

1. Improve everything continuously.
2. Abolish old, traditional concepts.
3. Accept no excuses and make things happen.
4. Say no to the status quo of implementing new methods and assuming how they will work.
5. If something is wrong, correct it.
6. Empower everyone to take part in problem-solving.
7. Get information and opinions from multiple people.
8. Before making decisions, ask “why”-questions five times to get to the root cause. (5 Why Method)
9. Be economical. Save money through small improvements to spend the saved money on further improvements.
10. Remember that improvement has no limits. Never stop trying to improve.

2.2.2. Gemba Kaizen

“Gemba” is a Japanese term that means “the real place”, which is the factory floor in manufacturing. Gemba Kaizen[3] is the method that allows for improvement through direct team action in the Gemba.

The problems are visible so the best improvement ideas will come from going where things happen: the Gemba walk is an activity that takes lean management to the front lines to look for waste and opportunities to practice Gemba kaizen or practical shop-floor improvement.

The term Gemba, in international practice, became widely known after publications about the Toyota quality management system. In practice, if a problem occurs, the engineers must go to the source to understand the full impact of the problem, gathering data from all sources. This Japanese decision-making principle differs from a traditional American approach where management typically takes decisions remotely.

[3] Massaki Imai, “Gemba Kaizen. How to get growth and profits with continuous innovation”, Il Sole 24 ore, November 2001

The golden rules of Gemba management, called the 5-Gemba principles, are as follows:

- When a difficulty (abnormality) arises, consider going to Gemba first.
- Check with gembutsu (machines, tools, rejects, and customer complaints).
- Take temporary countermeasures on the spot.
- Find out the root cause. By repeating the question “why” several times, you can find out the root cause of the problem.
- Standardize for prevention of recurrence.

Kaizen method strives toward perfection by eliminating waste (Muda) in the workplace (Gemba).

2.2.3. The Seven Wastes (Muda)

The focal point of the Kaizen philosophy is the centrality of the customer and consequently of what constitutes value for him. All the activities requiring the investment of company resources but not contributing to the construction of this value are to be considered waste.

Industrial engineer Taiichi Ohno, the father of the Toyota Production System, noticed that there is an 80% loss in every process and the value of the process is less than 20%. A portion of micro-processes functioning as part of the full process (from start to finish) does not make any transformation to the product that the consumer is willing to pay for. After analysing manufacturing processes, Ohno was able to identify which steps add value and which ones do not. As a result, he developed a better way for organizations to identify waste with his “Seven Wastes” model.

These wastes include those reported in the following:

1. Delay, waiting or time spent in a queue with no value being added. A large part of an individual product’s life is spent waiting to be worked on.
2. Over-processing or undertaking, non-value-added activity. Over-processing occurs when more work is performed on a piece than what is required by the customer.
3. Production of Defects. Defects cause extra costs for reworking the part and can sometimes result in doubling the cost of one single product.
4. Transportation. Each time you move a product, it stands the risk of damage, loss, delay, etc. as well as to have a cost for no added value.
5. Unnecessary movement or motion. The motion refers to the damage that the production process inflicts on the entity that creates the product. This may be either over time (wear and tear for equipment and repetitive strain injuries for workers) or during discrete events (accidents that damage equipment and/or injure workers).
6. Inventory. Being it raw materials, work-in-progress, or finished goods, it represents a capital outlay that has not yet produced an income, either by the producer or for the consumer.
7. Producing more than you need. Overproduction usually hides and/or generates all the other wastes. It leads to excess inventory, which then requires the expenditure of resources on storage space and preservation. These activities do not benefit the customer.

2.2.4. Kaizen and Management

In today’s situation of having to manage multiple projects and to make decisions quicker, managers often try to apply the latest high-cost technologies to handle problems that can be solved with a common sense, low-cost approach.

Defining and implementing a Kaizen Lean Strategy can provide the maximum value for the customer at the minimum cost, through the involvement of people. It involves changing the way of thinking of a large number of people and therefore it is essential to have clear support from top management and to set clear objectives.

2.2.5. Processes and Results

Kaizen encourages process-oriented thinking as processes need to be improved to increase results. The improvement process involves all company functions, from workers to supervisors up to the top management. The subsequent process must always be considered as a customer: therefore, there are internal and external customers.

The first step in the Kaizen process is the PDCA (plan-do-check-act) cycle which leads to improvement, while the SDCA (standardize-do-check-act) cycle standardizes and stabilizes the current processes (maintenance). The two steps are shown in Figure 3, where improvement and maintenance are assimilated figuratively to a wheel on an inclined surface.

By improving processes and standardizing activities involving everyone, everywhere and every day, companies can reach the ultimate goal: customer satisfaction through quality, cost and delivery.

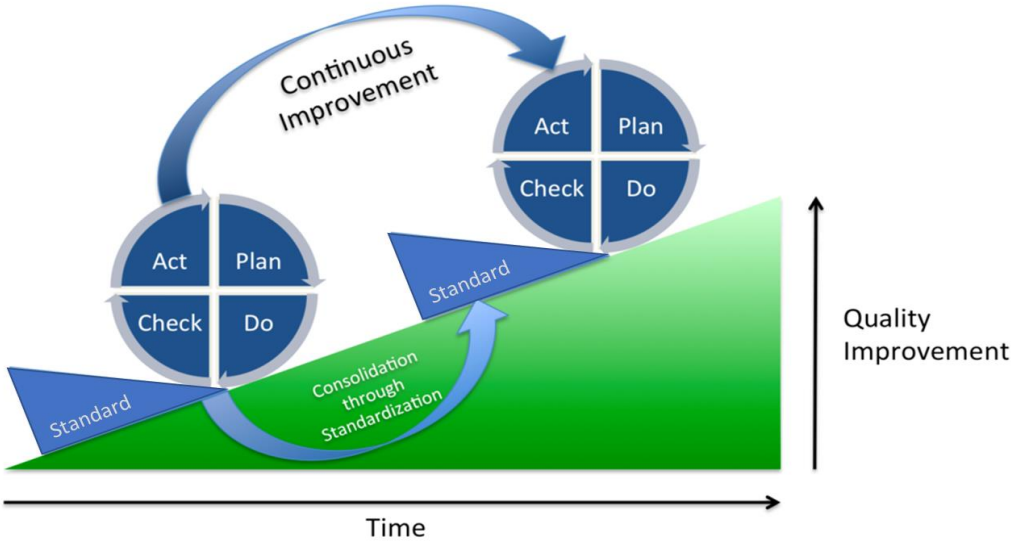


Figure 3. Improvement (PDCA) and maintenance (SDCA)

2.3. Kaizen and Lean Tools

There are different tools that can be applied in the manufacturing process to eliminate the seven wastes and to achieve the process of optimization. Some of these devices will be described below, others (such as SIPOC and Makigami) used during the Kaizen activity to develop the Lean Operational Model for Local cMDFs and their Federation, will be described in the next chapters.

2.3.1. Value Stream Map

The Value Stream Map (from now on also “VSM”) is the process that creates the value provided to the customer. It uses a visual display method to map the flow of materials/information through the production process.

The objective of the Value Stream Map is to identify the value-added activities and non-value added activities. It tries to reflect what actually occurs rather than what is supposed to occur, in order to define opportunities for improvements.

The Value Stream Map is used frequently in manufacturing processes to reach cycle-time improvements starting from the analysis of step-by-step process operations. An example is reported in Figure 4. It supports continuous improvements by identifying and eliminating the time spent on no added value activities.

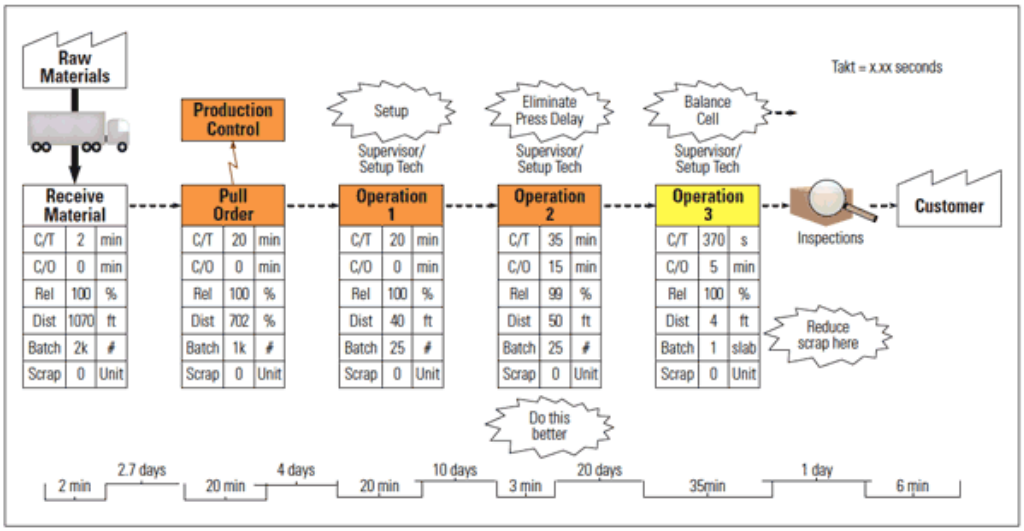


Figure 4. Example of Value Stream Map is used in manufacturing processes

The main aim is to eliminate waste, increase effectiveness, uncover hidden capacity, generate more revenue, and reduce costs while focusing only on the activities that truly enhance the final product.

The VSM of the iPRODUCE Federation and its future evolution were investigated in the Kaizen workshops: the outputs of the analyses are reported in Chapter 5.

2.3.2. 5S

5S is a method of organizing a workspace to make it safe, efficient and effective, as shown in Figure 5. The goal of 5S is to create a clean, uncluttered environment that allows the reduction of the risk of injury while minimizing the waste of time.

Figure 5. The objective of 5S is to make the workspace safe, efficient and effective

There are five activities that should be implemented to reach this goal and they are referred to 5 Japanese words seiri, seiton, seiso, seiketsu and shitsuke that mean sort, set, shine, standardize and sustain. Here's an overview of the five activities.

Sort: the Sort activity aims at making the use of the working space more effective by clearing out hazardous items and clutter that distracts from doing the job. The worker sorts everything in a workspace into what is and what is not needed and analyses the frequency of usage in order to store it appropriately.

Set or Set in Order: it aims at making visible and easy to use what is in the workplace. The worker finds a place for everything, defining a precise position in order to get everything in place keeping closer at hand the items with high-frequency usage.

Shine: cleaning is a workplace inspection process. It helps to identify and eliminate the source of contamination. This maintains the gains made in the Sort and Set phases.

Standardize: this step takes the progress and changes made by the first three activities and makes them the standard procedure. The standardization helps to identify abnormal conditions and maintain the workspace going forward. It requires oversight and enforcement in order to let it become a habit.

Sustain: the aim of this phase is to properly maintain the habit of the new rules. The workers keep the new standards in place and perform the first three steps every day until they become automatic and the accepted way of doing things.

5S will be used in chapter 8, where a few guidelines for the correct organization of information and its flow through the Federation will be illustrated.

2.3.3. Kanban

Kanban is a visual system used to manage and keep track of work as it moves through a process, as shown in Figure 6. The goal of Kanban is to move every task of work efficiently from beginning to end with as little waste and lag as possible.

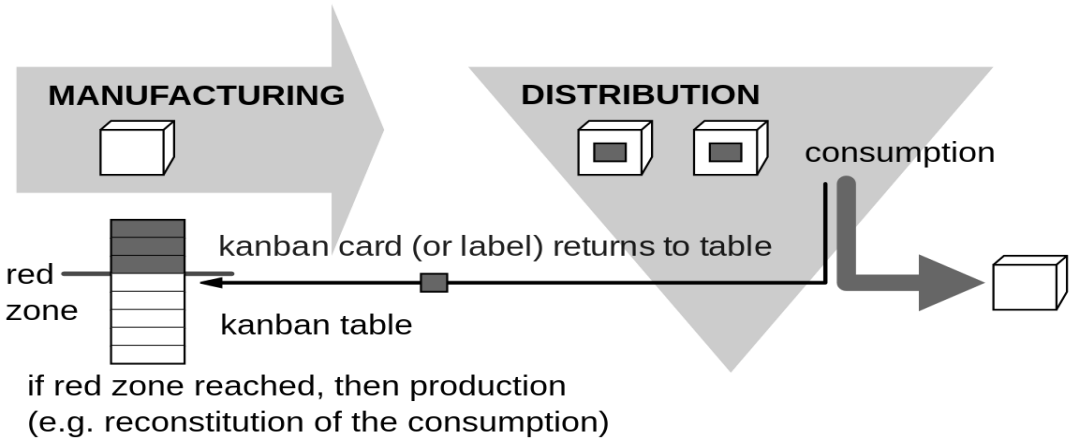


Figure 6. Kanban: an efficient way to keep track of work as it moves through a process

Kanban requires that work in progress should be managed in a way that it can easily be visualized. To begin a Kanban improvement, it visually maps the process as it currently exists. Only then will opportunities for improvement become obvious. Visualization continues once Kanban is implemented and communicates the state of projects, processes, and inventory.

In manufacturing, Kanban starts with the customer's order and follows production downstream. At its simplest, Kanban is a card with an inventory number that is attached to a part. Right before the part is installed, the Kanban card is detached and sent up the supply chain as a request for another part.

Kanban tool will be used in Chapter 7 – in this case in a digital and not physical version – in the framework of the Lean Operational Model.

3. Lean Transformation Model and Kaizen Activity Performed

3.1. Introduction

Organizational transformation happens when lean methodology meets Kaizen. Lean methodology is focused on eliminating wastes, and increasing productivity and value adds for the consumer, while Kaizen focuses on continuous improvement. This transformation is not a short term fix for the problem of the day. It is achieved by making incremental changes over time with the goal of improving processes, efficiency, quality, and the overall work environment. Although the tools and techniques of lean may be implemented by managers, everyone is responsible for their implementation.

The work performed in the Task T3.1 has been based on the organisation of a series of Kaizen workshops that involved the project partners. The starting point was the definition of a common basis for the Lean Operational Models development. Specifically, a series of working dimensions have been identified, according to the most commonly exploited Lean Transformation principles, such as Situational Approach, Process Improvement, Capability Development and Responsible Leadership, Basic Thinking, Mindset, Assumptions.

3.2. Identification of the Working Dimensions

The Lean Transformation principles[4] are very useful to support the starting and carrying out of change activities in an organisation, as, for instance, in the production process of an industrial product or in the structuring of a service. The principles do not fit only in the industrial production world, besides they can be thought of as a way to perform change in almost any context implying human resources working collaboratively.

It was decided to apply them to iPRODUCE cMDFs network, to design its transformation from the initial status (a constellation of nodes partially and loosely linked one to each other) to a final status (a Federation of interconnected and collaborating entities). The lean principles do not impose strict rules or codified practices, but they leave enough room for the iPRODUCE members to think and experiment: no prescription is envisaged.

In the following subsections, the 5 working dimensions of Lean Transformation are examined. Furthermore, the section also describes how they have been embodied into the Kaizen/lean activity performed in T3.1.

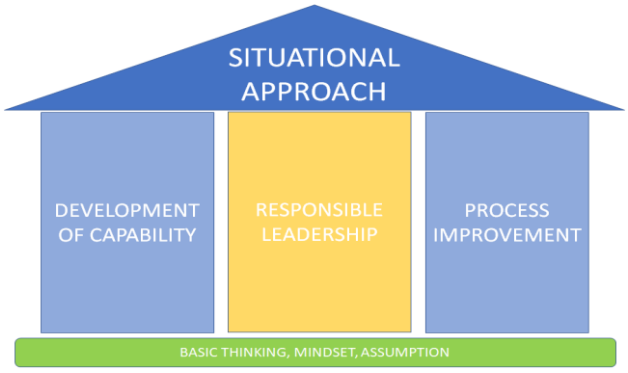


Figure 7. Lean Transformation modelled as a house

[4] https://kanbanize.com/lean-transformation/model

The five working dimensions are linked together and they are shown in Figure 7. They can be logically thought of as the building block of a house: they are all necessary and they support one another.

3.2.1. Situational Approach (the Roof)

Situational Approach tries to answer the question “What problem are we trying to solve?” The Lean Transformation follows a top-down approach. It must be initiated by the management and then it involves lower hierarchical levels.

The management must target a problem of its organisation and focus on it. Typical issues are productivity (how to increase it), quality (how to improve it), etc. They must be explicit and made known to the lower hierarchical levels: they must not remain in the brains of the managers, besides they must be documented and presented to all the interested parties during the rollout. The employees, the teams and their leaders must be informed of what the real objectives of the transformation are. “Less is more” is a modern saying, but in the case of lean it is the truth: when implementing it, the focus must be on only one or two issues; targeting many issues can bring confusion in the team and failure.

In the iPRODUCE project the management coincides with the T3.1 leader, Trentino Sviluppo, supported by Hub Innovazione Trentino and Energy@Work. These three project’s members decided to organise a series of Kaizen workshops with the aim to solve the following problem: “iPRODUCE network starts as an ecosystem of local cMDFs (formal clusters composed by different entities and actors whose main purpose is to support collaborative manufacturing and all the necessary services to involve users in co-creation, prototyping, validation, training and other related activities), but it must become an international federated network of entities collaborating together according to an efficient operational model that will make them appear to the client/users as an iPRODUCE entity. How can we foster this transformation? What is the Operational Model most suitable for the iPRODUCE federated network of cMDFs?

3.2.2. Process Improvement

In this phase, we have to answer the following question: “How are we improving the actual work?” Answering this question means to identify a list of process improvements to be made, in order to get to the goal stated in the following section 3.3.

The lean methodology suggests running numerous experiments and continuously improving the processes all the time, according to Deming's cycle “Plan Do Check Act” (PDCA), shown in Figure 8 and previously explained in section 2.2.5. In the iPRODUCE project context, two obstacles have prevented the recursion of successive experiments:

- the nature itself of iPRODUCE (it is a project with a limited timeframe) and the short term duration of the project;
- the pandemic, that slowed down and, in some cases, blocked the operational activities of many members of the cMDF network, making their interaction more complex than in a “normal” international socio-economic context and obliging them to carry out the joint activities in virtual mode.

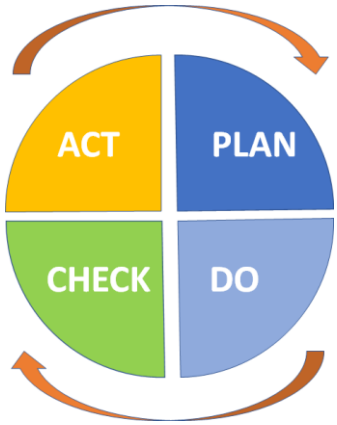


Figure 8. PDCA cycle is made of 4 recursive steps

The T3.1 partners decided to mitigate the effects of these obstacles, focussing during the project timeframe with the planning, doing (in the pilots of WP9) and checking activities of the cycle and leaving the action and reiteration after the project's end.

The main processes to be improved/developed are listed in Table 1, where the baseline situation (each member of iPRODUCE network is an isolated node) and the To Be (how could be in the future, after the project; asymptotic situation) are briefly described. Let us make the realistic hypothesis that each node of the network offers to the clients at the same time both its own services and iPRODUCE services (that are services differently branded and offered according to different methodologies and procedures/processes): a situation like two different businesses in the same organisation.

Table 1. Main iPRODUCE processes and how to improve them

Process	As Is	To Be
Procurement process	Each node has its suppliers' list (materials, machines, equipment, etc.)	The iPRODUCE nodes should lower their supply costs, higher their purchasing power and the quality of the suppliers sharing a few procurement processes phases. For instance, synchronising orders for obtaining supplies of raw materials at lower costs (e.g.: titanium, other metals for 3D printing) or for obtaining supplies of machining equipment at lower prices or with additional maintenance or upgrading services, etc.
Administrative processes	Each node has its own administrative procedures/processes	When acting as an iPRODUCE "shared enterprise", the nodes share common administrative procedures, supported by the OpIS platform that provides administrative tools and a common interface to the client.
IPR policies and processes	Each node of the cMDF network has its own IPR policies (open source, proprietary-commercial, etc.) and its own contract templates and procedures.	When offering services under the iPRODUCE umbrella, the IPR policies and the IPR contracts (Non-disclosure agreements, licensing agreements, service agreements, etc.) should be harmonised. The IPR sharing should be addressed when the iPRODUCE service is offered by more than one cMDF

		member together.
Logistics processes	Each node of the cMDF network has its own logistics organisation, involving the network of suppliers (if present), the internal logistics, and the logistics for reaching its clients.	Thanks to the OpIS platform (digitalisation supports the decoupling between the final product and the physicality of the production place), the co-creation activities performed by the cMDF Federation nodes and the lean operational model, the iPRODUCE nodes should share part of their logistics processes or optimise them by distributing the logistics functions among the nodes involved in a specific co-creation activity.
IT processes	Each node of the cMDF network has its own IT processes and tools (CRM, administrative software, machine-control software, designing software tools, etc.)	Surely the single nodes of the iPRODUCE Federation will not change their internal IT processes. IT processes are core assets of organisations and need a long time to be changed. Nevertheless, the OpIS platform will allow the single nodes to share part of the IT processes (f.i. Ricardian contract functions).
Organisation processes	Each node of the cMDF network has its own organisational processes, in terms of organisational chart, functions (general direction, design department, administrative department, etc.)	When acting as an iPRODUCE node, the member of the cMDF federation shall be part of a distributed “temporary organisation” (in each co-creation activity instance a few nodes will collaborate for a limited time framework working according to a lean operational model; when the activity ends, the temporary organisational scaffold ends). This temporary organisation will rule the way in which the nodes cooperate with each other (is there a central node? Is there a master-slave collaboration model? Etc.)
Production processes	Each node of the cMDF network has its own production processes, with different machines, different layouts, different kind of competences/skills	Nodes could share a few production processes. In many cases, a single node could not be able (in terms of competences, machineries, etc.) to satisfy a client by itself. Nodes could share their production assets as one.

3.2.3. Capability Development

In this phase, we have to answer the following question: “How are we building capability?” Answering this question means to work with the people of the cMDF Federation and, in case, extending the involvement to all the consortium members. Improving processes, without improving people that should carry them out is useless.

In the first meetings, people participating in the Kaizen activities were taught about the lean methodology and the methodological conceptual tools used to simplify the way to work together. To tackle this dimension of the Lean Transformation, the Kaizen workshops involved representatives of the cMDF nodes with different competences and roles (technicians as well as economists; managers as well as operatives).

Furthermore, representatives from other tasks were also involved (tasks dealing with the iPRODUCE business model in WP7, tasks dealing with the iPRODUCE stakeholders in WP6, tasks dealing with the iPRODUCE community building in WP3 itself).

By allowing people with different perspectives and competencies (technical, business modelling, etc.) to work together in the Kaizen workshops, Trentino Sviluppo and Hub Innovazione Trentino succeeded in the endeavour of enriching and enlarging the outputs of the Kaizen activity.

3.2.4. Responsible Leadership

In this phase, we have to answer the following question: “What leadership behaviours and management systems are required to support this new way of working?”

In a lean activity, each participant should be a leader that is aware of his/her importance in the improvement journey, even if his/her role is not managerial.

One of the most challenging efforts in the organisation of the iPRODUCE Kaizen workshops was to engage organisations and people not working in T3.1 and also not belonging to the consortium. The lock-down periods and other related economy and operational stand-by periods connected to the pandemic made it much more difficult to work together and changed the business priorities of the organisations directly or indirectly involved in iPRODUCE.

To overcome the above mentioned issues, Trentino Sviluppo, Hub Innovazione Trentino and Energy@Work decided to organise sub-meetings (involving only part of the team), one to one meetings with the single nodes of the cMDF Federation and plenary meetings. The collection of data from the single nodes was performed both during the plenary meetings and in the separate sessions: this flexibility guaranteed an easier process of data collection.

3.2.5. Basic Thinking, Mindset, Assumptions (the Floor)

In this phase, we have to answer the following question: “What basic thinking and mindset are driving this transformation?” If a company/organisation is facing a Lean transformation without the readiness to change its culture, it will not work and the change will not happen.

From this point of view, being the participant part of an innovation project like iPRODUCE made it easier to make them understand the philosophy of change underpinning the Kaizen activity and participate with the right approach.

Nevertheless, being most of them already part of an open source community, based on co-creation, collaboration axioms and knowledge sharing paradigms, made it more natural for them to share opinions, data, visions, etc.

The Kaizen activity plan was officially presented to all the partners during a weekly consortium coordination call and then repeated shortly in other plenary calls. This was made with a multiple aim:

- to make all the consortium partners aware of the activity of T3.1 (to share the leadership);
- to collect feedbacks also from tasks other than T3.1;
- to open the activity to whoever wanted to contribute, independently from its participation in the Task 3.1, to engage a broader audience and get a broader set of feedback.

3.3. The Kaizen Activity Carried out in iPRODUCE

This section describes the operative work done during the Kaizen activity. The activity was planned for late 2020, when Trentino Sviluppo and Hub Innovazione Trentino decided to use the methodologies of Lean and Kaizen to implement the operative work of T3.1.

The problems brought in by the unexpected pandemic - no physical contacts, physical workshops, new organisational priorities of the members - imposed to run the Kaizen activity only virtual, on line.

Facing an online Kaizen activity is completely different than performing it physically. Kaizen, lean principles put the person at the centre of their model: people must meet, know each other, work in the Gemba….the online process does not allow these activities.

The hiring of a consultant specialised in the Kaizen workshops became necessary in order not to fail in these unpredictable pandemic constraints.

The design of the Kaizen activity started in October 2020 and it involved a restricted team made up by Trentino Sviluppo, Hub Innovazione Trentino, Energy@Work representatives, together with Kaizen the Institute specialists.

The official first plenary workshop was organised on 1 December 2020.

The last official plenary workshop was organised in October 2021.

3.3.1. The Team Involved

In the preliminary phases of the Kaizen activity an extended team was involved. With a view to developing an extensive capability, all the consortium partners were invited in open workshops in order to share the knowledge of the Kaizen and lean principle and methodologies.

Afterwards, the operative activity involved two kinds of teams:

- the restricted team, made up of representatives from Trentino Sviluppo (T3.1 leader), Hub Innovazione Trentino, Kaizen Institute;
- the extended team: made up of representatives from:
    - Trentino Sviluppo, Hub Innovazione Trentino, Energy@Work (Italian cMDF);
    - AIDIMME, Oceano Naranja (Spanish cMDF);
    - CBS, Betafactory (Danish cMDF);
    - Makerspace Bonn (German cMDF);
    - AIDPLEX (Greek cMDF);
    - MATERALIA, Excelcar (French cMDF).

3.3.2. Structure and History of the Meetings

Due to the pandemic constraints - travelling abroad was not allowed in a few timeframes in 2020 and 2021, moreover, the restrictions of the safety rules of a few organisations of the consortium - the Kaizen activity was performed online, organising restricted meetings and plenary meetings:

- restricted meetings involved only the Task 3.1 leaders;

- plenary meetings were run involving representatives from all the cMDFs, even if not all of them were part of T3.1. According to the Responsible leadership pillar of the Lean Transformation principles, all the cMDFs accepted to be part of the game, in order to guarantee a complete and successful activity.

Table 2 shows the list of the workshops organised along the entire Kaizen activity period.

Table 2. List of the workshops of iPRODUCE Kaizen activity

Date	Participants	Work performed
14 October 2020	Restricted Team	Kaizen activity preliminary design.
21 October 2020	Restricted Team	Kaizen activity preliminary design.
16 November 2020	Restricted Team	Kaizen activity preliminary design.
1 December 2020	Plenary (all cMDFs' representatives plus other partners not directly involved in the activity)	Training about Kaizen and Lean basics: ● project introduction; ● Kaizen/lean foundations; ● training on Operating Model Canvas; ● team definition (specifically for the Kaizen activity team members).
23 December 2020	Plenary (all cMDFs' representatives)	Identification of the actual cMDFs processes through SIPOC and Makigami models.
15 January 2021	Restricted Team	Definition of the canvas of iPRODUCE.
18 January 2021	Restricted Team	Canvas check and validation.
20 January 2021	Restricted Team	Recording of the video instructions concerning the filling in of the iPRODUCE canvas.
1 March 2021	Restricted Team	Pre-analysis of the use cases conceived by the 6 cMDFs and creation of an archetypal use case.
19 April 2021	Plenary	Joint analysis of the use cases and definition of different service model scenarios by means of Makigami.
4 June 2021	Italian cMDF + Spanish cMDF	Analysis of pros and cons of the service models identified.
21 September 2021	Plenary	Consensus meeting in order to choose the most suitable service model.

3.3.3. The Methodology Adopted: Operating Model Canvas

The main tool adopted in the Kaizen workshops carried out in iPRODUCE was the so-called "Operating Model Canvas" (Figure 9). The analysis of the "As Is" state is a key phase in business process analysis such as that of the iPRODUCE Federation one, hence, it is fundamental to have a complete vision of the process, considering all the factors that might affect it.

Operating Model Canvas is a strong visual management tool that helps decision-making at several levels. It focuses on operations and value proposition and it takes its cue from the back end of Business Model Canvas, as a sort of plug-in. It is a strategic management and lean startup template for developing new or documenting existing business models, created by Alex Osterwalder. Both Business Model Canvas and Operational Model Canvas are described in depth in Annex 1 - Canvas.

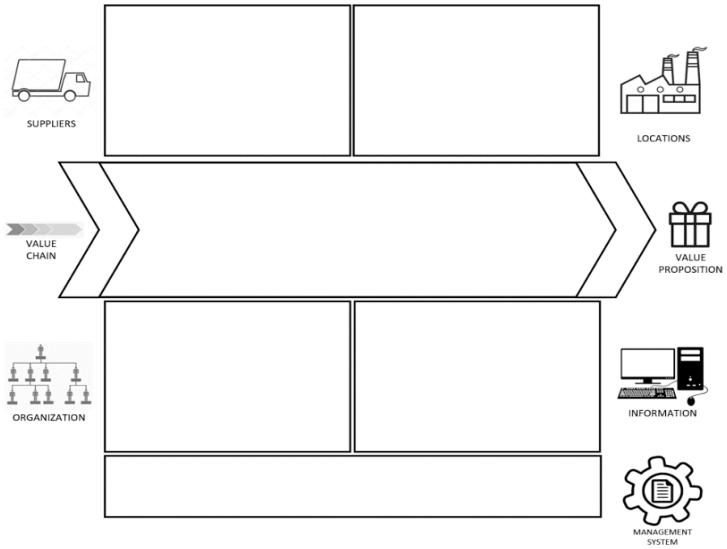


Figure 9. Operating Model Canvas structure

Operational Model Canvas is suitable to describe an existing business process, since value proposition, customer identification and financial structure should be already cleared and set as the output of the canvas[5]. It can be exploited in several cases:

- change of strategy: it helps to identify the feasibility of the project, focusing on costs, resources and time;
- performance problems: it helps to identify problems' root causes, plan intervention and lean processes;
- team misalignment: it helps to show the main differences about team's view, in order to identify the weak points on which to intervene;
- important organizational change being implemented: it helps to verify the feasibility of the project and align the employees about current and future structure.

It seems clear that the tool is strongly connected to a business process intervention, since, once the "AS IS" situation has been clearly represented on the canvas, a new "To Be" structure can be planned

[5] The value proposition does not belong to the model, but it drives it, since the aim of the process is to deliver the value proposition, according to corporate strategy.

and shown again through this tool. A comparison between the two versions can be very useful to get a complete view of the changes.

In addition to the Operational Model Canvas, also other methodologies have been used to carry out the Kaizen workshops in a suitable way. In order to describe the processes of the iPRODUCE Federation a few standards have been adopted. Processes can be described through universally recognized standards, which are intelligible to anyone who knows the language used. In literature there are several process mapping languages that can be categorized into four main categories, shown in table 6.

Table 3. Main process mapping languages

Language type	Description	Example
Data flow-based	It emphasizes data flow and document exchange during process execution.	Data Flow Diagram
Task-based	It describes a process as a sequence of tasks linked together by precedence constraints and synchronization points. It also has an interesting exception management system.	WIDE language
Communication-based	It focuses on interactions between actors (e.g., customer-vendor), defining the cycle of steps and the information needed to run the process.	Action Workflow
Object oriented	It is used primarily for describing Information Technology processes made by software that interact with each other.	Unified Modelling Language (UML).

They are not process analysis methods, but languages aimed to represent the process objective and how to perform it.

In order to delve into the operational tools that allow to describe a process, a focus on the most effective and commonly used ones is proposed in this section. The tools - most of which were used in the Kaizen workshop - are furtherly explained in more detail in “Annex 2 - Most Used Tools for Process Description”.

- Interviews. In order to start mapping a process, as that of the iPRODUCE cMDF Federation, a practical and efficient way is interviewing the people working into the Federation members. In general, the interview should involve many people engaged into the organisation (operational people, as well as their managers). In the iPRODUCE Kaizen activity a reference figure was pinpointed for each cMDF and he was asked to synthesize the process as a reference person. The interview output was then represented graphically;
- SIPOC Diagram. The SIPOC diagram is a high-level process documentation tool, commonly used in the Lean Six Sigma, which highlights the relationships between the fundamental elements that make up a process. It summarizes the inputs and outputs of one or m[7]ore

[6] Casati F., Pernici B., “Linguaggi per la modellazione dei processi aziendali”, Sistemi Informativi, Vol. 2, 2001
[7] Six Sigma is described in “Annex 4 – Kaizen and Lean Systems and Tools”

processes in table form. In the iPRODUCE Kaizen activity a SIPOC was created for each cMDF, highlighting its suppliers, inputs, processes, outputs, customers.

- Flowchart. A very simple and widespread way to represent processes is the flowchart, also called block diagram. A flowchart is a tool useful to describe a process at various levels of detail, usually taking advantage of geometric shapes, connected by arrows, representing the flow of activities within the process. The chart nodes, then, describe the activities while the oriented arcs indicate their chronological and causal sequence.
- BPMN - Business Process Model and Notation. It is a flowchart-inspired notation that, as any graphical modelling language, uses a shared and standardized set of symbols to represent business processes.
- Makigami. The Makigami mapping methodology is normally used for mapping processes in service companies, where value for clients isn't always physically identifiable (the Gemba is intangible). In the iPRODUCE Kaizen activity a Makigami map was used to map different ways in which a customer is driven along the Federation in order to obtain the iPRODUCE service requested. Makigami schemes were discussed in plenary sessions and a specific one was chosen by means of a consensus meeting and a questionnaire.

4. Design Principles Underlying the Kaizen Activity Carried Out

4.1. Introduction

Before starting with the iPRODUCE lean project, carried out through a series of Kaizen workshops, the cMDFs have identified four priority strategic objectives. The strategic objectives of the iPRODUCE cMDF Federation are the following:

- presenting itself to the clients/users as an “iPRODUCE system", now non-existent;
- maintaining the revenues/turnover of the nodes also in the future;
- creating a sustainable iPRODUCE operational model working even after the project duration;
- identifying the iPRODUCE value proposition towards potential new nodes.

4.1.1. iPRODUCE System

Currently, the nodes of the cMDF Federations offer stand-alone services to their clients/community members. They use their own branding or that of their hosting organisation. In fact, iPRODUCE started from scratch, involving makers, SME’s, fablabs, manufacturing facilities, professionals, not linked or partially linked one to each other (a constellation of bodies dealing with prototyping).

In the future, the iPRODUCE constellation shall become a networked community (ref. Figure 10), with a shared model to co-operate and a federated network of local Collaborative Manufacturing Demonstration Facilities.

Figure 10. iPRODUCE system: from a constellation of nodes to a networked federation

Each node shall be able to work with its own branding in some cases. In other cases, when an iPRODUCE client knocks its door, it shall represent the entry point of iPRODUCE System, representing the whole Federation and the iPRODUCE brand.

4.1.2. Revenues/Turnover

iPRODUCE must represent an opportunity for a node, not an obstacle or a competitor. To involve more nodes, iPRODUCE must offer to the newcomers a clear value proposition. Federated nodes shall increase their turnover/revenues thanks to iPRODUCE branding and not see them lowered by an unfair competitor.

4.1.3. Impact During and After the Project End

We must create a self-sustainable iPRODUCE operational model. Even if during the project the consortium will focus on pilot activities, organising open missions, measuring performances indicators (both heuristic evaluation of software tools and usability, etc.) of the OpIS platform and experimenting

co-creative activities, since now we must think about creating an operational model - as well as business models than are sought for in WP7 - that will work after the project deadline, surviving to the project and asymptotically reaching a market service.

The efficient way the federated nodes shall work together in the future depends on the foundations we are laying today.

4.1.4. iPRODUCE Value Proposition for the Nodes

Another strategic objective of the T3.1 activity is finding out the added value for a node to join the Federation: that is the value proposition of iPRODUCE for its potential partners.

4.2. Issues/Open Points

Four main issues have been identified, too:

- local clients preferably want a local contact point to deal with for iPRODUCE services;
- the Federation of the nodes must be created from scratch;
- the Federation must avoid overlapping and fill in lacks of competences;
- the nodes are really different from one another.

4.3. Challenges

The challenges to switch from the current iPRODUCE cMDFs organisation (a cloud of nodes non dealing with each other) to the future Federation are mainly 5, as summarised in the following:

- harmonizing nodes that have different business models (customers, policies, networks, etc.);
- making the Federation suppliers coexist with the cMDFs' suppliers (win-win coexistence);
- creating iPRODUCE knowledge and skills within the cMDFs (each cMDF node is also an "iPRODUCE point of contact";
- the cost / revenue breakdown model;
- optimizing logistics (in case of parts production).

4.4. Design Principles

Design principles are the guidelines for the design activity of the future iPRODUCE configuration: they define the borders of the design, what must be the result of the design and which constraint must be taken into account. They come out from multiple sources, as, for instance:

- the strategic objectives of the Federation;
- the issues/challenges the Federation must face;
- the strength that the Federation wants to keep;
- the constraints from the stakeholders.

A simple way to represent the iPRODUCE cMDF Federation design principles is reported in Table 4, where in the first column the design principles are reported. The second column concerns the motivation underlying them. The last column on the right lists the implications related to the design principles.

Table 4. Representation of iPRODUCE cMDF Federation Design Principles

Design principle (design must...)	MOTIVATION ('to be able...')	IMPLICATIONS ('and may foresee')
Creating an iPRODUCE system without causing imbalances to individual nodes of the Federation	iPRODUCE must be an advantage for a node	An iPRODUCE Unit inside the node or special iPRODUCE orders
Defining a modus operandi of the Federation - now non-existent (Federation vs individual nodes disconnected from each other) - to be experimented in demo-case	iPRODUCE must work differently from simply delegating the service to one of the federated nodes	The change in the functional model of the single node depending on whether it acts as an iPRODUCE node or a "stand alone" node
Identifying the post-project modus operandi (costs/revenues, network expansion, etc.)	iPRODUCE must create business to survive the project	Post-project management by a centralized body co-financed by the federated nodes? A network of nodes?
Developing iPRODUCE capabilities in the nodes of the Federation	To ensure average QoS and continuity of service	Specialized personnel of nodes training activities, creation of a group of referents aligned with each other
'In varietate concordia': harmonizing/enhancing nodes that must maintain their specificity	To facilitate the adhesion of a facility to the iPRODUCE network	A selection process of the news nodes to favour the plurality of federated subjects

4.5. Stakeholder Mapping

Table 5 represents the iPRODUCE Federation stakeholders. It has been processed starting from the stakeholder mapping activity made in Task 6.1, clustering stakeholders, analysing their interactions with iPRODUCE and identifying the difficulties/issues about their involvement in the community.

Seven main categories have been identified:

- manufacturers/industrial organisations;
- makers (and their communities);
- consumers;
- the scientific community;
- facilitators (intermediaries);
- enablers (generally, institutions);
- civil society (the people).

Table 5. iPRODUCE Federation stakeholders

Macro Stakeholder Category	Stakeholder	Possible Interactions with the iPRODUCE System (as Emerged from T6.1 Activities)	iPRODUCE Stakeholder Difficulties
MANUFACTURERS & INDUSTRIAL STAKEHOLDERS	**Consumer-goods manufacturers**	• iPRODUCE service/technology/processing providers. • Customers. • iPRODUCE end-user training providers. • Platform usage feedback providers.	How to hire them as customers?
	Manufacturing Startups		Manage them as iPRODUCE customers or single Facility customers?
	Software companies		Will iPRODUCE be seen as a competitor for those that offer services and processes?
	Service providers		Can a Spanish client be managed by the French cMDF, if it operates in the specific field of the client?
	Equipment/Material suppliers		

MAKERS AND MAKER COMMUNITIES	**Fablabs**	• OPIS Customers. • Joint Projects/Collaborations • They can support the expansion of the iPRODUCE market (network creators). • Joint Events. • Joint Online Training (Material Providers).	How to make them adhere to iPRODUCE as nodes (what advantages do they have?)
	DIY communities and maker groups		The standardized governance of iPRODUCE can be combined with governance of different types (e.g., voluntary basis, etc.)
	Co-working spaces		Must the iPRODUCE referent be certain/fixed within the makerspace or can he/she be dynamically assigned?
	Artists and designers		Times and methods: will they be able to respect the times and quality of supplies (estimate in certain times, etc.)?
	Engineers, inventors and relevant experts		
	Individual makers		
CONSUMERS	**Individuals**	• OpIS customers. • New application areas for iPRODUCE (e.g., sport, culture, etc.)	Area customers already trained to interact with iPRODUCE? What about newbies?
	Targeted market audience		How to conquer new market segments outside the makers' network?
SCIENTIFIC COMMUNITY	**Research organisations**	• Supporting dissemination, events. • They could provide	How to promote iPRODUCE at research institutions?

	R&D units in private companies	interns, trained students. • Clients for particular types of iPRODUCE products/services.	How to find prepared figures?
	Experts and individual researchers		How to "hook" their facilities for any subcontracts?
FACILITATORS	**Associations of engineers and manufacturers**	• Spreading the knowledge of iPRODUCE to associates/networks. • They could act as "commercial agents" of iPRODUCE towards companies, professionals. • Participation in iPRODUCE events • Project owners	Why should these subjects' "privilege" iPRODUCE over other public/private entities?
	Funding agencies/Business incubators		How to engage them in the iPRODUCE events?
	Policy making institutions		
ENABLERS	**Local /Regional authorities**	• Engagement of non-native iPRODUCE communities (e.g., high school students) • Dissemination/Events • Grants	How to sensitize them to iPRODUCE?
	National authorities		Does iPRODUCE have a legal entity to participate in tenders/tenders?
	EU networks and initiatives		
CIVIL SOCIETY	**Civil, social organizations/NGOs**	• Participation in events. • Stimulate new application sectors of iPRODUCE services/products (e.g., tourism, school, etc.)	Is iPRODUCE an authoritative interlocutor for public/para-public subjects (e.g., hospitals, etc.)?
	Public infrastructure (e.g., health, education)		

4.6. Preliminary “As is” Canvas and Possible “To be”

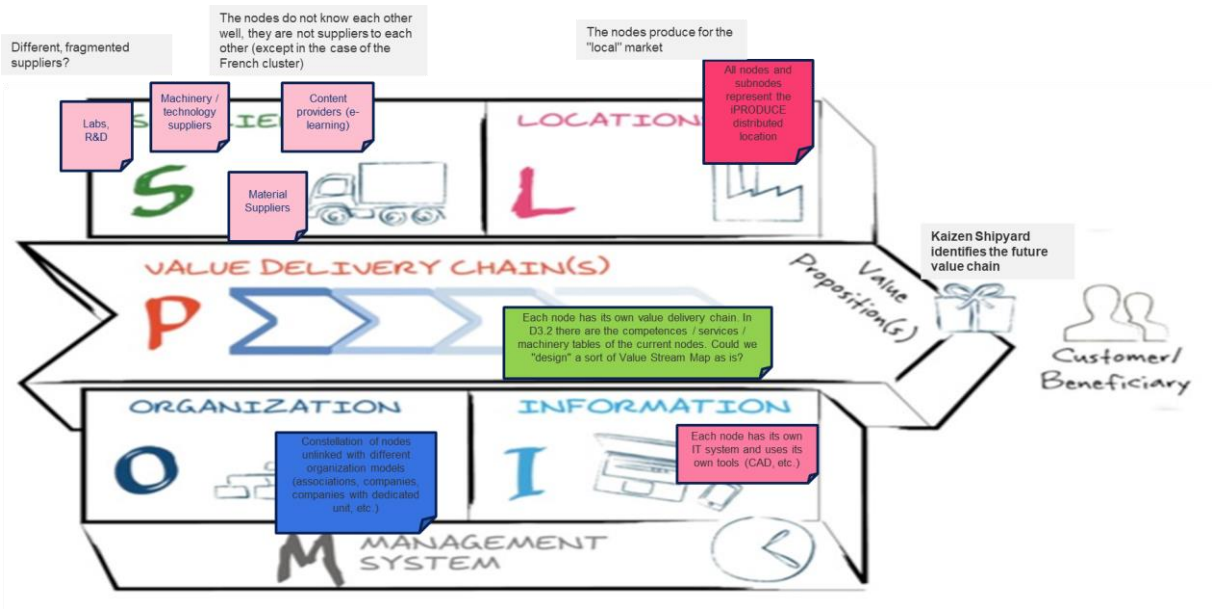


Figure 11. iPRODUCE Operational Model Canvas As Is

Figure 11 and Figure 12 show respectively the As Is Canvas operational model canvas of the starting point - with post-it notes that highlight the main (not all) open points, and the To Be Canvas operational model canvas with a few hypothesis to be deepened during the Kaizen workshops.

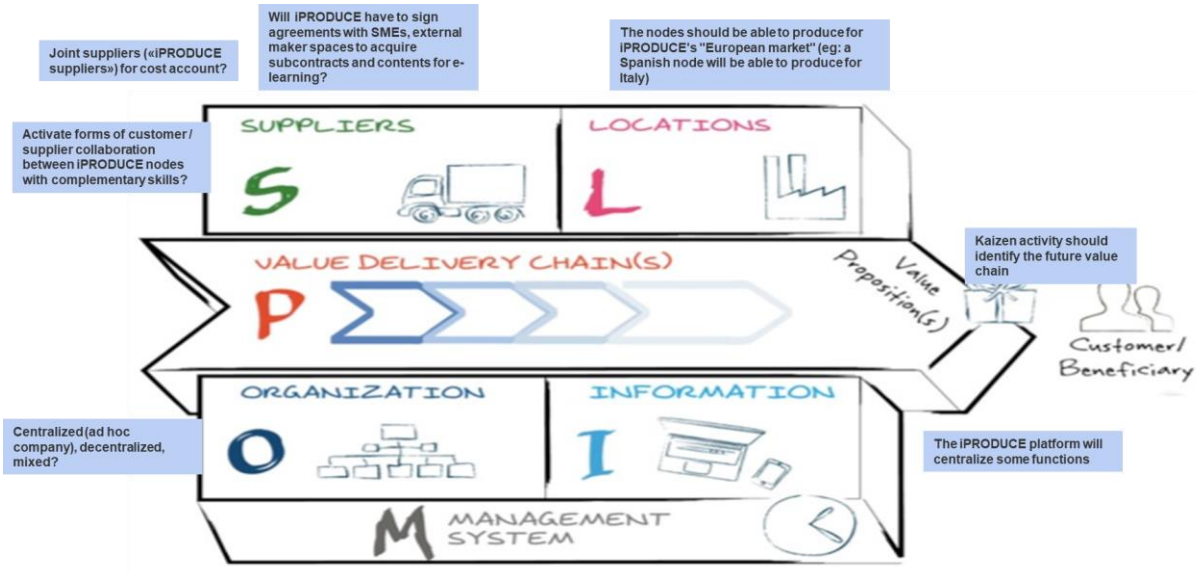


Figure 12. iPRODUCE Operational Model Canvas To Be

5. The iPRODUCE cMDF Federation: As Is

5.1. Identification of the Current Value Stream Map

In the first meetings of the Kaizen activity, the 6 cMDFs' representatives reflected on their current customers. Three main types of clients were identified:

- persons not experts of prototyping (inventors, consumers, etc.);
- experts of prototyping (makers);
- companies (SMEs, etc.).

Figure 13. Customer segments of current iPRODUCE cMDFs

cMDFs exchanged views on the different types of customers segments and on their importance for their own business model. Figure 13 graphically reports the output of the analysis.

Table 6 instead shows the industry focus of the nodes taking part into the Kaizen Team and their affiliates. Mainly, the nodes are multisectoral.

Table 6. Industry focus of cMDFs

				Cathegory				Industry Focus					
Country CMDF	Legal ENTITY Name	PARTNER	AFFILIATED	Manufacturer/SME	FabLab/Makerspace	Facility	Research	Automotive/mobility	Medical Products	Wood Works & Furniture	Mechatronics & Microelecttronics	Not related to specific industry or sector	ICT
Denmark	BetaFactory	x		x	x							X	Potential
	CBS	x					x					X	X
France	Materalia	X						x	x				
	Excelcar	X			x			X					
	FabLab-Vosges	X			x							x	
Germany	ZENIT						x					x	
	Makerspace Bonn				x						x		
	FIT						x					x	
Greece	OKthess	x			x		x					x	Research Center
	AidPlex	x		x					x				
Italy	PROM-TS	x				x						x	
	Energy@Work	x		x							x		x
	NoiTECH makerspace		x		x							x	
	MUSE		x		x							x	
Spain	AIDIMME						x			x			
	Lagrama			x						x			
	VLC Fablab				x					x			

Afterwards, the analysis of the processes of the nodes were carried out. Table 7 shows the entrepreneurial clients of the six cMDFs and the types of processes implemented by each of them ("something to create"). Letter "O" stands for "As Is", letter "P" stands for "Potential, in the future", letter "O" stands for "out of the scope". Some of them are engaged in the preliminary phase of idea development. Others also cover the prototyping phases. Moreover, some deal also with final production. Spanish and Italian nodes cover all the processes. France and Germany focus on design and technology transfer. Denmark and Greece focus on production.

Table 7. Entrepreneurial clients and processes implemented by cMDFs

CMDFs	Clients		SOMETHING TO CREATE						
	Companies	Start-ups	Concept idea description	Design phase	Challenge test	Prototype	Experiment	Manufacturing planning	Production
France	O	O	O	O	O	O	P	-	P
Germany	O	O	O	O	O	O	-	-	-
Spain	O	-	O	O	O	O	O	O	O
Denmark	P	O	P	-	-	-	-	P	O
Greece	-	O	O	O	-	O	-	O	O
Italy	O	O	O	O	O	O	O	P	O
				Design		Technology transfer		Industrialization	
			Idea ok for the customer (virtual product)			Create something feasable (1 piece)		Start-up the process (Massive production)	

During the Kaizen workshops, a similar scheme was developed also for training activities (training tools are part of OpIS). Table 8 shows that theoretical training is their main focus, even though Spain and Italy show potential interest in practice oriented training.

Table 8. Training activities featuring the six cMDFs

CMDFs	TRAINING				
	Online training (autonomous)	Online training (LIVE)	On site training	Immersive training (live+machineries)	Trainee present Trainer remote
France	O	P	O	-	-
Germany	P	-	O	-	-
Spain	O	O	O	P	P
Denmark	P	P	O	-	-
Greece	-	-	-	-	-
Italy	O	P	O	O	P

Theory Practice

Table 9. Final current state analysis

Current state analysis

KAIZEN™ INSTITUTE

Main processes synthesis – I-Produce added value

	Clients									Value Proposition										
	PRIVATE					BUSINESS				SOMETHING TO CREATE							TRAINING				
Country CMDF	Inventors	Students	Researchers	Consumers	Makers	Start-ups	Small Medium Enterprises	Multi National Companies	R&D Companies	Concept idea description	Design phase	Challenge test	Prototype	Experiment	Manufacturing plannig	Production	Online training (autonomous)	Online training (LIVE)	On site training	Immersive training (live+machineries)	Trainee present Trainer remote
Denmark	2	4	2	2	4	4	4	1	3	4	4	3	4	2	3	4	3	3	4	3	3
	1	4	4	1	1	2	1	1	1	4	4	4	4	4	1	1	4	4	4	1	4
France	3	2	4	2	2	4	4	3	4	4	3	3	1	1	1	1	2	3	3	2	2
	3	3	3	2	3	4	4	3	3	3	4	2	4	2	4	3	4	3	4	3	2
	2	4	2	4	4	4	3	3	2	4	4	4	4	3	2	1	4	3	4	2	2
Germany	3	3	4	2	3	4	4	3	4	3	1	1	1	1	1	1	3	3	2	1	3
	4	4	3	4	4	4	4	3	4	3	4	3	4	4	2	2	2	2	4	4	3
	3	3	4		2	3	3	3	3	3	1	1	1	1	1	1	4	4	3	3	3
Greece	3	2	4	3	3	3	3	3	4	4	4	4	4	4	3	2	2	2	2	2	2
	3	1	2	4	3	3	4	4	3	4	4	4	4	4	3	2	2	2	1	1	1
Italy	4	3	4	3	2	4	4	3	4	2	3	3	4	4	2	1	1	3	4	4	1
	1	1	3	2	1	3	4	3	4	4	4	3	4	4	3	2	1	1	1	1	1
	4	3	3	1	3	4	4	3	4	3	3	3	4	4	2	2	2	4	4	4	1
	3	4	3	3	4	2	2	1	1	2	2	3	4	3	1	1	2	4	4	4	2
Spain	1	1	3	1	1	2	4	3	3	3	1	3	2	4	1	1	2	4	4	1	2
	2	1	1	4	3	1	4	3	2	2	2	1	2	2	4	4	1	1	1	1	1
	3	4	3	3	4	2	3	1	1	4	4	3	4	3	2	1	4	4	4	4	4

I-Produce platform opens the door to CMDFs to new clients and to integration of new value proposition opportunities

Putting together what emerged in the previous analysis, a final matrix (

Table 9) has been created. It summarises the current state analysis.

Each cell contains a number from 1 to 4, where:

1. Out of scope
2. Occasional
3. Potential
4. Core Business

The yellow cells - lower scores - represent the weaknesses that should be overcome by means of iPRODUCE, that should open the door to new clients and offer new value proposition opportunities.

6. The iPRODUCE cMDF Federation: To be

6.1. Introduction

This chapter concerns the design of the future Value Stream Map of the iPRODUCE Federation. First, the Team has identified possible governance models for the customer journey through the iPRODUCE processes. As a consequence of the chosen governance, the future Value Stream Map has been designed. For an easier understanding of the Stream Map, a complex theoretical multi-node/multi-country use case has been used and the interactions among the client and the different nodes of the Federation have been defined[8].

6.2. Key Questions to Identify the Governance Model

The restricted Team, with the support of Kaizen Institute, identified a few key questions to share with the cMDFs participating in the workshops, in order to jointly reach a common vision on the governance model of the future Federation. They are reported in the following lines:

- does the customer know the single cMDF or the iPRODUCE platform?
- Is iPRODUCE a partner or does it sell the service? E.g., Home renovation: the enterprise (iPRODUCE) gets a job and coordinates the craftsmen; alternatively, the customer buys single services from different craftsmen.
- How does the client interact with cMDFs (sketches are reported in Figure 14)?
    - Local hub: the local cMDF is the only reference for the customer. The customer finds iPRODUCE through the **OpIS marketplace** and its local hub (for instance, in the sketch, a node of the Italian cMDF) contacts other iPRODUCE cMDFs and deals with the client;
    - Maker hub: the customer is supported by iPRODUCE **OpIS marketplace** and contacts various cMDFs on its own;
    - Hybrid hub: both the client and the first involved cMDF contact the other cMDFs.

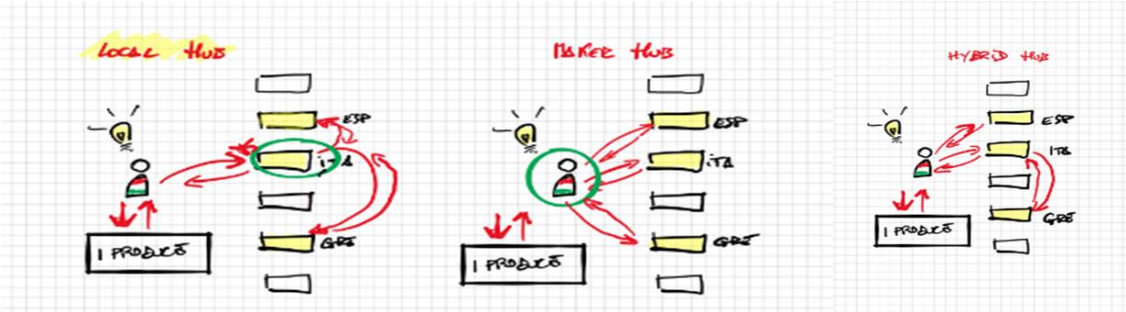


Figure 14. Possible interactions of the iPRODUCE client with a cMDF

- What should be promoted in the local areas? iPRODUCE or cMDFs?
- If the maker's project does not involve his country's cMDF, shall the cMDF have a role anyway? (E.g., brokerage, speak the same language, etc.)?

[8] Usually, the Value Stream Map describes the journey of the product through the process. Vice versa, in this section the Value Stream Map has been described focussing on the interactions among the nodes implementing the process, in order to make the description clearer to the reader.

- If a cMDF is the hub for a project, how is it managed? Who oversees the consistency and the integration of the contributions from the various cMDFs?
- How are revenues distributed?
- Who oversees the commercial area? How does the handover from Marketplace Manager (MPM[9]) to Project Manager (PM[10]) happen?
- Does each cMDF have his own MPM and PM or are they "central" figures, directly connected to iPRODUCE?
- Which tool does the MPM use to make quotations? OpIS?
- How are experiences and cases shared with the whole network (in order to guarantee the continuous update of iPRODUCE partners about platform value proposition)?
- How is the MPM training managed (support technical sale)?
- Who has the responsibility of the project in case of disputes? Hub or cMDF?

6.3. Possible Governance Models

In this chapter, various governance models of the Federation operations are proposed. The models are the result of the discussion and comparison carried out during the first Kaizen workshops, on the basis of the open point reported in the previous section, and have been represented graphically as follows in the next chapters.

The pros and cons of each solution are outlined as well as open points and considerations that have been put forward when formalising the strategy. This work has been carried out by a restricted team (T 3.1) which later shared the outputs of the process in a plenary consensus meeting.

The models proposed are the following:

- Centralised Model;
- De-centralised Model;
- Hybrid Model.

Each of these models is described by a Makigami map which outlines the responsibilities of all the involved entities, starting from the customer, down to the local hub (iPRODUCE node, belonging to the local cMDF). This strategy allows for a clear depiction of the whole process and accounts for user experience and interface.

At this stage, the time between a step and the next is not taken into consideration, since the future structure has to still be defined and time estimation would only represent an element of redundancy.

In the following, the term "client" will be used to address the entity that contacts iPRODUCE to get a service/product or to get cooperation opportunities, be it a citizen, a maker, a professional, a manufacturing SME, etc.

6.3.1. Centralised Model

The first model that has been considered by the Kaizen team is what is called a Centralised model. Its Makigami representation is reported in Figure 15. The main figure that characterises this model is a Central Project Manager.

[9] MPM (Marketplace Manager): Technical/Commercial Supervisor
[10] PM (Project Manager): Project coordinator

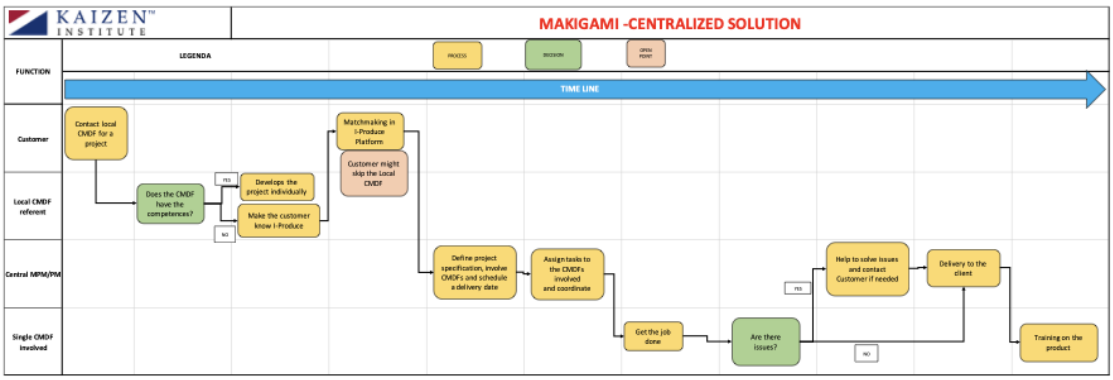


Figure 15. Makigami representation of the centralised model

When a customer contacts a local cMDF, if the cMDF is able to develop the project internally, the process is carried out individually. Instead, when the local cMDF does not possess the competences (all of them or part of them), the client is made aware of the iPRODUCE platform and selects the cMDF that best fits the requirements.

The contact can be physical (the client “knocks the door” of the local cMDF) or digital, by means of the **marketplace tool**, that provides the consumer the ability to register, editing its own profile and list of ideas/products. The **matchmaking tool** can support the consumer to find suitable partners, products and services to enable the development of agile collaboration networks.

From here on a central Project Manager takes charge of project specifications and delivery schedules. The central Project Manager interacts with local cMDF’s nodes to deliver the required services and coordinates each step of the process. Once the project is open, the Project manager is the responsible of solving any issue that may arise and is the only link between client and local cMDF.

This model offers the advantage of having a single figure ahead of the entire process, from order to delivery. The downside is the fact that a centralised PM may be located in a region far from the local cMDFs and may also be abroad. Issues related to the language, the logistics, etc. can arise.

Another aspect that has to be clarified is the client’s ability to contact iPRODUCE centrally. Although this may seem reasonable, the Makigami chart does not take into account this possibility, leaving space for further definition.

6.3.2. Decentralised Model

In opposition to the centralised model, the de-centralised model has been examined by the Kaizen Team. Its Makigami representation is reported in Figure 16. This model is characterised by the lack of a well-defined central Project Manager.

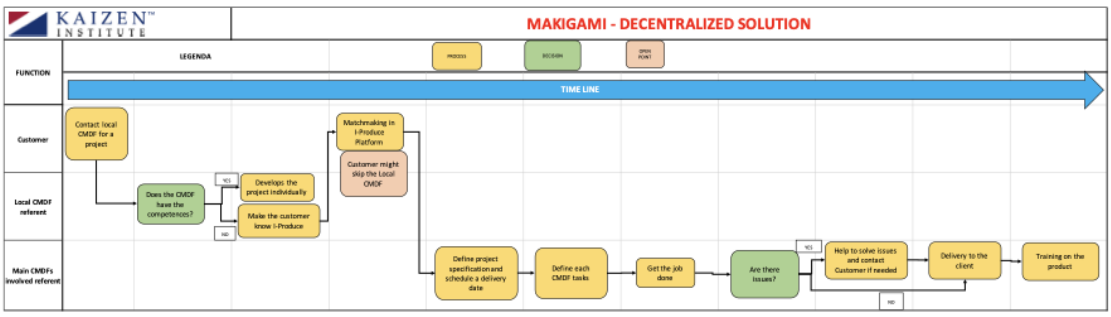


Figure 16. Makigami representation of the de-centralised

In this case, if the local cMDF cannot deliver the project individually, the client matches with the cMDF that can best deliver the job (via **marketplace and matchmaking** tools) the Produce platform.

Whenever the local cMDF contacted by the client does not possess all the required competences internally, the iPRODUCE platform enables the client to match with a cMDF that does. The chosen cMDF becomes responsible for project specifications and delivery estimations. At this level, the Makigami map does not explicitly point out who in the organization is responsible for all the coordination activities. If any issues arise, the main cMDF involved in the project is in charge of the problem solving activities needed.

Once the project is completed, the same cMDF delivers all the training activities that may be required.

One of the limits of this approach is that the main cMDF involved in the delivery of the project could be located in a different region/country with respect to the client. This can limit the ability of each cMDF of creating a network and may also compromise the training activities.

6.3.3. Hybrid Model

The final model that has been envisaged in the Kaizen workshops is what is defined as a Hybrid model. Its Makigami representation is reported in Figure 17. The hybrid solution draws the most beneficial characteristics from both the centralised and decentralised models.

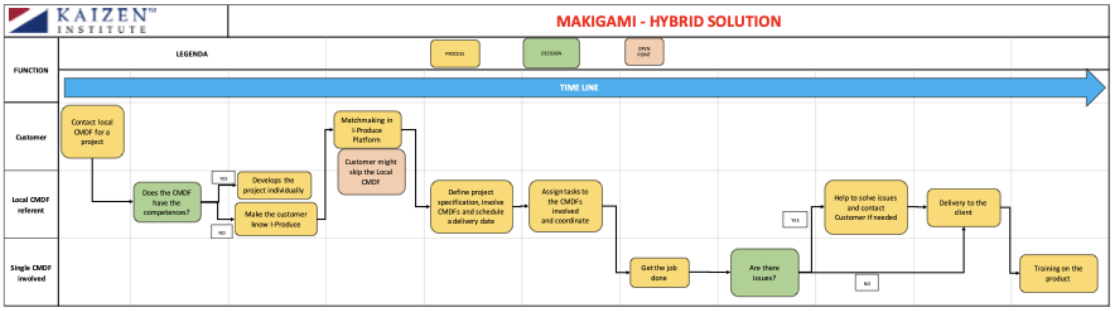


Figure 17. Makigami representation of the hybrid model

The centralised solution is advantageous because there is a clearly defined Project Manager (from now on, also “Super-user”), responsible for specifications and delivery estimations, while the decentralised model offers the local cMDFs the ability to develop regional networks and interact with the client in a more direct manner.

In the hybrid solution, if the local cMDF contacted by the client does not possess all the necessary skills to deliver the project internally, it acts as Project Manager. The local cMDF defines project specifications, a delivery date and also coordinates other cMDFs that act as suppliers on specific parts of the project.

Once all the involved cMDFs complete their tasks and the project is completed, the local hub delivers the outcome to the client.

The necessary specific training activities are delivered by the cMDF that conducted the development of the relative product.

6.3.4. The Chosen Model

All the three proposed models present important aspects that need to be taken into account by the Federation, relating to the interaction of the various cMDFs among themselves and with clients.

The benefits of having a centralised model reside mostly in the fact that there is a well-defined figure responsible for managing the project and keeping track of developments. The downside is the fact that this figure could be located far from the local hubs directly working on the project and therefore may not be completely in touch with these entities and the way they operate (language barriers, etc.).

The decentralised solution removes the figure of a centralised Project Manager. The cMDF that has the competences to develop the project is in charge of defining specifications and a delivery date. Once again, this reality may be located far from the client, so the possibilities of creating a regional network are definitely lower.

The hybrid solution encompasses the advantages of having a specifically defined figure managing the project, together with the ability of local hubs to create a regional client network. The local hub defines project specifications, while other cMDFs act as suppliers whenever an outside contribution is needed.

The various models have been developed during the Kaizen workshops. Then, the Restricted Team (T3.1) has worked to identify the various pros and cons of each solution. In order to decide which of the three solutions would best shape the Federation, a plenary consensus meeting has been finally organised.

Having outlined all the possible solutions, the representatives of each cMDF discussed the various models with their teams and afterwards voted for the preferred solution.

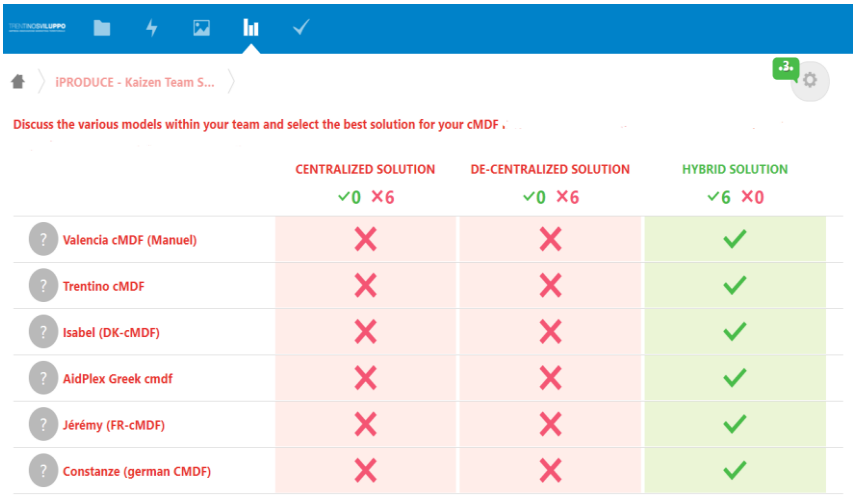


Figure 18. Result of the cMDFs' vote on the governance model

As shown in Figure 18, with a staggering six out of six votes the hybrid solution has been chosen.

6.4. The Future Value Stream Map

Starting from the **Hybrid governance model** chosen by the six cMDFs participating in the Kaizen workshops, the Team has proceeded to outline the Future Value Stream Map of the Federation.

To make the design work easier, a fictitious and wide **use case** has been conceived, as in the following:

- an entrepreneur wants to design an innovative armchair;
- the idea consists in piloting a relax armchair with an automated device that can customize the position of the chair and providing micro vibration for therapy benefit;
- through the iPRODUCE website, the entrepreneur gets in contact with its local Italian cMDF;

- the Italian cMDF helps the entrepreneur to verify the feasibility of the project and provides support for the mechatronic device for movement and vibration; but it lacks competences on other design aspects;
- the Italian cMDF takes the role of Project Manager and invites the entrepreneur to join OpIS using the platform features;
- the entrepreneur, with the support of Italian PM, finds the right competences in the Spanish cMDF;
- besides the Italian cMDF decides to involve the Greek cMDF for its competences in the medical sector for the development of the vibration algorithm;
- the co-creation process starts;
- the Spanish cMDF supports the entrepreneur with a business model;
- design finalization (Italian cMDF), prototyping (Italian and Spanish cMDF) and assembly (Spanish cMDF);
- the entrepreneur signs an IPR agreement with the iPRODUCE Federation represented by the Italian cMDF Project Manager.

The main innovation of the project consists of a device that allows the chair to automatically customize the resting position to increase comfort and provides micro vibration for therapy benefits. Since the technology must be developed from scratch (no such products/prototypes are found in the iPRODUCE platform), the entrepreneur gets in contact with the Italian cMDF.

The Italian cMDF starts working on project specifications but, before the Kick off meeting, visual management instruments are implemented. The main visual management instruments used for this use case are the Obeya Room and the Barashi boards (digital).[11] Once all the first specifications are outlined together with the client and the main criticalities have been discussed, the client is presented with a price quotation and delivery estimations. The initial concept is then confirmed and a contract signed on the basis of the Federation protocols. IPR is being signed too, using the platform features.

The team is formalised (Italian, Spanish and Greek) and the different cMDFs start working in parallel on the project on their specific subprojects, according to their competences, using the platform features to manage the collaboration workflow and create**.** The Super-user acts as the Project Manager and is in charge of reviewing project specifications and delivery together with the other divisions.

Weekly alignments are organised and put in place by the Italian PM to keep track of progress. Whenever obstacles are encountered the Super-User must decide whether or not the problem requires extra weekly meetings.

In the following a possible scenario of the map of the process is presented:

1. When the teams meet an obstacle, they have never encountered before, it is the Super-User's responsibility to involve all the members to participate in test reviews and problem solving activities. This allows the whole team to grow and develop specific competences on the job;
2. the Super-user is the only link between the various cMDFs and the client (that is: in the armchair use case example, the client can technically interact with the Spanish and Greek cMDF technicians, but the governance of the project and the main contact is the Italian PM);
3. while the Italian and the Greek cMDFs work on the mechatronic device, the Spanish cMDF develops a Business Model that will help the maker's project succeed;

[11] Obeya Room and Barashi Board tools are described in Annex 3 - Visual management tools.

4. the Greek cMDF is the first to finish its task and hands the work over to the Italian cMDF that must finalise the mechatronic device;
5. thanks to the visual management instruments, that will be discussed more in detail in the next chapter, the prototype is ready on time;
6. the Italian cMDF carries out testing activities;
7. alert! The tests show clearly that there is a problem with the mechatronic device;
8. the Super-user informs the client and the Spanish cMDF about the problem and starts to investigate the root cause;
9. problem solving activities within the Italian cMDF were not able to solve the problem, so the Super-user contacts the Greek cMDF which manages to find a flaw in the vibration algorithm;
10. after the armchair passes all the tests, final assembly activities are carried out by the Spanish division;
11. the maker collects feedback from the community via the mobile App for social media (a mobile application is in development in order to obtain Voice of Customer feedback through which iPRODUCE can actively solicit input about new ideas, stress test existing ideas, etc.).
12. the feedback collected via the App for social media should not be used separately from the use of the others OpIS tools; on the contrary they should be used alternately, when testing, for a better fine tuning of the final output;
13. the maker is satisfied with the outcome of the project so, together with the help of the Super-user, he signs an IPR agreement, through the Ricardian toolkit, with the involved stakeholders;
14. the Spanish cMDF is engaged for the final assembly.

7. Lean Operational Model

7.1. Introduction

In this chapter the Lean Operational Model developed in iPRODUCE is presented. The operational model is designed to fit the needs of the chosen governance choice (Hybrid one) and the related Value Stream Map. The Model considers every step of the Federation's operations, from when the client contacts a local cMDF to when the project is delivered.

In order to accurately describe every step that leads to project completion the following structure will be employed:

- From contact to contract;
- From contract to PoC (Proof of Concept);
- From PoC to final project.

When describing the various steps, all the necessary modules and instruments will be discussed to capture the true essence of the proposed structure. In the following, specific Kaizen tools that can be used by the Super-user in his/her project management activities are described[12].

Let us start introducing the phase-gate approach and the Deming Cycle, foundation concepts of the Operational Model.

7.1.1. The Phase-gate Approach

The Lean Operational Model takes advantage of the Phase-Gate approach (Figure 19), a project management technique that logically divides a project or initiative into multiple development phases, each separated by what is called a "gate". A gate is a decision point at which managers, steering committees or boards decide on continuation by evaluating data, risk analysis, available resources, etc.

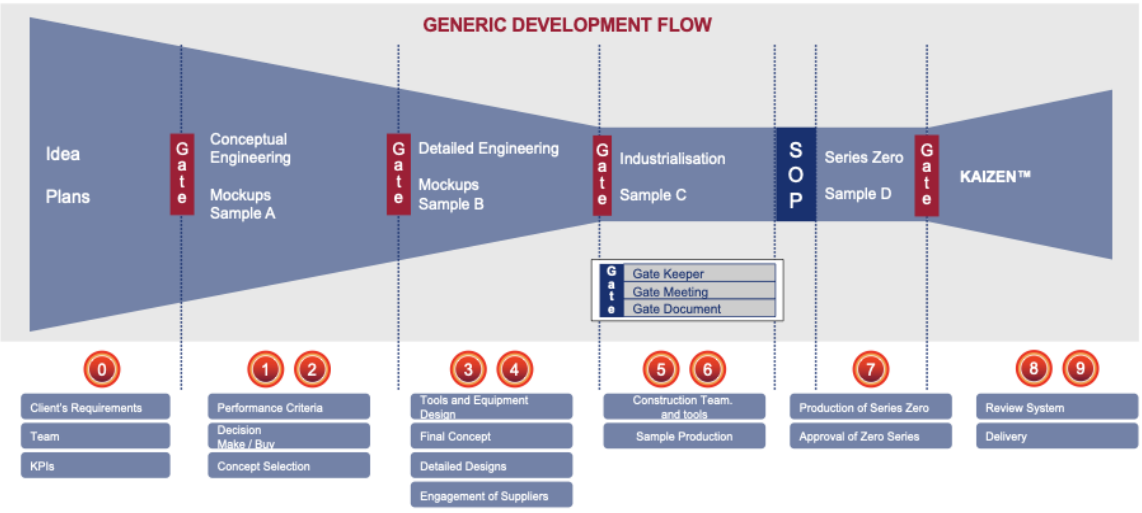


Figure 19. Phase-gate approach in the development of a project or initiative (source: Kaizen Institute)

[12] The Kaizen tools described in the section are suggested for a lean transformation. Of course, other tools can be used in case of different needs.

Phase 0: At this stage all the ideas are gathered. It is important to work closely with the iPRODUCE clients to collect all relevant requirements on the product. In case, also the voice of the customer can be included at this stage (for instance, using the **Mobile App for Social Media)**. All the teams are decided on the basis of competence and KPIs (Key Performance Indicators) are set to keep track of advancements or problems.

Phase 1-2: At this stage the product starts taking shape as a conceptual design. This must obviously account for a more detailed study of the product and the market. The strengths and weaknesses of the new product are compared with what already exists on the market and what is under development can be classified according to the diagram reported in Figure 20. The first mock-up can also be developed as a result of this stage. The Project Manager and the iPRODUCE client will start using from now on the **Generative Design tool(s)** and the **AR/VR tools**.

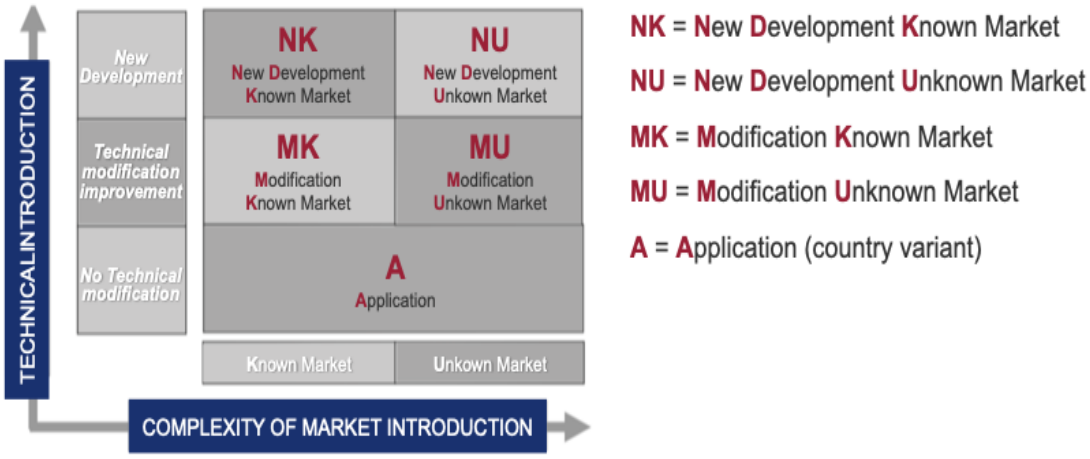


Figure 20. Bi-dimensional diagram market-technical positioning of the product (source: Kaizen Institute)

Phase 3-4: This is the last phase of concept development. It is one of the most complex and resource consuming steps, since it must produce all the necessary outputs in order to understand the feasibility and the path to industrialization.

Phase 5-6: During this phase, all the plans from the previous steps are put into action. After producing a proof of concept, the development team must define milestones and production KPIs.

Phase 7: At this point, the product/process must be validated by a series of testing activities. It is also possible that new and improved concepts are developed and approved. The **Mobile App for Social Media** can be used in this phase to collect feedback from the community.

Phase 8-9: It coincides with product launch. All no added value activities have already been removed thanks to the Kaizen approach to project management. This aspect can be illustrated through Figure 21, where activities like delays, defects are shown as typical non added value activities. In iPRODUCE that deals with services more than products, the no added value activities could be, for instance movement of information or excess of design files, etc. The OpIS platform, thanks to tools like Agile Network and Matchmaking, should effectively contribute to the reduction of these issues.

	DEVELOPMENT	EXAMPLE	EXPLANATION
T Transportation	Handoffs		Movement of Information or Material
I Inventory	Partially completed work	Every Feature that was started (e.g. specified) but will not make it in any release	Waiting of Information or Material
M Movement	Task Switching		Movement of People
W Waiting	Delays		Waiting of People
O Overprocessing	Relearning	Investigating again, since the previous investigation lacks clarity	Excess of Processing
O Overproduction	Extra Features	Adding a feature not requested by customer	Excess of Production
D Defects	Defects	Redesign Loops	Mistakes

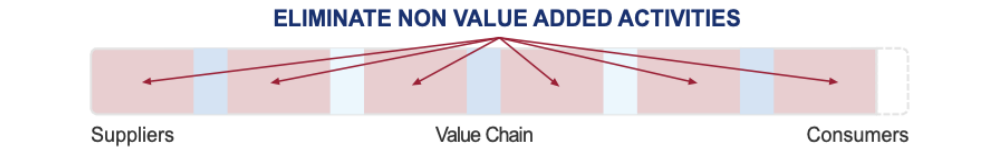


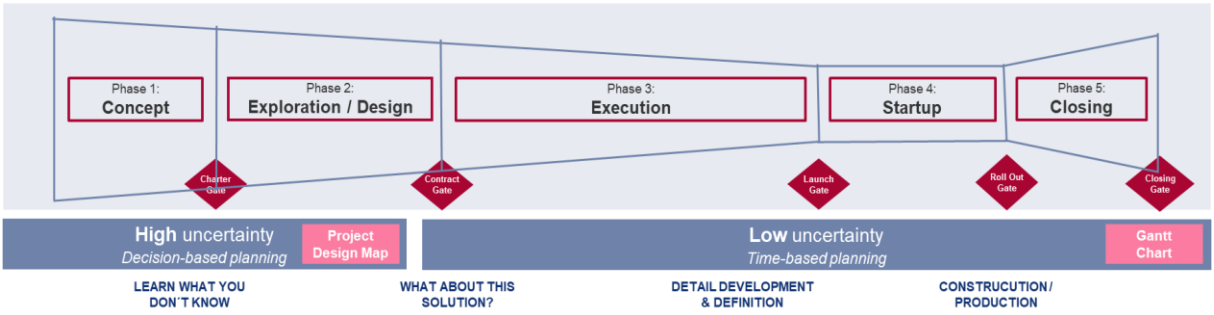
Figure 21. Kaizen approach aims at eliminating activities which do not add value to the production workflow (source: Kaizen Institute)

According to the hybrid governance model, all along the above mentioned phases the Project Manager, the Super-user, is the reference for the client and can, via the **OpIS platform tools**, activate all the necessary competences and skills of the iPRODUCE cMDF Federation.

Another possible visualization of the project development funnel can be made distinguishing two main phases within the process: high uncertainty and low uncertainty (Figure 22).

High uncertainty: During the first phases (first two gates where the Team is engaged to learn what we do not know) planning is mostly decision based. It is the moment in which all the needed information is gathered and during which the team can learn most of the new skills.

Low uncertainty: The following phases are characterised by time based planning. From the reliable release promise point to industrialised production, there is a low chance of having to deal with fatal criticalities. This also means that teams are usually used to solve the problems they encounter during



these phases.

Figure 22. Production workflow as a funnel featured by different uncertainty level phases (source: Kaizen Institute)

7.1.2. Project Development & Deming Cycle

All the phases of project development (that is each phase between a gate and the following one) can easily be identified as steps in the Deming cycle. The Deming cycle is an iterative method used in business to control and fuel continuous improvement of processes and products. It can be represented as a wheel on a slope (Figure 23): a cycle follows another as the wheel moves upwards.

After each improvement, new standards must be put in place (steps) to avoid the wheel from sliding downwards.

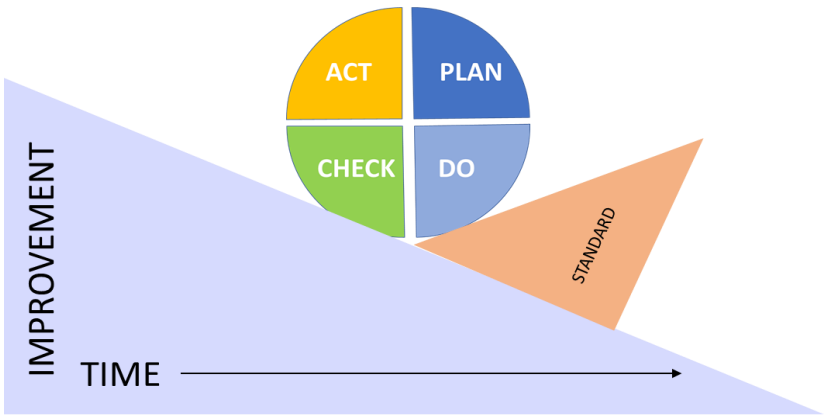


Figure 23. Deming cycle logical representation

Hereafter, a short explanation of the different steps of the cycle:

- Plan: at this stage objectives and expected results must be established;
- Do: the solutions developed at the previous step are tested;
- Check: an analysis of the data collected at the “do” phase is done. All the similarities and differences with respect to the objective should be highlighted. If the outcome does not match the objective a new cycle is deployed.
- Act: after evaluating the results of the *do* and *check* phases, if the outcomes aligned with the objective, the process/project is improved with new standards, instructions and goals;
- Standard: a standard is the best way of doing something until the next improvement. Once a PDCA activity ends, standards are put in place to maintain the improved state (without the step, the wheel of improvement would slide downwards)

It is easy to see how the Deming Cycle applies to project development.

The following image in Figure 24 summarises the steps that lead to industrialization based on the Deming Cycle (PDCA). The light blue rectangles represent common tools used in a Kaizen approach to project management. A few of them will be illustrated in the following sections.

P: **PLAN**	D: **DO**	C: **CHECK**	A: **ACT**
Project Initiation A3	Meeting Standards	Barashi	Project Standards
Project Design	1W Last Planner	Team KPIs	Risk & Opportunity Matrix
Pull Planner	Resource Load	Project KPIs	Integration & Advisory Meetings
6W Last Planner	Follow-Up of Subactivities	Design Review Control	Issues + 3C Kanban

Figure 24. Deming phases and project management tools that can be applied in each phase (source: Kaizen Institute)

After explaining the two principles of phase-gate and Deming cycle governing the product/service development workflow, let us now see the detailed phases that in iPRODUCE Operational Model bring from the first contact of a client with the Federation to the final product development. Let us take into consideration, with a pragmatic approach, the armchair use case.

7.2. From Contact to Contract

In the following, the steps of the Operations from the first contact of the client with the local cMDF to the contract with the iPRODUCE Federation.

1. An Italian entrepreneur from the furniture sector has the idea of creating an armchair with mechatronic features that make it innovative with regard to what is currently on the market.
2. The main innovation consists of a mechatronic device that allows the chair to automatically customize the resting position to increase comfort for the user and provides micro vibration movements for comfort and also therapy benefits.
3. The entrepreneur knows the market and is aware that the technology could be developed from scratch.
4. He has not all the skills needed to realise the new product and so he decides to get in contact with the Italian cMDF, in particular the geographically **closest node** of the Italian network.

Figure 25. Mechatronic armchair technical requirement identification

5. The Italian node helps the entrepreneur to verify the feasibility of his idea, helping him identifying technical requirements (Figure 25), and tells him that it could directly provide support for the mechatronic device for movement and vibration, however it does not possess all the competences needed to implement the whole project.
6. The Italian cMDF node, after realising that it does not possess all the competences internally (previous point), invites the entrepreneur to join **OpIS** using the **marketplace tool.**
7. The entrepreneur creates an account on OpIS and then, by means of **Matchmaking & Agile network**, he finds the missing right competences in a Spanish node and in a Greek node of the cMDF Federation (besides those offered in the local Italian node).
8. The Super-user (PM of the Italian cMDF) gets in contact with the Spanish and Greek colleagues through OpIS.

9. The Italian cMDF starts working on the project preliminary specifications with the Spanish and Greek nodes through the **Generative Design platform and Process Automation** tools to manage the collaboration workflow and create.
10. In this first collaboration phase the cMDF nodes must focus on what is valuable for the client and remove non-value added activities. To this end, all the criticalities of the project must be visualised: this can be done by developing a Barashi board. This is a powerful instrument that highlights the priorities that must be tackled in order to achieve tangible advancements. It consists of a series of boards, each with specific data and drawings, on which the criticalities are highlighted three at a time, while the others are put in a "parking lot" where they wait to be dealt with.
11. Once the boards are standardised and made digital there must also be a recursive date of advancement; the digital way allows them to be shared easily between the various co-working nodes - it can be done integrating them in the platform tools, too; furthermore, everyone "speaks the same language" in terms of advancements.
12. On the basis of criticality, advancement meetings can be weekly or twice a week. This is a rule of thumb that is helpful to avoid certain steps slowing down the whole process.
13. The developed instruments help to quantify costs, delivery dates and all the necessary information to give a first estimation to the entrepreneur.
14. If the Super-user gets the feeling that the entrepreneur is on his way to confirm the projects, during the meeting he will highlight it so that also Spanish and Greek cMDFs will get ready.
15. A final contract is then signed between the client and the Federation via the **Ricardian toolkit**.

7.3. From Contract to Proof of Concept

In the previous chapter the work was mostly carried out by the Super-user (that is, the PM) together with the selected members of the cMDF Federation, in order to collect all the elements to create the contract with the client. Now, let us go on with the Lean Operational Model steps suggested in the process phase starting from the contract and ending with the proof of concept.

Once the contract is signed, 1) visual project management instruments (the main ones are shown in the following) must be implemented and shared. Furthermore, 2) regular meetings must be scheduled to keep track of advancements and tackle problems that may arise on a daily basis. These rules allow the organization to obtain optimal levels of efficiency across all stages as illustrated in Figure 26, which shows a comparative study made in Toyota.

Figure 26. Comparative study made in Toyota about efficiency levels obtained following lean principles (source: Kaizen Institute)

Of course, the steps and tools that follow are suggestions based on daily experience in carrying out lean activities: they all should be followed as a whole, but, on a case by case basis, some of them may be ignored or partially implemented on the basis of the responsibility of the PM. Being the present document of limited length for legibility reasons, the tools will be shortly described, at a high level, leaving the reader the right to deepen them separately. Two out of them – Barashi Board and Obeya Room - will are described in depth in “Annex 3 - Visual management tools”.

7.3.1. Teams and Meetings

Each cMDF node will have a natural team (that is a team of people that meet every day and work together on the same project, function) working on the project at hand.

A more diverse part of this team also participates in feasibility discussions while the rest only join when the project gets the green light.

In iPRODUCE the project team is intended as a group of people, belonging to different nodes that work together in a joint project of the Federation.

At the beginning, more functions are involved since the criticalities must be recognised from multiple angles.

Hereafter a few suggestions for the meetings of the project team:

- meeting agenda: the Project Manager should meet team members singularly (Barashi rolling) once a week for ordinary advancements, twice or more for problems that are difficult to solve;
- when discussing problems that have never been dealt with before, it is important to include all the team;
- Plenary team meeting once a week.

Now, let us start from the design of the project and then examine a few useful tools to manage it.

7.3.2. Barashi Board

One of the most important visual management tool, in this phase, is the preliminary Barashi board, used to intercept all the critical aspects of the project:

1. all criticalities are added to the board and are also divided;
2. the most critical aspects of the project must be tackled first while the other problems can be put on hold;
3. it is best to consider a maximum of 3 criticalities at a time in order to avoid confusion and delays;
4. red colour is used for the most critical problems (usually problems that have never been dealt with), while yellow colour is used for aspects for which there is no risk of delaying the project;

The preliminary Barashi Board is a valuable instrument for the Super-user and can be presented to the members of partner cMDFs and the client:

- in this way the Barashi board becomes a shared language thanks to which all the involved parties can understand whether a project is feasible or not;
- once the preliminary Barashi board has been presented for the first time, the team can discuss each criticality and study a solution in time for the following meetings.

As the project develops, the preliminary board becomes the main Barashi board. It will split into multiple boards that refer to single components or assemblies and the person/hub responsible for developing the component/assembly will also be responsible for updating the Barashi board and presenting the developments to each advancement meeting.

7.3.3. Pull Planner

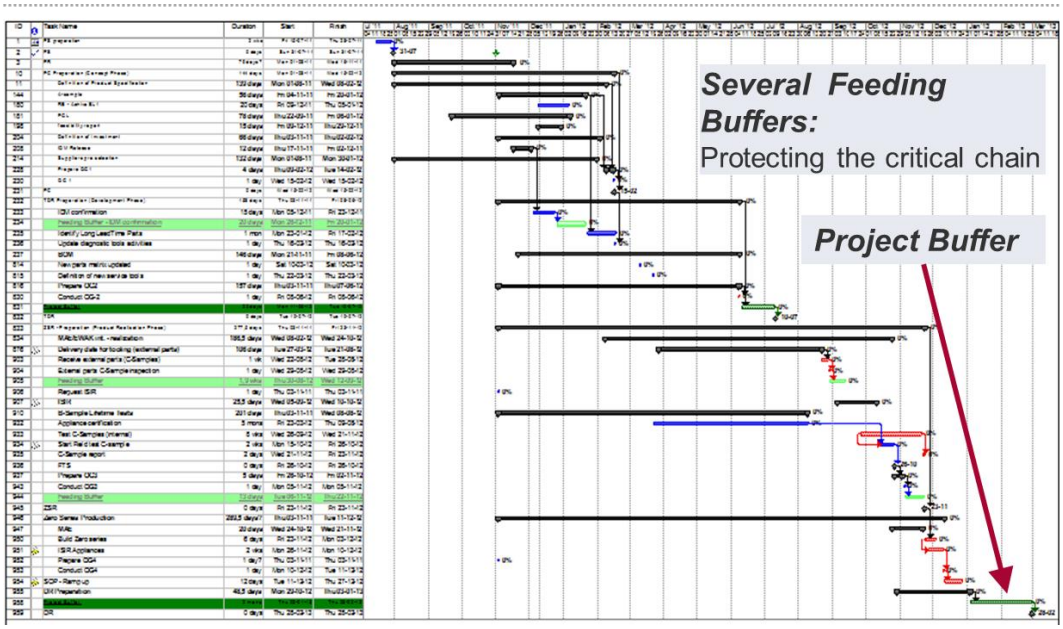


Figure 27. Pull Planner (source: Kaizen Institute)

The visual task plan (Gantt chart) can be optimised using the Pull Planning methodology (shown in Figure 27).

It implies that the duration of each step should initially be estimated without buffers. Afterwards, two types of strategic gaps are placed in the project plan:

- feeding buffers, in paths that run alongside in the critical path;
- project buffers at the end of the critical path (or before each important project milestone).

Pull planner should be updated with visual identification of what has already been completed.

7.3.4. A3 Project Initiation

An additional visual tool can be used in this phase: the A3 Project initiation. It is used as a contract charter. It should give the management team an overview at a glance on the project and usually contains the following elements:

- the scope and the targets;
- a deliverable structure;
- an organizational structure;
- a milestone planner.

This visual tool was born as a pioneering practice invented in Toyota to highlight the problem, the analysis, the corrective actions and the action plan on a single large sheet of paper (A3 format), often with the use of graphics. Figure 28 shows an example of an A3 tool.

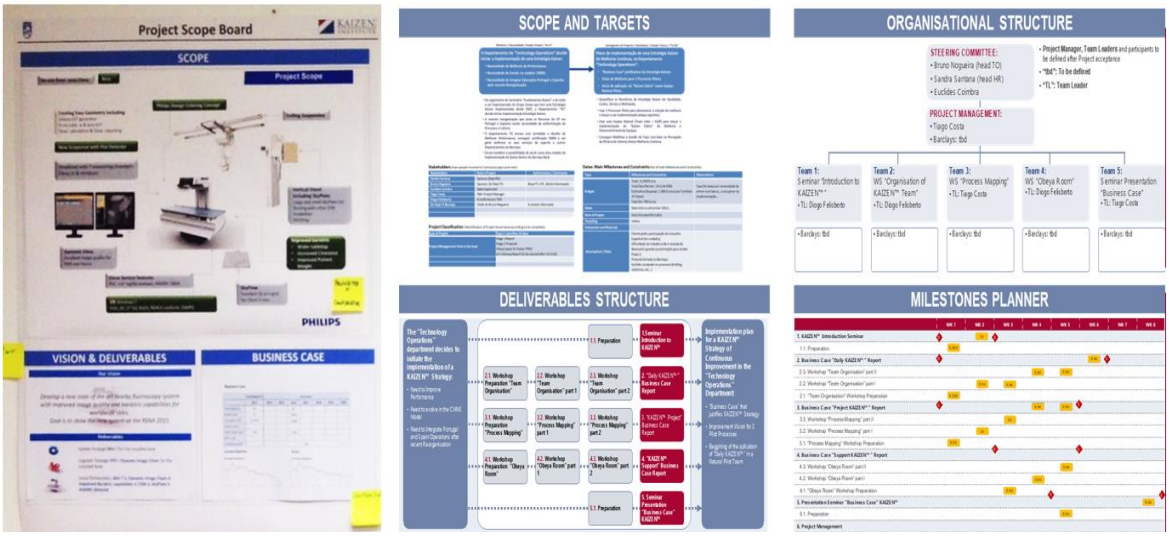


Figure 28. Example of A3 project initiation visual tool (source: Kaizen Institute)

7.3.5. 6 Weeks Planner

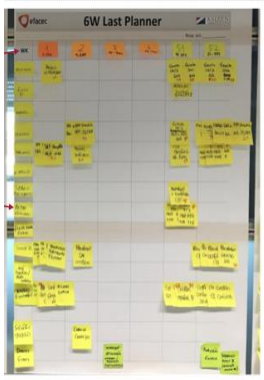


Figure 29. Example of 6 weeks planner (source: Kaizen Institute)

A project can involve a long lasting work plan (months, years). But humans often think about shorter time frames. A useful tool in this regard is the 6 weeks planner that provides a mid-term vision of the team work plan (an example is reported in Figure 29). The goal is to eliminate constraints: it represents a connection between the macro plan and the day-to-day work.

7.3.6. Obeya Room

Another useful visual tool for the implementation of the project is the Obeya Room (an example is reported in Figure 30), a sort of control room which gathers all the necessary information on the project all in one place. Hereafter its main features:

- it can be both physical and digital;
- all the documents discussed before can be added to the Obeya Room;
- this is also the place where plenary weekly meetings are held;
- all criticalities can be highlighted in front of the team and information is available for everyone;
- all teams can view the advancements on the rest of the project.

Figure 30. Example of Obeya Room (source: Kaizen Institute)

Its main advantages are:

- everything is in the same place;
- it is physically visible;
- regular and periodic updates;
- it guarantees an appropriate level of detail;
- only relevant information is displayed.

In particular, the Obeya Room simplifies the management of the project at different level:

- Steering Committee: relevant information is always available and gathers periodic feedbacks;
- Project Manager: the reaction time to problems is reduced, which makes management simpler;
- Project Team: reduction of presentations and reports for different stakeholders, boosting internal communication.

7.4. From Proof of Concept to Final Project

As described in Deliverable D3.6, the production process (from ideation until the final project and the delivery of the prototype) can be grouped in four sets of activities (stages); each stage ends with a clear result:

1. Definition of the product's requirements: the result of this interaction among users is the definition of a set of product requirements that are summarized in a document named 'design brief'; it considers all aspects covering aesthetics, usability, compliance to engineering standards & environment protection regulation [result: design brief].
2. Definition of the final design of the product, considering all specification and restrictions from the design brief (for example with respect to the selection of the materials used, presence of electronics, etc.) [result: product design].
3. Organization and scheduling of the prototyping process: definition of the stages for the delivery of the prototype and scheduling for proper monitoring of the prototype's production [result: production plan].

4. Prototype production and delivery - including lab test and focus group validation [result prototype].

The last two points above correspond to the phases from the proof of concept to the final project (and delivery of the prototype/product to the client).

In the following, two tools that particularly fit for use in this final stages of the lean project are described.

7.4.1. Work Breakdown Structure

In this phase the deliverables must be defined.

Deliverable are tangible outputs of the project activity. They may include:

- reports;
- hardware;
- software;
- tools;
- information.

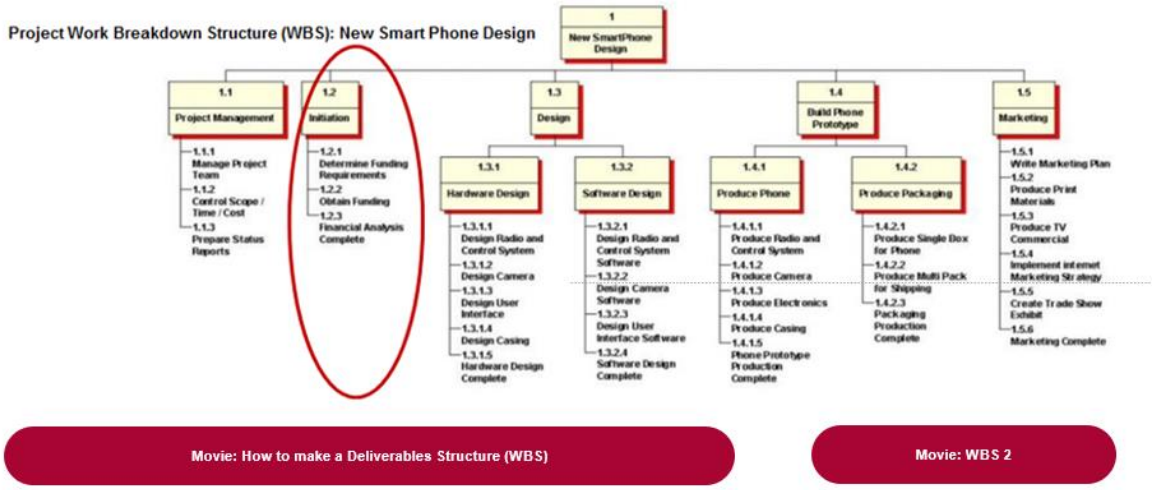


Figure 31. Example of Work Breakdown Structure (source: Kaizen Institute; details not relevant)

Once the deliverables of the project have been defined, the PM and the team can start breaking the project into tasks following the WBS (an example of Work Breakdown Structure for the development of a new smart phone is reported in Figure 31), a structured deliverable list that:

- graphically represents to an inferior level;
- focusses on the tasks needed to execute the deliverables;
- in which each deliverables and tasks branch is called “Work Package”.

7.4.2. Kanban

The output of the WBS can be transformed into activities that can be considered Kanban cards. Using OpIS as a digital tool for project management, Kanbans are digital and not physical. Kanban are very useful in this phase to synchronise the activities.

Every time there is an advancement the card can be moved to the next step, so that it is visually clear that the project is moving forward. Moreover, it is easy for the PM to keep track of advancements and hiccups.

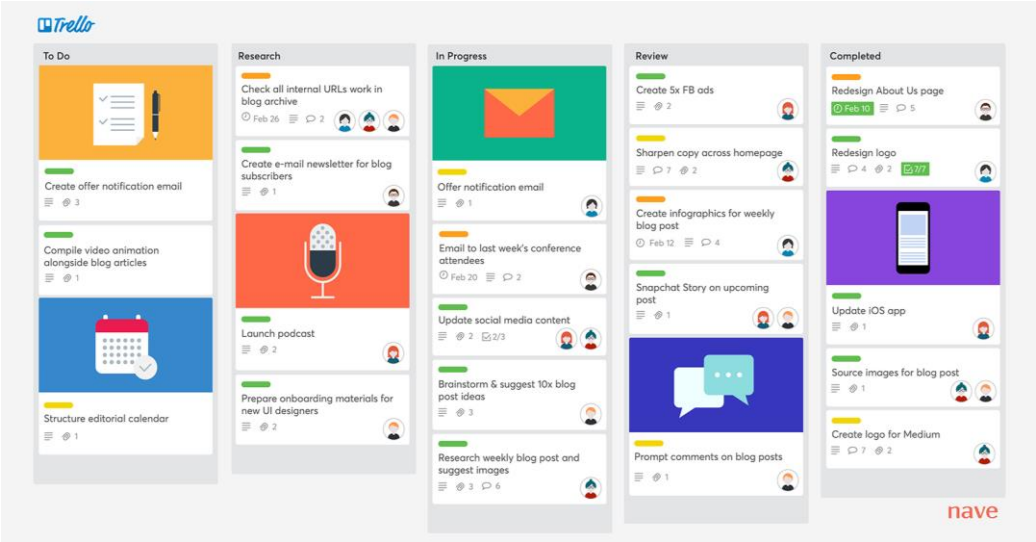


Figure 32. Example of Kanban management in iPRODUCE project

Programs like Teams, Monday, Trello (for this latter, an example of Kanban managed advancements is shown in Figure 31Figure 32), as well as features implemented in the **Process Automation Tool** algorithms can be used.

8. Implementation Roadmap of the iPRODUCE Federation

8.1. Introduction

In the previous chapters, on the basis of the Lean Transformation principles and the adoption of the methodological prescriptions of Lean and Kaizen, the working team identified the current state map (i.e. the current Value Stream Map) of the Federation and the optimal governance model to be adopted in the future.

Furthermore, on the basis of the archetypal use case of the mechatronic armchair creation - built up with the aim to create a general and multi cMDF process flow - a future state map (i.e. the future Value Stream Map) has been identified.

Finally, a Lean Operational Model functional to the implementation of the future state map in a Federation made up of different and multidisciplinary nodes has been defined.

In the following chapter, an implementation roadmap of what has been developed is proposed, complemented by a set of guidelines useful for the future collaboration activities of the nodes of the iPRODUCE Federation.

8.2. Implementation Roadmap

Making use of the phase-gate approach, already introduced in Chapter 7, the evolution of the iPRODUCE service (and, of course, of the Federation) over time can be assimilated to the creation (engineering) and launch of a new product on the market. Figure 33 graphically summarises the roadmap of the implementation process of the iPRODUCE services and Federation. In the following sections, the phases of the roadmap are examined in depth.

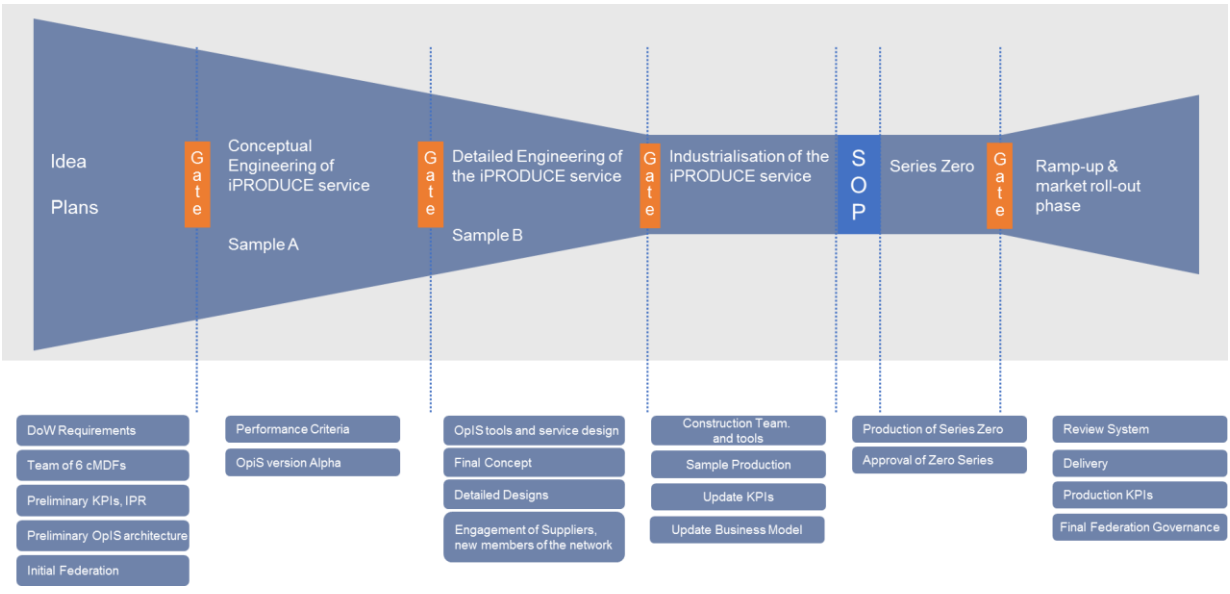


Figure 33. Implementation roadmap of iPRODUCE service and Federation

8.2.1. Ideation Phase

The starting ideation phase was implemented before the project submission and it is described in the project DoW (Description of Work). It established, on the basis of the advanced experience and knowledge of the project partners:

- a set of preliminary requirements,
- a preliminary team, covering six geographical areas in Europe,
- a set of preliminary KPIs,
- a preliminary definition of the OpIS architecture, complemented by the main features of its tools,
- preliminary hypotheses about IPR issues,
- a preliminary configuration of the Federation,
- preliminary governance models,

postponing to the following phases of the project implementation the refinement of these preparatory assumptions.

8.2.2. Engineering Phases

The Conceptual engineering phase has been carried out by the iPRODUCE consortium in the first 24 months of the project, leading to an updated set of performance criteria (developed in WP2 and WP9), to the refinement of the OpIS tools and a first version of it (Sample A).

The Detailed engineering phase concerns the last year of the project. In this phase, which includes also the pilot use case testing, new members will be engaged in the cMDFs, enlarging the Federation, in order to increase the critical mass of services, know-hows, MMC community representability, etc. At the end of the project, a final sample of the iPRODUCE service/Federation will be available (Sample B).

8.2.3. Industrialisation Phase

After the project conclusion, the “Industrialisation phase” shall start. The platform shall furtherly develop and test the OpIS tools. Specific legal agreements shall be signed by the members of the Federation (including IP, governance rules, etc.), establishing roles (members, associated members, collaborators, etc.). Updated KPIs shall be identified. Also, a Federation detailed business model shall be created, as a fine tuning of the previous temporary models developed in the project phase.

8.2.4. Market Landing

After the validation of the “Zero release”, the Ramp-up and Market Roll-out phase will follow: iPRODUCE service will be on the market. In this last phase, a final governance model shall be created, suitable for facing the market challenging environment.

In the phases prior to the Ramp-up and Market Roll-out phase - pre-market phases - as proposed in the Deliverable D3.4 (Chapter 2.4 - “Project Management”) the collaboration among the members of the Federation is loose and based on the willingness to test new prototyping and co-creation paradigms in the framework of an “open value chain”, with loose constraints and under a loose form of governance.

In fact, in the pre-market phases, the main objectives of the Federation, shared among the first-movers belonging to it, are:

- the facilitation of the user participation;
- guaranteeing coherence of the open innovation missions and challenges;
- optimising the relationships among the processes set up by the framework.

According to these principles, initially the Federation moved without the need of a central controlling body or of an additional legal entity. On the contrary, the governance was taken in charge by one member for each local cMDF, designated by the Core Group of the local cMDF founding members. This "governor" must coordinate with his peers in order to find a shared model of distributed governance. The main activities to be submitted to the Federation governance team concern:

- the definition and implementation of an initial activity programme of the local cMDF, connectable with other bottom-up activities that could be originated in the MMC Community;
- the prioritisation of the activities of the local cMDF;
- the identification of IPR models/rules to be implemented in Smart Ricardian Contracts for the pilot/test activities, a first "battlefield" where to test them. Governance on the rest of the cases is to be implemented under the supervision of the core group, which will appoint responsibilities and specific resources whenever necessary.

In the market phase of iPRODUCE a new governance model shall be identified. A central governing body will probably be necessary to guide the cloud-like iPRODUCE Federation. In the long term, probably, also a central legal entity could be created.

About this latter, a possible model could be a network of the legal subjects administrating the nodes of the Federation. A governance model similar to that invented in Italy in 2009 and currently tested at European level in a few EU funded projects (i.e., the pilot project Look-EU-Net, co-financed by the COSME Programme of the European Commission). In a network of SMEs governance model[13] more entrepreneurs pursue the aim of increasing, individually and collectively, their innovative capacity and their competitiveness on the market and to this end they undertake, on the basis of a common network program, to collaborate rare in forms and in predetermined areas relating to the operation of their businesses or to exchange information or services of an industrial, commercial, technical or technological or still to jointly carry out one or more activities falling within the scope of the own company.

Using this network contract (or similar ones), a group of companies (in case of the iPRODUCE Federation, the networked legal entities can be companies, companies that own the business units operating as a node, associations, universities that own the makerspace/fablab node, etc.) operate in a regulatory-organizational framework with which, for example, they can pool their know-how, increase their production capacities with the acquisition of common production units, or even create a common distribution network, achieving economies of scale, efficiency gains, improvement of relations with the outside world.

The Federation nodes will have to dedicate particular attention to the regulation of aspects concerning the protection and management of confidentiality of information and intellectual property rights (IPR), both of the pre-existing ones of the nodes participating in the network and entered by them, both of those that are produced during the daily activities of co-creation/research. The aspects to be governed will be mainly the following ones:

- who will have ownership and access to information and intellectual property rights held by each one before the formalization of the contract and then made available to the network;
- who will be responsible for the ownership, use and disclosure of the results obtained from the activities made by the network;
- the methods for managing confidentiality between the network operators (members of the nodes working in the iPRODUCE activities).

[13] The business network contract in Italy is governed by the Law Decree 10 February 2009, n. 5, converted with amendments into Law 9 April 2009, n. 33, (Article 3, paragraphs 4 ter, 4 quater and 4 quinquies)

With regard to subsequent accessions to the contract by new nodes, the contract should be open: on the one hand it should be left to the autonomy of the federated nodes to decide what are the mechanisms of entry of new nodes, but also, on the other hand, it should be possible to structure the rules of entry in such a way as to effectively exclude the adhesion of new nodes to the network.

Furthermore, the network should designate a Common Organism for the administration of the common activities.

As regards to production KPIs, they shall be defined and monitored frequently at the Federation level. A few possible sets of these KPIs are listed in the following sections of this deliverable.

8.3. Guidelines for Applying Lean Transformation to the iPRODUCE Federation

Hereafter a set of guidelines useful for the future collaboration activities of the nodes of the iPRODUCE Federation is described. The guidelines refer to the best practices and methodological tools of the project management, Kaizen and Lean disciplines.

They are not based on pure theory. On the contrary, they are the result of the long lasting experience in the field of the writers of the present deliverable and of Kaizen Institute, subcontractor in the iPRODUCE Project.

The following guidelines consider four fundamental aspects of the operational activities of the Federation that emerged during the Kaizen workshops:

- measuring of the performances;
- quality of the information flow through the cooperating nodes of the cMDFs and quality of their physical workplaces;
- organisation of daily project activities;
- redundancies and shortcomings in the Federation assets.

8.3.1. Guidelines for the Measurement of the Federation Performances

To turn the iPRODUCE project into a successful market service, the assets that have been developed during the project period are not sufficient.

The network (that is, an initial international distributed network of prototyping centres located in six European countries), the experimental platform named OpIS made up of innovative co-creation tools, the real scenario use cases tested during the project framework, are only a preliminary scaffold for future successful market results and self-sustainable services.

To survive and thrive on the market, iPRODUCE shall implement a strong business model (dealt with in WP7) and measure its performances periodically.

A proper way to measure the Federation performances is to define its objectives and identify a set of performance indices (“Key Performance Indicators”) to evaluate the success in achieving those objectives.

iPRODUCE service KPIs can be at a "high level" and focus on overall Federation performance or business strategies, or "detailed", focussing on the processes/functions of the network.

They should be set when starting the iPRODUCE market service and updated constantly (for instance, every quarter or even more frequently).

6 main sets of KPIs should be identified and defined, as shown in Figure 34.

- Production. This function refers to the provision to a client of a service (for instance, the design/rendering of an object or the provision of a training course on additive manufacturing technologies) or a product (for instance, a 3D printed object);
- Client Relationships. This function refers to the day-to-day contact with and support to the iPRODUCE clients (makers, SMEs, members of the MMC community, etc.);
- Marketing. This function refers to the engagement of new clients, maintaining of the reputation of the service, the collection of feedback, nurturing relationships with the stakeholders, etc.
- Sales. This function refers to the activities of selling the iPRODUCE services;
- Research and Development. This function refers to the development/innovation of the services offered to the market (for instance, new tools of OpIS, etc.);
- Human Resources. This function refers to the development of the human factor: the teams of the cMDFs working for iPRODUCE, as well as the core central team, in case of a central unit that works only for iPRODUCE and coordinates the nodes of the Federation.

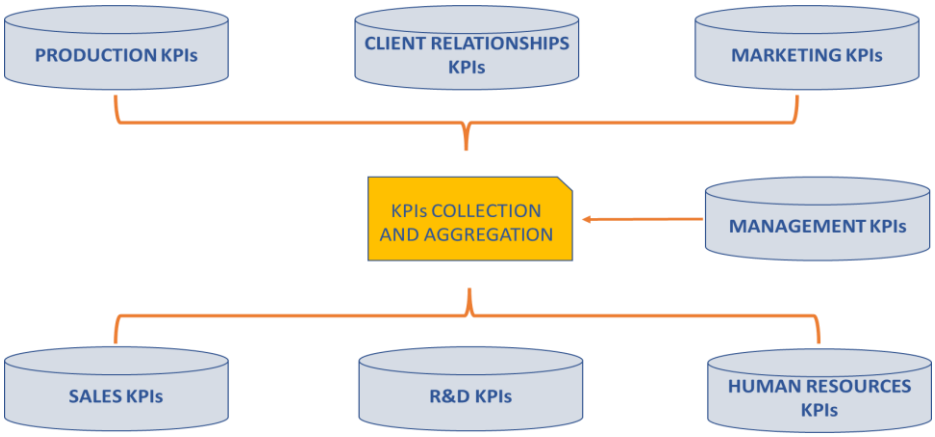


Figure 34. The six iPRODUCE service functions and their contribution to KPIs measurement

At a higher hierarchical level, also the iPRODUCE management team must measure its performances.

Many of the KPIs identified above shall be measured in each node of the Federation (for instance, those related to the human resources) and then will be centrally “summed” to obtain a unique KPI identifying the Federation performance. Furthermore, a performance index viewed individually could be not significant or it could be misleading. In this regard, therefore, it could be necessary to improve the level of interpretation of the KPIs by enriching them with additional measurements or details.

Others KPIs will be measured transversely to the nodes of the Federation, because they refer to functions distributed among the teams of the nodes, and then properly aggregated. Aggregate KPIs are sometimes necessary as they help give you the right idea of the context you intend to measure.

From a point of view of the means through which to perform the measurements, many KPIs shall be retrieved by the automatic analysis of the big data coming from the daily tracing activity of the use of the OpIS platform (an Agile Data Analytics and Visualization suite is being developed in WP5 also for this purpose). Others will be measured by the nodes teams and provided to a central repository.

Starting from the KPIs' sets identified and object of measurement during the project duration and on the basis of the lean practices, a few examples of KPIs that could be adopted is reported in the following:

- Production:
  - number of customer-driven products manufactured in the cMDFs;
  - number of external partners/number of Federation own staff (Outsourcing rate);
  - allocated demand of active projects [hours]/total available productive capacity [hours] (Prototyping Utilization);
  - total work time booked against "billable" projects [hours]/total contractual work time [hours] (Prototyping Productivity);
  - budgeted cost of work performed/actual cost of work performed (Cost Performance Indicator - CPI);
  - budgeted cost of work performed/budgeted cost of work scheduled (Schedule Performance Indicator - SPI);
  - number of services/products released on time/total number of services/products (Prototyping On-Time Delivery - OTD);
  - number of services/products submitted without rejection/total number of services/products (Prototyping First Pass Yield - FPY).
- Client Relationship:
  - number of requests per day;
  - average length of a conversation/contact;
  - number of exhaustive responses to clients;
  - number of client complaints processed per day.
- Marketing:
  - marketing costs per contact or lead (makers, SMEs, professionals, etc.);
  - number of (positive) reports about iPRODUCE in the media per year;
  - number of followers on iPRODUCE social networks;
  - number of MMC communities developed;
  - number of the new associates to the cMDFs;
  - SEO positioning in search engines;
  - number of contacts from the web;
  - number of new leads in OpIS;
  - number of presentation emails sent;
  - number of users of the Mobile App for Social Media;
  - number of ambassadors/stakeholder involved.
- Sales:
  - number of clients visits/contacts (in the OpIS Marketplace) per week;
  - number of new customers;
  - number of new projects in which iPRODUCE is engaged;

    - average iPRODUCE services sales per year;
    - open sales opportunities;
    - response time to prospects;
    - percentage of closed sales;
    - average hours and actions (understood as man cost) for closing sales;
    - revenues from sales;
    - marginality of sales.
- Research and Development:
    - number of service development projects positively evaluated per year;
    - number of projects entering pre-production per year;
    - development project planning time deviation and realisation time;
- Human Resources:
    - number of Federation members (members of the iPRODUCE team) leaving iPRODUCE each year;
    - number of training days per year[14];
    - personnel development costs per year;
    - overtime per team member;
    - Non-compliance reports from team members.

8.3.2. Guidelines for the Correct Organization of Workplaces and of Information Flow through the Nodes

As explained in Chapter 2, 5S is a method of organizing a physical workspace to make it safe, efficient and effective. The goal of 5S is to create a clean, uncluttered environment that allows the reduction of the risk of injury while minimizing the waste of time.

The following guidelines concern the application of the 5S principles to an information system (that is a digital workplace), as that implemented in OpIS and, more in general, the iPRODUCE Federation. The items of this distributed virtual information workspace are digital objects like files (documents, drawings, etc.), directories, emails, computer coded libraries.

Shared libraries must be organised following shared criteria (5S) so that everything has its place and there is no need to ask for where things are.

Nevertheless, the 5S guidelines of this section can be also applied to the physical management of the workplace inside the local iPRODUCE node (i.e.: a makerspace lab).

In order to efficiently and effectively work together, the Federation nodes shall organise their distributed workspace by identifying and storing the digital items used, maintaining the “area” and items, and sustaining the new organizational system. The decision-making process usually comes from a dialogue about standardization, which builds understanding among team members about how they should do the work.

[14] Being iPRODUCE a Federation, training of the people working in the different nodes is highly important to maintain the quality of the human resources competences and its homogeneity through the Federation itself.

Hereafter there are the guidelines for an effective and efficient way of storing and exchanging information all along the Federation, according to the 5S principles.

Each sections reports the goals of the “S” and a few implementation guidelines.

Sorting (“Seiri”)

Seiri is sorting through all items in a location (it can be the OpIS server repository/ies as well as the computer of a team member in an iPRODUCE node) and removing all unnecessary items from the location.

Goals:

- reduce time loss looking for an item by reducing the number of unnecessary items;
- reduce the chance of distraction by unnecessary items;
- simplify inspection;
- increase the amount of available, useful space (in physical workplaces as well as digital workspaces);
- increase safety by eliminating obstacles.

Implementation guidelines:

- check all digital items in a location (i.e. the OpIS server or the local node storage) and evaluate whether or not their presence at the location is useful or necessary (for instance, a multiple copy of a file);
- remove unnecessary digital items as soon as possible. Place those that cannot be removed immediately in a 'red tag area' (i.e.: a digital bin) so that they are easy to remove later on;
- keep the “working floor” clear of materials except for those that are in use for production (this can be a physical component in an iPRODUCE node - like a 3D printed object not necessary for the project - as well as an obsolete file in the Generative Design workspace).

Setting in Order (“Seiton”)

Seiton is putting all necessary items in the optimal place for fulfilling their function in the workplace.

Goal:

- make the workflow smooth and easy.

Implementation guidelines:

- arrange work stations in such a way that all tooling/equipment is in close proximity, in an easy to reach spot and in a logical order adapted to the work performed. Place components according to their uses, with the frequently used components being nearest to the workplace. In case of OpIS tools, it can be intended as a well organised human machine interface;
- arrange all necessary items so that they can be easily selected for use. In case of OpIS platform, it can be intended as, for instance, the storage position of a file, the position of a widget, etc.
- make it easy to find and pick up necessary items;
- assign fixed locations for items. Use clear labels, marks or hints so that items are easy to return to the correct location and so that it is easy to spot missing items.

Shining (“Seiso”)

Seiso is sweeping or cleaning and inspecting the workplace, tools and machinery on a regular basis. This can be the physical workplace where the Federation node realises the manufacturing/prototyping activity, as well as the tools of OpIS, that must be easy to use and clear for the user.

Goals:

- improve production efficiency and safety, reduce waste, prevent errors and defects;
- keep the workplace safe and easy to work in (in OpIS, easiness to use);
- keep the workplace clean and pleasing to work in (OpIS tools human machine interface must be pleasant and friendly);
- when in place, anyone not familiar to the environment must be able to detect any problems in a short time framework (seconds). Also newcomers must be able to quickly detect anomalies.

Implementation guidelines:

- clean the workplace and equipment on a daily –or appropriate- cleaning interval;
- inspect the workplace and equipment while cleaning.

In the case of an information system, the above mentioned implementation guidelines can refer to the use of an updated version of the tools or to keep the user interface simple.

Standardising (“Seiketsu”)

Seiketsu means to standardize the processes used to sort, order and clean the workplace.

Goal:

- establish procedures and schedules to ensure the repetition of the first three ‘S’ practices.

Implementation guidelines:

- develop a work structure that will support new practices and make it part of the daily routine;
- ensure everyone knows their responsibilities of performing the sorting, organizing and cleaning of physical and digital spaces;
- use photos, screenshots and visual controls to help keep everything as it should be;
- review the status of 5S implementation regularly using audit checklists;

Sustaining (“Shitsuke”)

Shitsuke or sustain is the developed processes by self-discipline of the workers. Also translates as "do without being told".

Goal**:**

- ensure that the 5S approach is followed.

Implementation guidelines:

- organize training sessions involving the members of the iPRODUCE Federation;
- perform regular audits to the members of the Federation to ensure that all defined standards are being implemented and followed;
- implement improvements whenever possible. Team members' inputs can be very valuable for identifying improvements (suggestions can be collected making the Federation team members use dedicated communication channels - i.e.: Slack – or can be collected in Kaizen Daily).

8.3.3. Guidelines for Daily Project Activity Management

Figure 35. Example of visual information for Daily Kaizen meetings (source: Kaizen Institute; details not relevant)

Both the natural team and the project team – as defined in The Team Involved 7.3.1 – should meet daily, if possible, at the beginning of the working day, in the Gemba (in case of pandemic constraints or team distributed kin different cMDFs' nodes, a virtual Gemba). The duration of the meeting can vary according to the complexity and number of items on the agenda. The frequency of the meetings is the most important thing.

Whether the meeting is face-to-face or virtual, attendees must be able to catch all the information needed for the meeting. A visual support (pictures on a board, a shared screen, etc.) is recommended. Figure 35 shows a generic example of a visual representation showing the Gemba, a workflow, diagrams, etc.

The Team Leader organises the meetings (from now on called also "Daily Kaizen" meetings), that are necessary to jointly decide what to do on the working day, which are the priorities and how to organise the team work at best. The meetings also have the positive effect of developing the team and sustaining improvements of the project. In fact, they allow the team to:

1. dynamically change its behaviour (standards and improvements);
2. affirm leadership by the Gemba leaders;
3. implementing better work standards;
4. control key KPIs and performances on a frequent basis;
5. act immediately with countermeasures;
6. frequently give and receive feedbacks;
7. create a culture of continuous improvement.

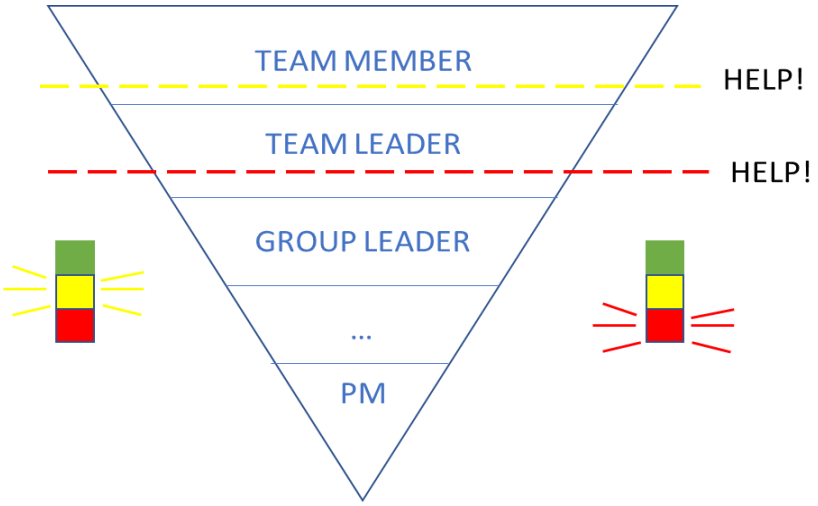


Figure 36. Escalation system: countermeasures to a problem can be taken at different hierarchical level

In case of situation number 5. above, for instance, when a team member highlights a serious problem during the meeting, the Project Manager can immediately react either directly himself or triggering the escalation system, involving the higher management structure, as shown in Figure 36, e.g., when a higher hierarchical level must take an important decision.

Daily Kaizen meetings act on the project at different levels:

- Level1: Team organisation.
- Level 2: workplace organisation.
- Level 3: best practice SDCA.
- Level 4: improvement PDCA.

In the following sections these levels are briefly described with respect to their improvement opportunities (the most common problems encountered that can be positively transformed in improvements), the methodology/ies to face the problems and the expected results from the application of the methodology/ies.

Team Organisation

Improvement Opportunities:

- lack of process monitoring KPIs (a need for new or updated process KPIs can be highlighted during the meetings);
- difficulty in planning work;
- team's work is not accompanied (need for a greater support, leadership, etc.);
- difficulties in following up on improvement actions;
- lack of team alignment (humans are not robots, face-to-face meetings can help alignment of the team members);
- team members' demotivation.

Methodology

- standardization of Daily Kaizen meetings;

- Daily Kaizen Board construction, as a support to team meetings, including different topics related to the process, as for instance:
    - mission;
    - KPIs;
    - action plan (PDCA);
    - work plan;
    - responsibility matrix.

Expected results:

- standardised team meetings focused on planning, KPIs and improvement actions;
- improvement of the team day-to-day and consequent improvement of KPIs;
- increased employees' motivation.

Workplace Organisation

Improvement Opportunities:

- long-time searching for materials/information;
- lack of productivity due to the disorganization of the working environment;
- inadequate layouts that lead to unnecessary movements (also, by way of example, inadequate structure of the human machine interface of an OpIS tool);
- deficient space usage;
- low ergonomics in the workplace;
- anomalies are harder to see or invisible.

Methodology:

- 5S (Physical e Digital);
- restocking materials/information (physical/digital Kanban);
- archive management.

Expected results:

- elimination of the time spent searching for materials/information;
- improved information management;
- increased employee motivation through workplace (physical/digital) organization;
- cost reduction through a better usage of materials and equipment.

Standard SDCA

Improvement Opportunities:

- lack of visual standards;
- lack of standard accessibility from every element;
- low productivity and quality problems originated by the unawareness of the best work method;

- unlevelled knowledge among team members (for instance, about the OpiS tools);
- hardship in training newer employees/cMDF team members.

Methodology:

- definition of each team's activities;
- definition of standardization priorities;
- development of visual standards;
- training employees/cMDFs' team members about the standards;
- confirmation that standards are being followed and subsequent improvement;

Expected results:

- increased productivity;
- increased team flexibility and ease in the integration of new employees;
- variability elimination;
- levelling of knowledge;
- reduction of errors and defects.

PDCA Improvement

Improvement Opportunities:

- quality problems in processes, products or services;
- long process lead times;
- lack of productivity,
- low equipment efficiency (both physical, e.g. the machines inside the cMDFs' workplaces and digital, e.g. the OpIS tools);
- lack of tools for structured problem solving and process improvement.

Methodology:

- structured problem solving;
- process mapping (for instance, with the support of the Agile Data Analytics and Visualization tool);
- standard work;
- job relations.

Expected results:

- better awareness of waste among the team leaders and elements;
- increased process awareness;
- critical problems solved;
- simplification and optimization of the workflow;
- KPIs improvement.

8.3.4. Guidelines about Redundancies and Shortcomings

The mapping activity of know-hows, IT-equipment, machines and services of the current Federation nodes that has been performed in Task 3.2, has highlighted overlaps and shortcomings. That is: the current group of nodes making up the iPRODUCE Federation, as a whole, has got redundant assets (tangible and intangible ones) - which should be “removed” in the future Federation - but also it lacks some assets which should be integrated in the future Federation.

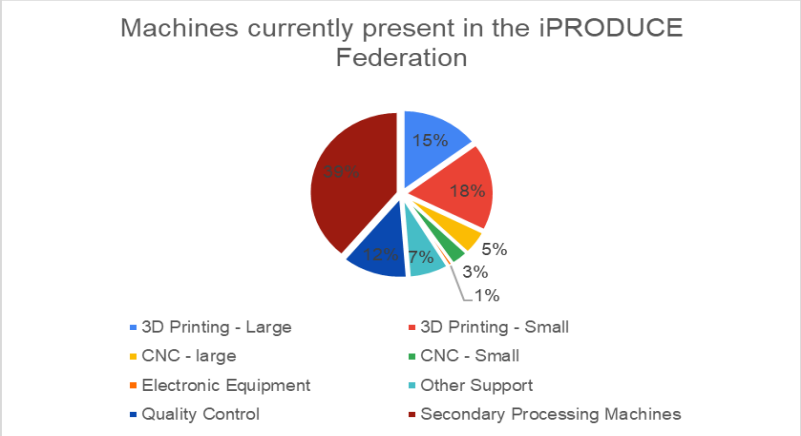


Figure 37. Mapping of the machines currently implemented in the Federation

The term "remove" in the previous paragraph must be understood as "exclude from the Federation database" and not as "remove from the assets of the single node".

Figure 37, Figure 38, Figure 39, Figure 40 report pie charts that represent the clustering of the machines, know-hows, IT-Equipment, services currently mapped in the activities of T3.2.

The clusters often highlight redundancies. For instance, looking at Figure 37, 18% of the machines hosted in the nodes are small 3D printing appliances and part of them represent redundancy.

Electronic equipment, instead, represent only 1% of the total: this means a possible shortcoming.

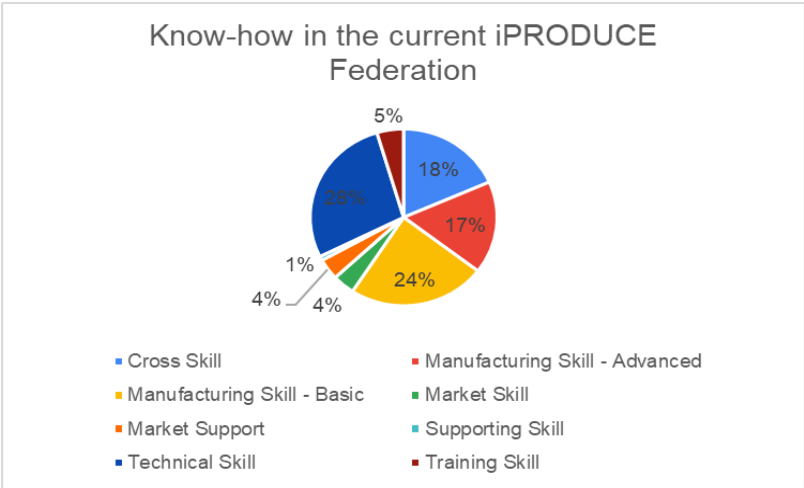


Figure 38. Mapping of the know-how present in the current iPRODUCE Federation

Moreover, looking, for instance, at Figure 38, 17% of the skill featuring the nodes concern advanced manufacturing competences: part of them can represent redundancy if seen as assets of the Federation.

A similar reasoning can be done also for IT-equipment and services.

In line with the management indications reported in chapter 2.4 of the Deliverable 3.4, in the project and pilot phases of iPRODUCE the different cMDF's governors should take the lead and put in place mechanisms to fill gaps and reduce redundancies.

This is especially important when a group of nodes is working together in a co-creation project and redundancies issues (for instance, similar machines) arise. The project manager must put in place a sort of negotiation phase, on the basis of Federation shared rules of engagement, between the different nodes involved in the redundancy case so that a final optimal solution is reached.

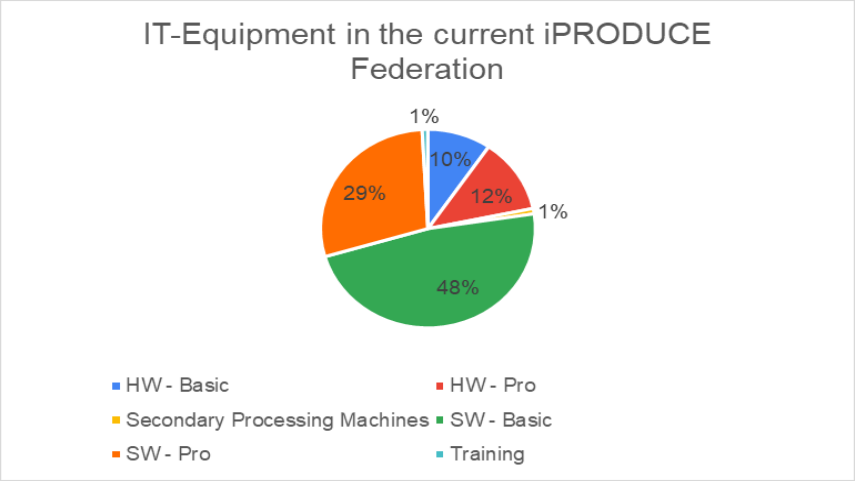


Figure 39. Mapping of the IT-Equipment present in the current iPRODUCE Federation

In the future Federation, the rules for the resolution of redundancy issues should be implemented in a decision support algorithm of the matchmaking tool or other OpIS tools.

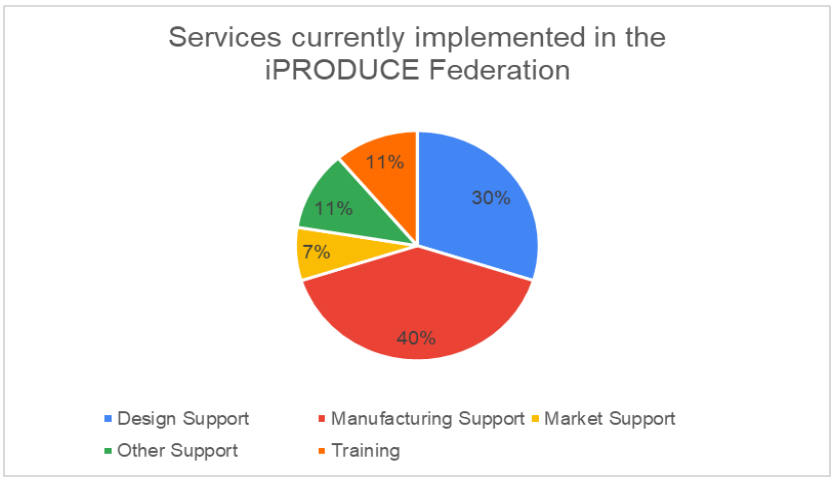


Figure 40. Mapping of the services currently implemented in the iPRODUCE Federation

Also, the shortcomings of machines, know-hows, etc. must be addressed by the Federation. In the project and pilot phases of the Federation these lacks can be considered of minor importance, because the Federation is in an experimental stage, without an urgent need to respond to all market demands.

But, in the market phase, these aspects shall be taken in serious consideration by the Federation governance bodies.

9. Conclusion and Recommendations

Similarly, to production chains, cMDFs require a structured organisation, a management and business model that can handle a plurality of members and objectives under a common operational model, which must, at the same time, preserve the differences and enhance the points in common.

In fact, the iPRODUCE Federation is made up of makers, fablabs, professionals, manufacturing facilities, etc. each operating with different clients (makers, SMEs, DIY, etc.) and different business models. However, they all work with prototyping, manufacturing.

The present deliverable is the result of a Kaizen activity involving all the 6 cMDFs of the iPRODUCE consortium. Kaizen workshops allowed the Federation nodes to highlight commonalities, differences among them. On the basis of these latter, a joint governance model of the future Federation has been created - “hybrid model” - that preserves, at the same time, the close relationship between an iPRODUCE client and its local node - that share a common language, a physical reciprocal knowledge and a common confidence - and, at the same time, the multidisciplinary and the multiple competences of the Federation, that can offer a 360° service.

The Kaizen activities produced also the following results:

- a lean operational model for the above mentioned hybrid governance structure, including visual management tools typical of project management and lean activities**;**
- an evolution roadmap of the Federation: from the project to the market;
- a set of guidelines useful to implement the roadmap in line with the lean principles.

The work performed and the above-mentioned outputs have been able to fulfil the objectives of the future Federation and to overcome the shortcomings of the current Federation.

In particular, the following issues have been addressed:

- a project is not a market service: the current Federation and its services are not ready for the launch on the market;
- after the project, the iPRODUCE services shall be sustainable from an economic and financial points of view;
- the iPRODUCE Federation is not a large distributed company, but it is a network of prototyping bodies (makerspaces, fablabs, manufacturing facilities, etc.) with different business models, operational models and governance. The harmonisation of this network of “monads”, all different one to another, is a turning point for the success in the future;
- the future of the Federation depends on the will and ability of its members to agree on a common governance and way of operating.

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Annex 1 - Canvas

A1.1 Business Model Canvas

As shown in Figure 41, Business Model Canvas can be divided into 4 sections[15]:

1. Back end (Operations): it describes the internal infrastructure in terms of partners, activities and resources needed to properly perform the company activities.

2. Value proposition: it is the collection of products and services a business offers to meet the needs of its customers. It is quantitative and qualitative (KPIs).

3. Front end (Customers): it deals with the identification of customer and their features.

4. Financial Model: it defines the financial structure of the business.

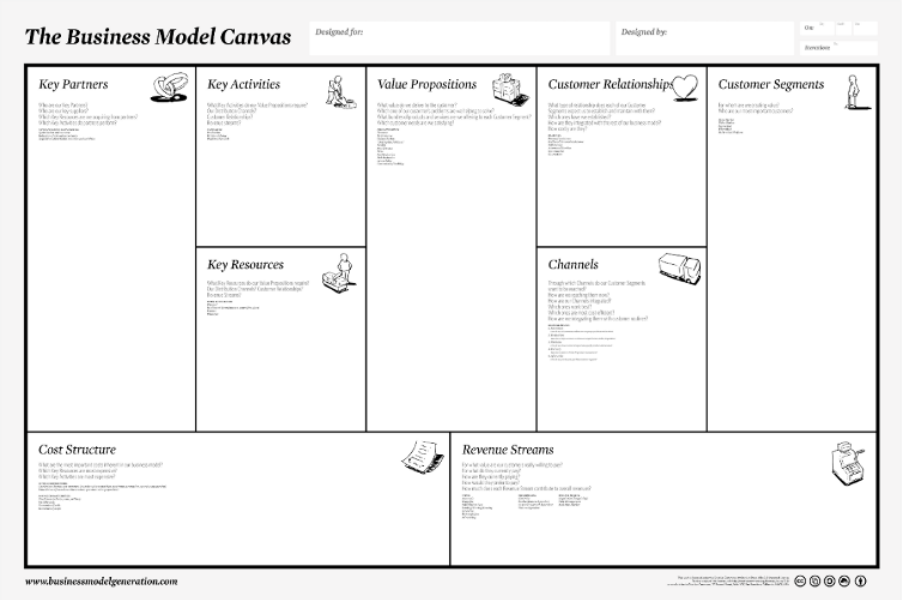


Figure 41. Graphical Representation of a Business Model Canvas[16]

The 4 sections are in turn divided into 9 blocks, that must answer a set of questions:

- Key partners. Possible questions to be answered are: “Who are our significant partners? Who are our significant suppliers? What critical activities do our partners perform? What important resources are we acquiring from our suppliers?”, etc.

- Key activities. Possible questions to be answered are: “What significant activities do our value propositions require? Which activities are the primary drivers of customer relationship? Where does our distribution channel provide value-add? What are the revenue streams for each channel?”, etc.

- Key resources. Possible questions to be answered are: “What significant resources do our value propositions require? Which significant resources do our distribution channels require? What significant resources do our customer relationships require?”, etc.

[15] Osterwalder A., Pigneurr Y., “Business model generation: a handbook for visionaries, game changers, and challengers”, John Wiley & Sons, January 2010
[16] https://www.danea.it/blog/business-model-canvas/

- Cost structure. Possible questions to be answered are: “Which costs are most critical our business structure? What primary resources are the most expensive? What primary activities are the most expensive?”, etc.
- Value proposition. Possible questions to be answered are: “What value do we deliver to our customers? Which customer needs are we satisfying? Which customer problems are we helping to solve? What bundles of products and services are we offering to each customer segment?”, etc.
- Customer relationships. Possible questions to be answered are: “What type of relationships do each of our primary customer segments expect us to build and maintain with them? Which ones have we established? How are they integrated with the rest of our business model? How costly are they?”, etc.
- Customer segments. Possible questions to be answered are: “For whom are we creating value? Who are our most important customers?”, etc.
- Channels. Possible questions to be answered are: “Through which channels do our primary customer segments want to be reached? How are we reaching them now? How are our channels integrated? Which channels work best? Which channels are most cost-efficient? How are we integrating them with customer routines?”, etc.
- Revenue streams. Possible questions to be answered are: “For what value are our customers willing to pay? For what value do they currently pay? How are they currently paying? What method would they prefer to use for paying? How much does each revenue stream contribute to overall revenues?”, etc.

A1.2 Operating Model Canvas

Operating Model Canvas is a pretty flexible tool that can be used to describe different levels of detail[17]:

Level 1 (1 page form): it deals with the whole organization structure and strategy;

Level 2 (10 pages form): it is a high level description of Company’s main processes;

Level 3 (100 pages form): it explains process at a good level of detail, providing useful information;

Level 4 (1000 pages form): it is the most detailed description of the processes and provides a total description of the processes, including for example safety policy and supply contracts.

Its structure is graphically described in Figure 42.

[17] Andrew Campbell, Mikel Gutierrez, Mark Lancelott, “Operating Model Canvas. Aligning Operations and Organization With Strategy”, Van Haren Publishing, April 2017

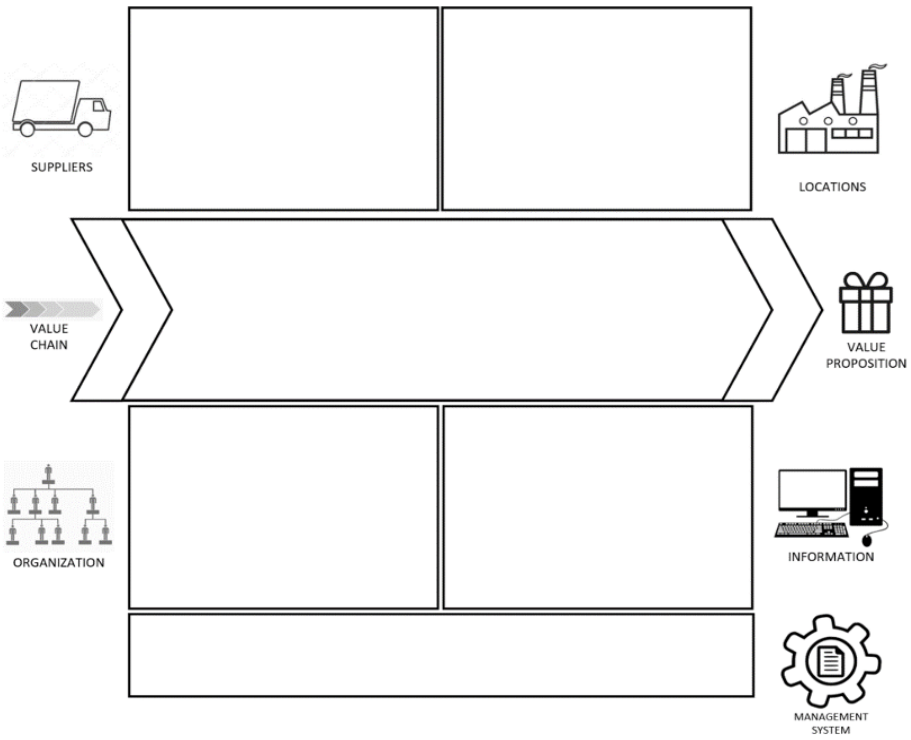


Figure 42. Operating Model Canvas structure

Though it can be applied at different levels, the structure of the canvas does not change, keeping its 6 elements, described in the following sections.

A1.2.1 Value Chain/Value Stream Map

The value stream map (value chain is the term for high level processes) is the representation of the processes; it shows how the organization provides value to the clients. Different processes could have different clients, internal or external. This element is in the middle of the canvas, as the role of any other part is to detail much better the activities.

A1.2.2 Suppliers

Suppliers are intended as partners who provide external inputs to the process.

A1.2.3 Locations

This box deals with the description of the areas where the activities are performed, including the description of typical features and resources.

A1.2.4 Organization

Here organizational structure and people are described. This area is highly connected to the way processes are carried out. Moreover, different locations could have slight differences in roles attribution, depending on many factors, like historical background and plant size.

A1.2.5 IT Systems

This box contains the list of apps and software needed to carry out the job. A powerful tool to describe this section is the Blueprint IT (Figure 43), which relates IT tools both to process activities and to the

organizational unit owner of the tool. The ownership implies the management, update and improvement of the IT system.

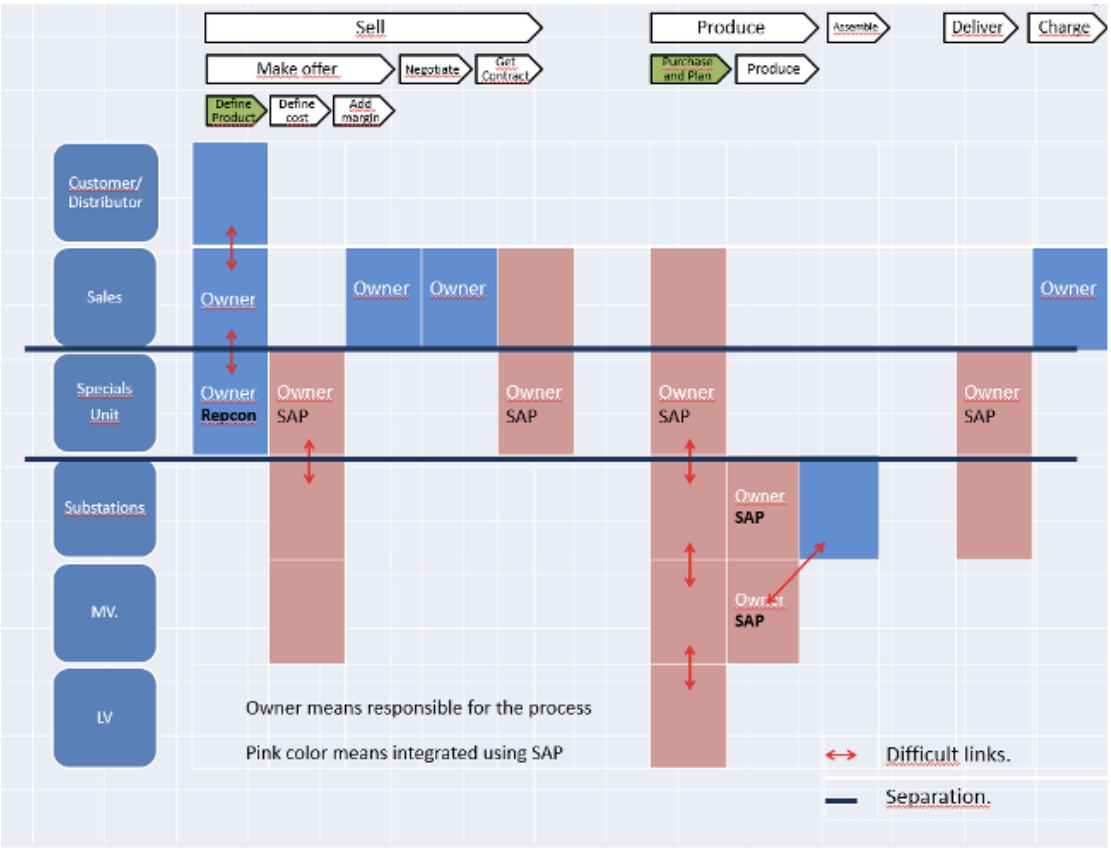


Figure 43. Blueprint IT example

A1.2.6 Management Systems

This area deals with the description of the processes used to plan, set goals, make decisions and measure performance.

There is no mandatory method to build the canvas; the only rule is to start from an analysis of the process activities and link them to the details described in the other boxes. The value proposition, instead, needs to be defined before starting.

Annex 2 - Most Used Tools for Process Description

A2.1 Interviews

The first step in mapping business processes is to gather the information needed to describe how the process works, which is normally done by interviewing the people working there.

The interview should involve operating figures, daily employed in the process, and the function managers or office managers, who, although slightly less operational, have a rather broad and complete view of the whole process and, therefore, are able to describe it in a coherent way from a logical-causal point of view.

However, the information collected from the first interview is not always exhaustive and consistent with the structure of the processes; it is often necessary to repeat the interview, even several times, until the picture is consistent, complete and approved.

The interviewer should be well prepared on the topic of the interview and ask the key questions to obtain the necessary information. The aim is not only to trace the activities, but also to understand their problems, motivations and to verify the information, even by requesting the most significant documents. The interviewer should also share the objectives of the analysis with his interlocutors and try to maintain as much super partes behaviour as possible, in order not to influence the description of the process and to foster the creation of mutually-trusting relationships with the interviewees.

The result of the interview can be documented by reporting for each process[18]:

- the sub-processes and activities carried out at the various stages of the process itself;
- the skills of human resources employed at various stages of the process and their evaluation;
- the necessary technological resources;
- procedures, practices and instructions used to carry out the process;
- constraints that affect the process, tasks, inputs, and outputs;
- customers and suppliers of the process;
- the process manager (process owner);
- the stakeholders;
- relationships and links that exist between tasks within the process or between different processes.

After collecting this information, it is necessary to rework it graphically in order to create a clear and comprehensive business processes map.

[18] Ostinelli C., “La mappatura dei processi gestionali: al cuore dell’activity-based management”, LIUC Papers, Serie Economia Aziendale, Vol. 22, n. 4, July 1995

A2.2. SIPOC Diagram

The SIPOC diagram is a high-level process documentation tool, commonly used in the Lean Six Sigma, which highlights the relationships between the fundamental elements that make up a process.

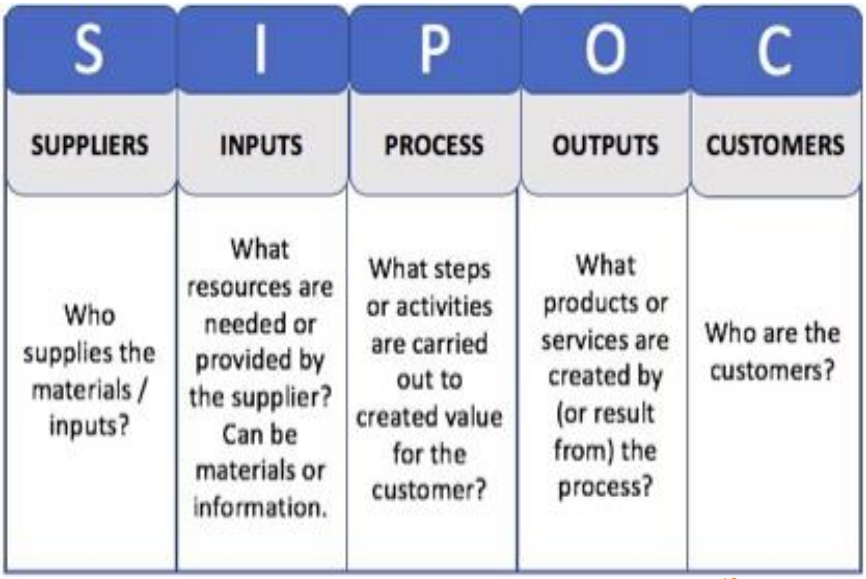


Figure 44. Representation of the SIPOC diagram model[19]

It summarizes the inputs and outputs of one or more processes in table form (Figure 44). The acronym SIPOC, whose elements form the columns of the table, stands for[20]:

- Supplier: it is the list of suppliers of the process, that are those who provide the inputs needed to carry out process activities. It consists of people, other processes, companies or systems that may be internal or external to the organization;
- Input: it is the set of resources needed for the process and can consist of people, materials, documents, equipment or information;
- Process: it is a description of the process in terms of the activities that compose it;
- Output: it is the set of products and services generated by the process;
- Customer: this is the list of customers in the process, who are the recipients of the output. Like the supplier, it consists of people, other processes, companies, systems or applications that may be internal or external to the organization.

A2.3 Flow Chart

A very simple and widespread way to represent processes is the flowchart, also called block diagram. An example is reported in Figure 45.

[19] https://auditandcompliance.wordpress.com/
[20] Sinibaldi A., La gestione dei processi in azienda: Introduzione al business process management, Milano, FrancoAngeli, 2009, pagg. 17-65

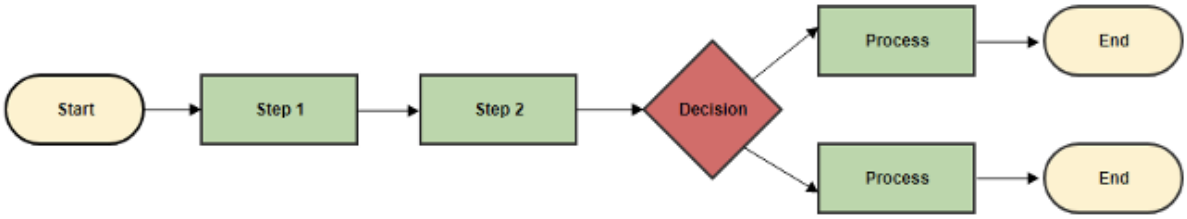


Figure 45. Representation of a simple flowchart[21]

A flowchart is a tool useful to describe a process at various levels of detail, usually taking advantage of geometric shapes, connected by arrows, representing the flow of activities within the process. The chart nodes, then, describe the activities while the oriented arcs indicate their chronological and causal sequence.

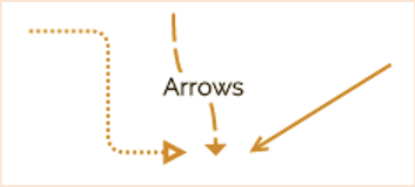
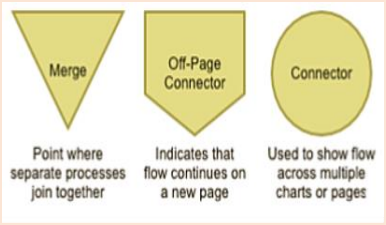
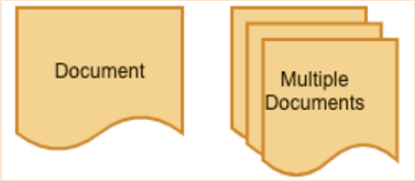
If there are decision-making points, they are represented as a question, whose answer, affirmative or negative, generates a branch of the process[22].

Table 10 shows the most common symbols used to draw flowcharts, each one with a particular meaning.

Table 10. Representation and meaning of the symbols used in flowcharts

SYMBOL	DESCRIPTION
	**Oval or terminator** It is used to represent the start and end of a process.
	**Rectangle** It is used to represent an action or activity that takes place within the process.
	**Diamond** It symbolizes that a decision is required to move forward. This could be a binary choice (yes/no) or a more one, with multiple choices.

[21] https://www.gliffy.com/blog/the-comprehensive-guide-to-flowcharts
[22] Harrington H.J., "Business process improvement: The breakthrough strategy for total quality, productivity, and competitiveness", McGraw Hill Professional, 1991

	**Arrow** It is used to guide the viewer along their flowcharting path. Although there are many different types of arrow tips to choose from, it is recommended to select only one or two for the entire flowchart. This keeps the diagram looking clean, but also allows emphasizing certain steps in the process.
	**Merging \& Connecting** Agreed-upon merging and connector symbols make it easier to connect flowcharts that span multiple pages.
	**Rectangle with wave** It is used to indicate that a document is produced at a certain point. Whether there are many documents, the symbol is multiple.

Whether different functions are involved in a process, it is possible to connect each one to their own activities, using a cross-functional flowchart (example in Figure 46).

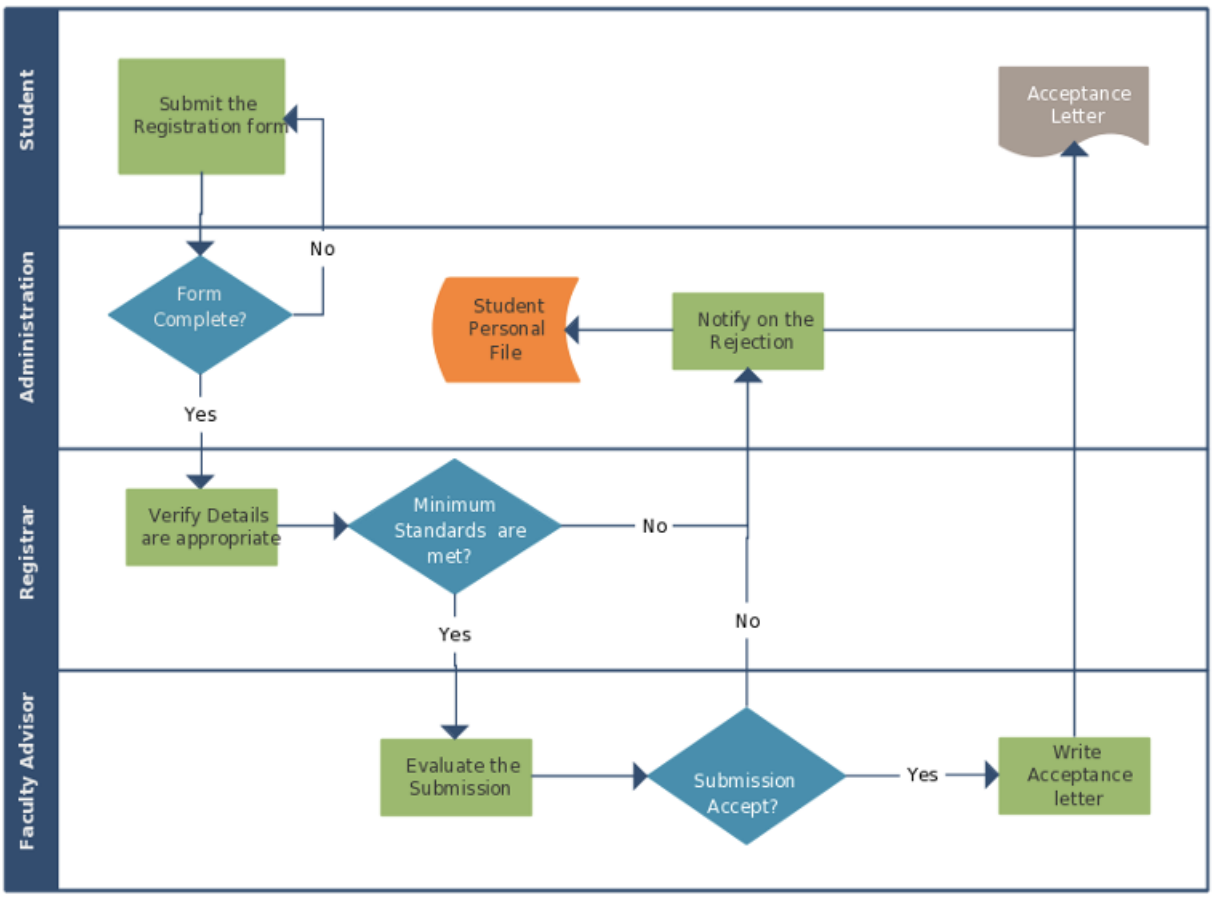


Figure 46. Representation of a simple cross-functional flowchart[23]

In lean context flowchart is also called value stream map, since it represents the value flow along the process. Through this tool, no adding value activities can be identified and reduced or eliminated.

A2.4 BPMN - Business Process Model and Notation

So far, the flowchart and its basic symbolism have been defined. However, there are graphical standards for processes representation, among which BPMN is the most currently widespread.

It is a flowchart-inspired notation that, like any graphical modelling language, uses a shared, standardized set of symbols to represent business processes.

A BPMN diagram is called Business Process Diagram (BPD) and allows to represent the three levels of a business process, at different levels of detail:

- private level, that describes the internal processes of the company/organisation;
- abstract level, that describes external relations;
- global level, that describes interactions between different companies or between different sectors of the same company/organisation.

[23] https://creately.com/blog/diagrams/cross-functional-flowcharts-planning/

The advantage of using the BPMN language lies in the greatest formality, completeness and universal understanding of the models, while maintaining a certain simplicity. Indeed, the presence of a unique language, at least at an enterprise level, greatly facilitates the understanding and sharing of diagrams.

There are several flowcharting software, even free, that exploit this BPMN notation[24].

A2.5 Makigami

The Makigami mapping methodology, an example of which is reported in Figure 47, is normally used for mapping processes in service companies, where value for clients is not always *physically* identifiable. In these scenarios e-mails, modules and websites become the Gemba. This strategy helps particularly when macro processes defined in the Value Stream Map require the interaction of multiple people or where it is difficult to understand which steps of the process are more critical in terms of time or quality.

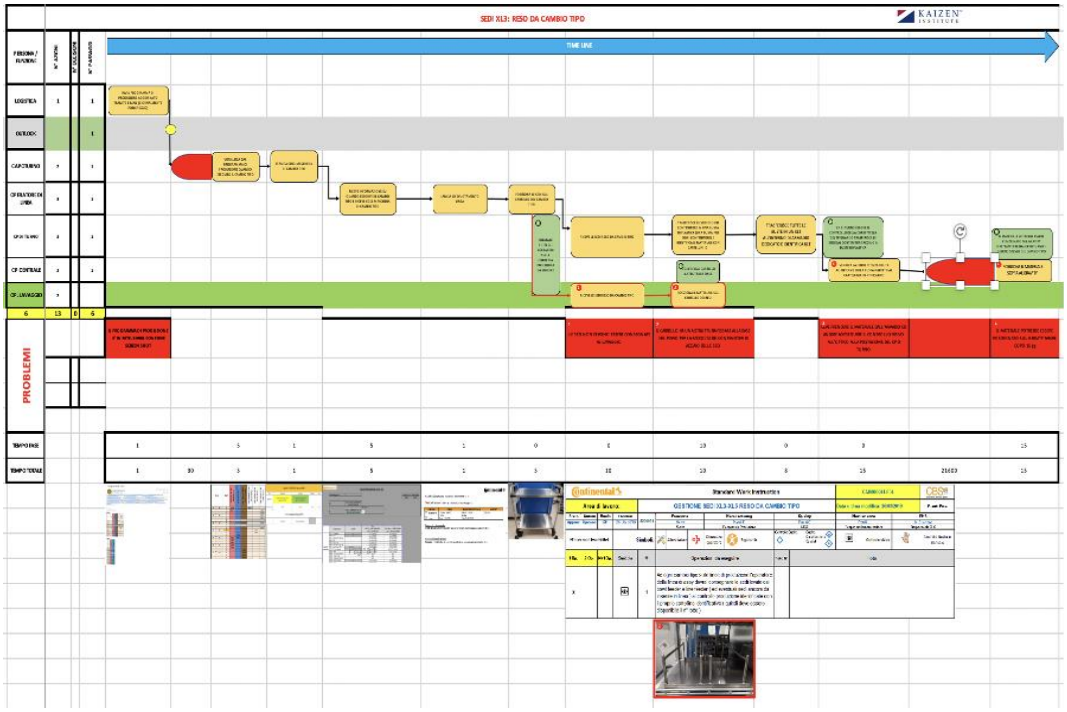


Figure 47. Example of Makigami process mapping (source: Kaizen Institute; details not relevant)

The Makigami also allows for a clearer visualization of responsibilities at each step of the process and explicitly keeps track of the time required for each advancement.

Each entity is assigned a “swim lane” (horizontal line on the map). At every step of the process, actions are added to the swim lanes of the responsible entity.

Analogously to the Value Stream Map, the Makigami is completed in two forms:

- **Current state**: captures the process “as is” and usually refers to a specific case;

  Future state: photographs the process after removing non-value added activities and unnecessary transitions between one or more offices/functions.

[24] Wohed, P., Van der Aalst W.M., Dumas M., “On the suitability of BPMN for business process modelling”, International conference on business process management, September 2006

After mapping the current state, there are two types of indicators that help evaluate the efficiency of the process:

- Primary indicators: Process Time (PT) and Lead Time (LT);
- Secondary indicators**:** Number of Actions, Number of Transitions, Number of Decisions.

The Makigami map also keeps track of loops in the process and critical points that may be the subject of PDCA activities.

To correctly complete the map it is important that:

- the team should include members that work directly on the process;
- representatives of the clients or suppliers can be added to the team.

Annex 3 - Visual management tools

A3.1 Barashi Board

After collecting all of the client's specifications, a Barashi board can be implemented to facilitate the individuation of what is value for the client and remove non-value added activities. Ideally, the Project Manager (or the leader) must use a single sheet of paper (or a similar digital counterpart) to depict visually the overall objectives of the new product. Then, the other partners that collaborate in the project break down that vision or purpose into a meaningful structure for their particular components or application, again using a single sheet of paper (or "digital" document). These depictions must also report the planned improvements in both products and processes that will achieve the project's overall objectives.

These individual depictions are called "Barashi", that loosely means "the visualization of purpose." The members of the team must identify and visualize their primary solution by which they will advance the overall effort to achieve the overall objectives.

An effective Barashi, is not a "simple" summary of a long presentation, but, instead, it is the result of a deep analysis activity that allowed to identify and visualize the essential contributions of the members of the team toward the overall objectives of the project or organization. To succeed in creating an effective Barashi, the members of the team must concentrate on the value they can bring to the entire community involved into the project.

The main purposes of Barashi are:

- make the project team benefit from the structured, disciplined process of creating the Barashi. By doing so, they ensure they have understood the policy deployment (the direction set by the project executives) and have created a robust plan to achieve it;
- the Barashi enhances communication among the overall project team. Each team leader understands the approach being used by all other leaders, enabling greater collaboration ("common language").
- the team's Barashi becomes a sort of "elevator's pitch," made powerful through its focus on targets and metrics. Through the Barashi, leaders and team members can explain the critical point s of their contributions within a short (3 minute) time span.

A3.2 Obeya Room

Obeya Room visual tool was invented in the early 1990s, when Toyota's chief engineer Takeshi Uchiyamada was involved in a difficult challenge: designing the 21st century car with very aggressive fuel consumption targets.

In less than three years, the first hybrid car, the Prius, was on the market - 15 years ahead of the competition. To accomplish such a challenging objective, Takeshi Uchiyamada invented a new product and process development approach. He designed a new type of visual management, which has since spread to all of Toyota's technical offices: the Obeya.

An Obeya room will be made of graphs, tables, photos and other visual material that will show the plan and its milestones, plotting progress against expectations and listing potential countermeasures. the problems identified. It is a sort of control centre and it should give you a clear idea of what your colleagues are working on.

Annex 4 – Kaizen and Lean Systems and Tools

A4.1 Introduction

The Kaizen and lean methods involve the usage of simple tools, checklists, and techniques. They do not require the investment of a great deal of money, yet they offer substantial benefits to any business.

The actions to be taken are organized into systems and tools, improvement methods that can be used to apply the strategic vision.

In the following, the main systems and tools of Kaizen and Lean are shortly described. Some have been used in the Kaizen workshops organised in T3.1. Others are mentioned in the Deliverable for their possible use in the iPRODUCE roadmap implementation. Still others could be used as well.

A4.2 Lean Six Sigma

Lean Six Sigma means a managerial concept that combines the Lean production philosophy and the quality management program, Six Sigma, a program that aims to eliminate eight types of waste/muda and an increased capacity of performance. The term "Six Sigma" is statistically based on the procurement of goods and services at the highest level.

The concept of Lean Six Sigma was first published in 2002, in the book, "Lean Six Sigma: Combining Six Sigma with Lean Speed", by Michael George and Peter Vincent. It uses some phases, similar to those of Six Sigma, invented in Motorola.

Training for Lean Six Sigma is provided through a system similar to that of Six Sigma: the so-called "staff belt", in analogy to karate, is divided into "white belts", "yellow belts", "green belts", "black belts" and "master black belts". For each "belt" there is a skill set that describes which of all the tools of Lean Six Sigma are expected to be part of a certain level. These skill sets provide a detailed description of the learning elements that a participant will acquire after completing the training program. The skill sets reflect elements of Six Sigma, Lean and other process improvement methods such as TOC (Theory of Constraints), TPM (Total Productive Maintenance) and WCM (World Class Manufacturing).

From experience it appears important to take automation into consideration in Lean Six Sigma projects. In fact, several years of application at General Electric it has been shown that the benefit of the Lean Six Sigma project comes for about 50% from organizational and system changes, and 50% from automation.

A4.3 TQM - Total Quality Management

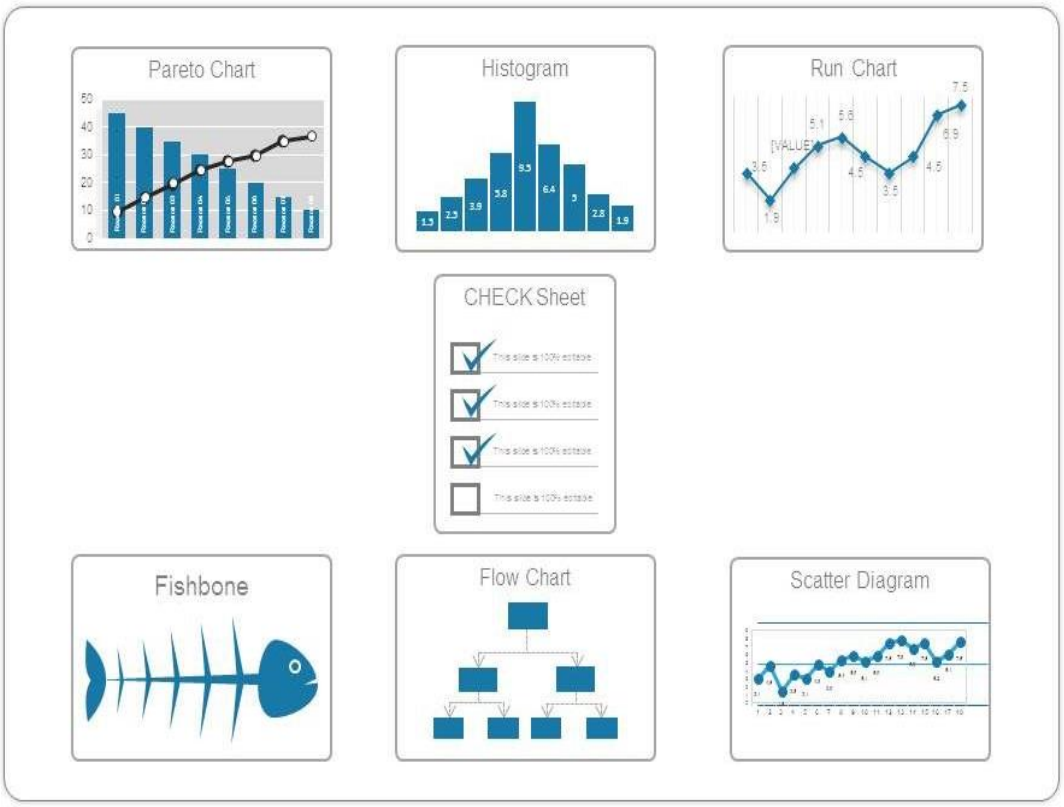


Figure 48. Main tools used for the implementation of the TQM

TQM is the management of quality at every stage of operations, from planning and design through self-inspection, to continual process monitoring for improvement opportunities (e.g. reducing production and service defects, increasing customer satisfaction, ensuring well maintained equipment and trained employees). TQM is a corporate culture characterized by increased customer satisfaction through continuous improvement, in which all employees in the companies participate actively. It focuses on control of business processes and customer satisfaction. It is based on 8 principles:

- customer-focused;
- total employees' involvement;
- process-centred;
- integrated system;
- strategic and systematic approach;
- continuous improvement;
- fact-based decision making;
- communications.

Some of the tools used for the implementation of the TQM are shown in Figure 48: Pareto Principle, Scatter Plots, Control Charts, Flow Charts, Cause and Effect Diagram, Histogram Graph and Check Lists.

A4.4 TPM - Total Productive Maintenance

The Total Productive Maintenance (TPM) is an approach to equipment maintenance that aims to achieve a perfect production process by increasing productivity, efficiency, and safety. The goal of TPM is to completely eliminate the following losses:

- unplanned downtime;
- personnel errors;
- product defects;
- employees' accidents;
- wasted resources;
- low labour efficiency.

TPM can be measured by calculating Overall Equipment Effectiveness (OEE). OEE is calculated by multiplying Availability x Performance x Quality.

Availability is measured as 100% minus the following: time losses related to equipment failure, time losses related to adjustments and set-up, and time losses related to restarting work after breaks and weekends.

Performance is measured as 100% minus the following: time losses related to minor interruptions, and time losses related to speed (actual vs. optimal speed).

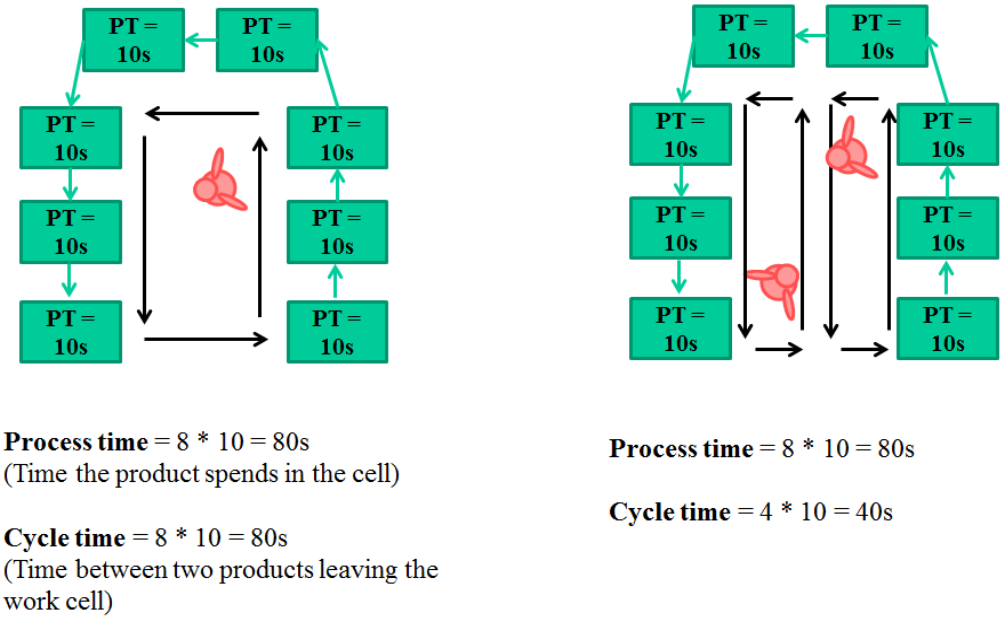
Quality is measured as 100% minus losses related to defects in production.

TPM relies on 8 pillars:

1. Autonomous Maintenance - operators trained to perform routine maintenance tasks on their assigned machine;
2. Focused Improvement: small teams improve processes and workflows through focused, continuous improvement;
3. Planned Maintenance: maintenance is scheduled, routine maintenance based on machine performance and failure-rate data.
4. Early Equipment Management: suppliers use the practical knowledge and experience of machine operators in the design of new equipment.
5. Quality Maintenance: quality teamwork to improve overall production quality and eliminate defects.
6. Training and Education: Continuous training and education guarantees maintenance tasks are adequately executed at all times.
7. Office TPM: also improvement of administrative operations are managed.
8. Safety, Health, Environment: TPM aims to maintain a safe working environment for employees at all times.

A4.5 Multi Cycle Time Study Analysis

Multi-Cycle Analysis is a series of data capture tools applied to the process (Figure 49). Its intent is to understand the flow of the primary and any secondary entities along with operator and equipment activities. It is based on the observation of the process operations and then it breaks down all activities into basic elements, recording step durations. After the data is captured, all the work activities are categorized as Value Activities and Non-Value Activities.



Process time = 8 * 10 = 80s
(Time the product spends in the cell)

Cycle time = 8 * 10 = 80s
(Time between two products leaving the work cell)

Process time = 8 * 10 = 80s

Cycle time = 4 * 10 = 40s

Figure 49. Data captured observing the flow of the process

Understanding the activity of the primary entity enables the process flow detection, hence it helps to identify inefficiencies. Understanding the activity of secondary entities (e.g., staff and equipment) helps to identify opportunities for removing work content and redundancy.

A4.6 SMED

SMED (Single-Minute Exchange of Die) is a system for the reduction of the time it takes to complete equipment changeovers (Figure 50). The objective is to convert as many changeover steps as possible while the equipment is running and to simplify and streamline the remaining steps.

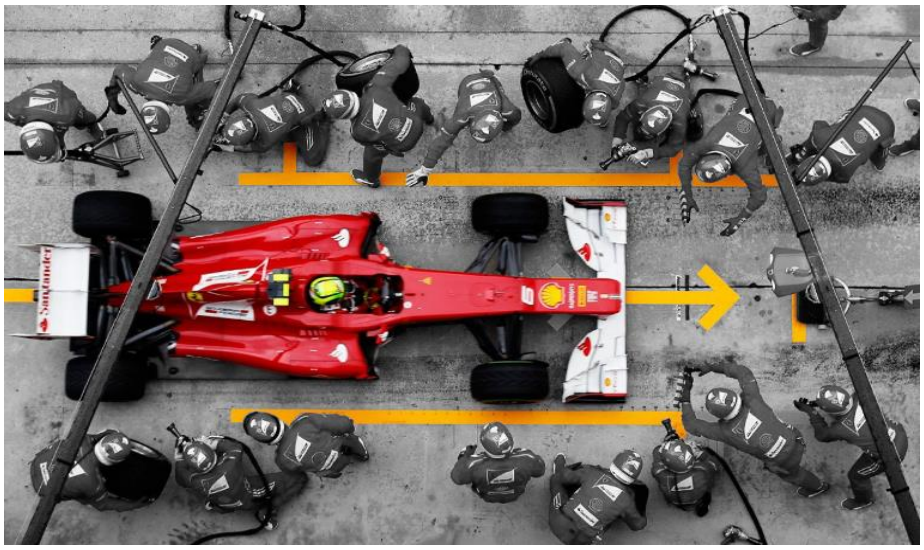


Figure 50. The reduction of equipment changeover delays is a priority in Kaizen

SMED has several benefits: lower manufacturing cost due to less equipment downtime; smaller lot sizes: faster changeovers enable more frequent product changes; improved responsiveness to customer demand: smaller lot sizes enable more flexible scheduling; lower inventory levels: smaller lot sizes result in lower inventory levels; smoother startups: standardized changeover processes improve consistency, quality and reduction of failures.

A4.7 POKA-YOKE

The Poka-Yoke management tool is about avoiding errors within the organisation and preventing mistakes in manufacturing processes.

Figure 51. Poka-Yoke concept

This ensures that the appropriate conditions are in place prior to a process or new step being executed, which will stop defects in the first place. A simple example is shown in the Figure 51.

It stops errors as soon as possible by bringing attention to the error that causes it. This involves adding design features that will make it impossible for errors to occur, and revaluating the whole process, therefore, ensuring quality products and services.

PRODUCE

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