Road 4 FAME

Deliverable 2.1

Typologies of Manufacturing Business Settings

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PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
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Project Acronym:	Road4FAME
Project Full Name:	Development of a Strategic Research and Innovation Roadmap for Future Architectures and Services for Manufacturing in Europe and Derivation of Business Opportunities
Grant Agreement No.:	609167
Programme	ICT – Challenge 7: ICT for the Enterprise and Manufacturing
Instrument:	Coordination Action
Start date of project:	01.06.2013
Duration:	29 months
Deliverable No.:	D2.1
Document name:	Typology of Manufacturing Business Settings
Work Package	WP2
Associated Task	T2.1
Nature [1]	R
Dissemination Level [2]	PU
Version:	1.2
Actual Submission Date:	2013-11-30 (Version 1.11)
Contractual Submission Date	2013-11-30
Editor: Institution: E-mail:	Eva Coscia TXT e-solutions s.p.a. eva.coscia@txtgroup.com

The Road4FAME project is co-funded by the European Community's Seventh Framework Programme under grant agreement n° 609167.

[1] **R**=Report, **P**=Prototype, **D**=Demonstrator, **O**=Other

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Change Control

Document History

Version	Date	Change History	Author(s)	Organization
0.01	2013-10-01	Document ToC drafted	Eva Coscia	TXT
0.02	2013-10-15	Document first draft	Eva Coscia	TXT
1.00	2013-11-12	Document revised	All partners	
1.01	2013-11-22	Document updated	Christian Albrecht Eva Coscia	SEZ TXT
1.1	2013-11-26	Document revision	Christian Albrecht Ursula Rauschecker	SEZ IPA
1.11	2013-11-29	Final version for submission	Eva Coscia	TXT
1.2	2014-06-19	Update with final manufacturing scenarios (section 6)	Christian Albrecht	SEZ

Distribution List

Date	Issue	Group
2013-10-01	Document ToC drafted	ALL
2013-10-15	Document first draft	ALL
2013-11-12	Document revised	ALL
2013-11-22	Document updated	Christian Albrecht Ursula Rauschecker
2013-11-26	Document revision	Christian Albrecht Ursula Rauschecker Eva Coscia
2013-11-29	Final version for submission	Christian Albrecht Eva Coscia

List of Contributions

Organization(s)	**Person(s)**	**Contribution**
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SEZ	Christian Albrecht	Classification descriptions Potential Business Settings
IPA	Ursula Rauschecker	Potential Business Settings
ALL		Industry categorisations

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1 Introductory Remarks

Remark: This document was updated as of 2014-06-19 (version 1.2) to include the final version of the four manufacturing scenarios used in Road4FAME. These are presented in section 6. All other sections remain unchanged by this update and equate to the version originally submitted to the EC on 2013-11-29 (version 1.11)

Road4FAME develops a research and innovation roadmap for future architectures and services – aligned with the specific *needs* of manufacturing businesses.

These needs, however, can be expected to depend strongly on the considered scenario: The business environment the particular manufacturing company is embedded in (e.g. served market, competition) but also, for instance, the degree of automation, the scale of production, etc. The entirety of these ***characteristics*** shall be referred to as ***Manufacturing Business Setting***. The respective Manufacturing Business Setting, then, will likely influence the need for IT services, and determine the most promising IT architectures in this case.

The existence of very different Manufacturing Business Settings implies that the consideration of architectures and services in the Road4FAME project cannot be made in abstraction from the specific demands holding in these several settings and one cannot expect to find architectures and services that will be a global optimum across all sorts of Manufacturing Business Settings. Rather, it is reasonable to expect *local optima* – that is, architectures and services optimal in a specific Manufacturing Business Settings but not necessarily optimal in others.

A certain differentiation according to Manufacturing Business Settings is thus necessary as a basis for any consideration of architectures and services in Road4FAME.

Task 2.1 is concerned with the identification of factors or ***characteristics*** which will likely have an influence on the needs and requirements of manufacturing businesses for IT architectures and services. Based on such differentiating characteristics, a set of four ***Manufacturing Business Settings*** shall be proposed for examination in the Road4FAME project. These four settings shall be constructed in a way so they are representative of particularly demanding manufacturing scenarios, with some of them also being representative of the situation faced by SMEs.

This purpose of this document is to describe considerations regarding the selection of relevant characteristics, taking into account well known classification systems of manufacturing businesses. Furthermore, it gives an overview of Manufacturing Business Settings considered for examination in Road4FAME.

The document is structured in 7 sections. Section 1 presents the motivation of the activities in T2.1, the results of which are reported in this document, and which will be further shaped over the course of the Road4FAME project; Section 2 clarifies the objectives and the approach adopted in D2.1; in Section 3, several commonly used classification systems are shortly reported together with an evaluation of their relevance for Road4FAME. Section 4 focuses on a methodology for classifying manufacturing firms accordingly to the adoption of ICT solutions. Section 5 introduces the system for the characterization of manufacturing companies elaborated in Road4FAME. This system will be adopted for the characterization of companies considered during the project and to put their

reported needs and requirements in perspective. Section 5 describes also an initial proposal of four Manufacturing Business Settings, each representing a group of similarly characterized manufacturing companies, likely facing similar challenges, and likely having similar needs and requirements regarding manufacturing IT. Finally, Section 7 contains conclusions and an overlook of how the results described in this document will be used and transformed in the other steps of the project.

Update: Section 6 has been introduced with version 1.2 of this document. This additional section contains the final manufacturing scenarios used in Road4FAME.

2 Objectives

The objective of T2.1 is to firstly identify set of ***characteristics*** which are suitable to sufficiently describe manufacturing businesses. A certain subset of these characteristics can be expected to have an influence on the needs and requirements of manufacturing businesses for IT services, and determine the most promising IT architectures.

Secondly, based on such differentiating characteristics, a set of four ***Manufacturing Business Settings*** shall be selected for examination in the Road4FAME project. A Manufacturing Business Setting can be described by a set of characteristics that represents a group of similarly characterized manufacturing companies, likely facing similar challenges, and likely having similar needs and requirements regarding manufacturing IT.

The set of characteristics will be used throughout the project for putting needs and requirements of manufacturing businesses into perspective. For companies which are similar to those described by the four Manufacturing Business Settings it will be examined if particular needs and requirements exist. It will be evaluated over the course of the project, if the four selected Manufacturing Business Settings are indeed suitable to capture major differences in needs and requirements. The proposed Manufacturing Business Settings will be redefined as necessary.

Operationally, any involved workshops participant, interviewed expert, or survey participant will be profiled using the developed characterization system, that is, he or she will be profiled by the characteristics of the company he or she represents. Having each involved expert “earmarked” this way, any articulated need or requirement can subsequently be put into perspective with the characteristics that describe the company he/she represents.

This profiling activity will result in a mapping of most of the contacted companies in the four Manufacturing Business Settings presented in this document and allow also the identification of further “contiguous” Manufacturing Business Settings.

The “earmarking” process will be performed through:

- In the case of an online survey: Respondent will be asked to characterize his/her company briefly along certain characteristics.

- In the case of telephone interview: The interviewee will be will be asked to characterize his/her company briefly along certain characteristics.
- In the case of an expert panel or workshop: Participants will be asked to characterize his/her company briefly along certain characteristics, using a short paper-pencil questionnaire.

Experts joining the Road4FAME Experts Group in the future could be asked (this alternative isnot yet implemented) to characterize his/her company in the course of the registration procedure.

3 Overview of possible classifications

The Manufacturing Industry includes a wide variety of firms, each one with its peculiarities.

Any activity which aims to study this sector needs to break it into smaller pieces that represent manufacturing firms sharing relevant commonalities.

Correctly identifying which are the commonalities to be taken into account heavily depends on the goal of the activity. In several cases, what makes the difference is the manufactured product and associated service, in other cases it is the manufacturing process or other more specific factors (such as level of technology adoption, R&D or Innovation intensity etc…)

In search for factors that suitably distinguish manufacturing companies for the purpose of the Road4FAME roadmapping activity – and that therefore potentially influence the needs and requirements regarding IT architectures and services – a number of commonly used classifications were considered. An overview and assessment is presented in the following sections.

Below, the list of analyzed classifications, the first three ones being code-based classifications for statistical purposes, the other ones presenting different approaches to categorisation :

- ***NACE****:* is a classification system for industries and economic activities in the European Union employed for statistical purposes
- ***NAICS****:* the classification of the American Bureau of Labour Statistics classifies manufacturing into hundreds of subfields and sub-subfields. This list will simplify these into six general sectors.
- ***ISIC*** is the United Nations' International standard industrial classification of all economic activities.
- ***GICS*** is the Global Industry Classification Standard (GICS) was developed by Morgan Stanley for economic analysis
- ***OECD Technology-intensity*** is a classification of the production process based on the level of adoption of technologies
- ***Design/Production dependency classification*** is a UK classification based on the degree of "information dependency" between the product design and manufacturing phases.
- ***IDC****:* is a 4-groups, value-chain based classification

3.1 High level classifications

At the highest possible level, all the product activities can be catalogued into several different markets.

According to Wikipedia (http://en.wikipedia.org/wiki/Vertical_market): "A **vertical market** is a market in which vendors offer goods and services specific to an industry, trade, profession, or other group of customers with specialized needs. It is distinguished from a horizontal market, in which vendors offer a broad range of goods and services to a large group of customers with wide range of needs, such as businesses as a whole, men, women, households, or, in the broadest horizontal Is there no other reference? Wikipedia is not really a reputable source.

market, everyone."

The activities of participants within any given vertical market are typically similar since they aim at solving the same or similar problems. These markets are typically competitive, due to the overlapping focuses of the products and services that are provided to the customers."

Main **Vertical Markets** are:

Banking/ insurance/ other finance, discrete manufacturing, process manufacturing, retail/wholesale, agriculture/construction/mining, business services, transport, communications and media, utilities, government, healthcare, education

They are graphically represented below (IDC courtesy)

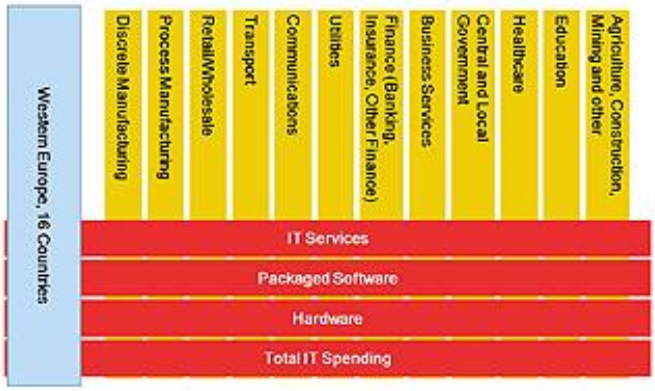

Table 1: Vertical Markets

The manufacturing sector, given the broad range of product and service offered, spam over several vertical markets in the above classification.

Trying to cover it all in the road-mapping activity is a too ambitious and complex objective, thus it is necessary to impose some restrictions to the domain that is addressed by Road4FAME.

Below we shortly present the high-level classification that is applied to identify the manufacturing subset of interest.

The Manufacturing Industry can be roughly divided into

- **Discrete manufacturing**: the manufacturing of finished products that are distinct items. These items can be counted, touched or seen and are usually composed of clearly identifiable sub-components. An automobile is a product of discrete manufacturing.

- **Process manufacturing:** here the product is created by using a formula or recipe to refine raw ingredients and the final product cannot be broken down to its basic components. An example therefore is the chemical industry.
- **Mixed-mode manufacturing:** is a combination of the two above, introduced because most companies are not entirely one way or the other, and even if the final products are discrete items, along the production line there are phases that are more process-oriented.

With respect of the above macro-classification, **process manufacturing is not covered** in Road4FAME.

It is also important to remark that the **retail sector is not addressed** directly, thus not object of analysis for the detection of its specific needs and requirements; however retailers will reasonably enter in the manufacturing scenarios of interest for Road4FAME, being relevant actors of the studied Value Chain and the business ecosystems.

3.2 Code-based classifications

The traditional separation of the Manufacturing Industry into Discrete Manufacturing and Process Manufacturing is indeed too generic and, as such, not sufficient to create a categorisation of the sector that might be useful to create a mapping of the European manufacturing industries.

Below, several low-level analysis of existing classifications is reported and it can be anticipated that both product (or code-based) and process-oriented classifications are not helpful for the identification of relevant Business Settings (as described in the Sect. 2 above) as they do not allow identifying and tracking industries that have relevant similarities even if what they produce and the way they produce is not the same one.

3.2.1 NACE Classification

NACE (Nomenclature statistique des activités économiques dans la Communauté européenne) is a classification system for industries and economic activities employed for statistical purposes. Alphanumerical codes (“NACE codes”) of length up to six characters refer to categories and subcategories of economic activities.

Manufacturing-related activities are classified under Section “C - Manufacturing”, comprising both discrete and process Manufacturing activities.

Examples would be “C14 - Manufacture of wearing apparel” or “C26 - Manufacture of computer, electronic and optical products”, with subcategories as detailed as “C26.1.1 - Manufacture of electronic components”.

List of NACE codes: http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

3.2.2 NAICS

Being a North American equivalence of NACE, NAICS (North American Industry Classification System) classifies economic activities similarly. Manufacturing is represented under sectors codes 31-33, again, comprising both discrete and process manufacturing activities.

Examples would be “335 - Electrical Equipment, Appliance, and Component Manufacturing”, with subcategories as detailed as “335121 - Residential Electric Lighting Fixture Manufacturing”.

List of NAICS codes: http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012

3.2.3 ISIC Classification

ISIC is a classification system suggested by the Department of Economic and Social Affairs of the United Nations. ISIC is intended to be a standard classification of productive activities.

The tabulation categories identified by letters, are called “sections”, the 2-digit categories “divisions”, the 3-digit categories “groups” and the 4-digit categories “classes”. Manufacturing is represented by section C.

3.2.4 Purpose and Limits of the code-based classifications

The code-based classifications presented above have been created for statistical purposes, to partition the manufacturing industry into categories that are as homogeneous as possible with respect to the characteristics of the object of the statistical survey.

The Statistical classifications are requested to provide:

- An exhaustive coverage of the observed universe;
- mutually exclusive categories, so that each element cannot be classified in more than one category
- methodological principles which allow the consistent allocation of the elements to the various categories of the classification.

The above code-based classification split the manufacturing sector into as many possible different categories as the different products are. Even if this approach guarantees to respect the first two requirements above, it looks at firms from an “external” point of view, where the whole process that leads to the manufacturing of products is considered as a black-box, of no interest for the classification purposes.

3.2.5 GICS Classification

The Global Industry Classification Standard (GICS) was developed by Morgan Stanley Capital International (MSCI), a premier independent provider of global indices and benchmark-related products and services, and Standard &Poor’s (S&P), an independent international financial data and investment service company and a leading provider of global equity indices.

The GICS structure consists of 10 sectors, 24 industry groups, 68 industries and 154 sub-industries. It is intended to be applied globally and reflect any industry relevant in the investment domain. It has been developed mainly for supporting economic analysis, investment research and for the preparation of reports for investors.

List of GICS codes: http://www.msci.com/products/indices/sector/gics/gics_structure.html

Similarly to the code-based classifications above, this kind of classification method is of poor interest for Road4FAME, as it takes into consideration only factors of interest to calculate investment opportunities on different groups of manufacturing industries.

3.2.6 Technology-intensity of the production process

The classification below is presented as an example of how further aggregations can be derived by applying additional criteria, not related specifically at the products, on top of code-based classifications.

Eurostat and OECD use the following breakdown of manufacturing industries according to overall technological intensity and based on NACE rev. 1.1 at 3-digit level .

As explained in the Eurostat website[3]: *"Data for industrial manufacturing are grouped into four levels of technological sophistication: high-technology, medium-high-technology, medium-low-technology and low-technology. The four technology groups are defined on the basis of the R&D intensity of economic activities, i.e. R&D expenditures in relation to value added* ".

Below are reported the results of that classification (also graphically depicted in Figure

- High-technology:
    - Aerospace
    - Pharmaceuticals
    - Computers, office machinery
    - Electronics-communications
    - Scientific instruments
- Medium-high-technology:
    - Electrical machinery
    - Motor vehicles
    - Chemicals, excluding pharmaceuticals
    - Other transport equipment
    - Non-electrical machinery
- Medium-low-technology:
    - Coke, refined petroleum products and nuclear fuel
    - Rubber and plastic products
    - Non-metallic mineral products
    - Shipbuilding
    - Basic metals
    - fabricated metal products
- Low-technology:
    - Other manufacturing and recycling
    - Wood, pulp, paper products, printing and publishing
    - Food, beverages and tobacco
    - Textile and clothing

[3] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/High-technology_versus_low-technology_manufacturing

Manufacturing industries	NACE Rev 1.1 codes
High-technology	**24.4** Manufacture of pharmaceuticals, medicinal chemicals and botanical products; **30** Manufacture of office machinery and computers; **32** Manufacture of radio, television and communication equipment and apparatus; **33** Manufacture of medical, precision and optical instruments, watches and clocks; **35.3** Manufacture of aircraft and spacecraft
Medium-high-technology	**24** Manufacture of chemicals and chemical product, **excluding 24.4** Manufacture of pharmaceuticals, medicinal chemicals and botanical products; **29** Manufacture of machinery and equipment n.e.c.; **31** Manufacture of electrical machinery and apparatus n.e.c.; **34** Manufacture of motor vehicles, trailers and semi-trailers; **35** Manufacture of other transport equipment, **excluding 35.1** Building and repairing of ships and boats **and excluding 35.3** Manufacture of aircraft and spacecraft.
Medium-low-technology	**23** Manufacture of coke, refined petroleum products and nuclear fuel; **25 to 28** Manufacture of rubber and plastic products; basic metals and fabricated metal products; other non-metallic mineral products; **35.1** Building and repairing of ships and boats.
Low-technology	**15 to 22** Manufacture of food products, beverages and tobacco; textiles and textile products; leather and leather products; wood and wood products; pulp, paper and paper products, publishing and printing; **36 to 37** Manufacturing n.e.c.

Table 2: Hi-Tech intensity in manufacturing

3.3 Design/Production dependency classification

The Government Office for Science (UK) has recently commissioned a Foresight Report looking at the transformations which will occur in the manufacturing sector and the environment in which it operates out to 2050. Published in October 2013, the Report focuses on manufacturing as a whole with a particular emphasis on the United Kingdom.

This report groups industrial manufacturing sectors depending on the level to which it is possible to keep separate the information about the product design and the manufacturing process.

Thus the key question is: can the manufacturing process be separated by the R&D and product innovation phase? Can the product and service conception, design and development be done in-house and their actual manufacturing outsourced?

From the analysis of the answers to these questions, 4 main typologies have been derived and presented in the chart below.

The objective of that classification was to evaluate the possibilities and the benefits of co-location of R&D with manufacturing, to maximise the innovation.

For example, some products are highly dependent on process-driven innovation, such as nano-materials and some electronics applications and thus benefit from the co-location of different parts of their production systems.

Figure 5: Product design/production and relationship to process maturity

Source: Pisano & Shih (2012)

Table 3: R&D and Production proximity

Clearly the above approach is not suitable for the Business Setting creation objectives of Road4FAME, as it takes into account just one single factor (required proximity of R&D with actual production) to distinguish companies.

However it is interesting as an example of classification that goes beyond the rigid distinctions operated by code-based classification.

As we can see below, the classification methodology finally created in Road4FAME is based on the idea of selecting factors that are not strictly related to the manufactured product or to the production process.

3.4 Value-Chain based classifications

When the analysis of the manufacturing sector is focused on the identification of the key activities performed by a firm to develop and bring into the market a certain product or service, on the "value" that is created during these activities and on the factors driving decision making and changes into these steps, a value chain analysis is necessary.

Consultancy firms and research organisations typically use a "calue-chain" based approach. A short introduction to the typical value chain for the manufacturing domain and an example of value chain-based classification is presented below in Section 3.4.1 and 3.4.2

3.4.1 Manufacturing Value Chain

Several definitions of *Value Chain* for manufacturing are available and used, differing mostly in the degree of granularity of the activities that are considered and on the emphasized value-creation steps. Two examples are reported below.

The first one is adopted in the report on the future of manufacturing [1] issued by the Government Office for Science, London.

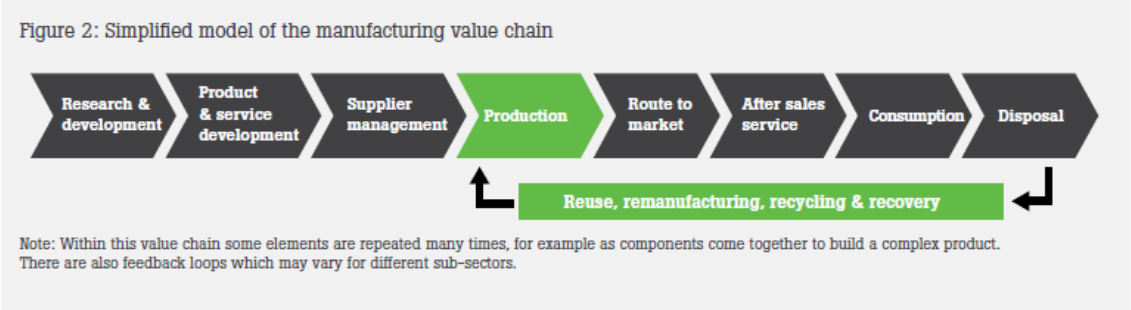

Figure 1: Simplified Value Chain from "Future of Manufacturing" Report[4]

The second one is provided by the Value-Chain Group (http://www.value-chain.org/):

Figure 2: Representation of Value Chain by provided by the Value-Chain Group

These value-chain models differ mostly by the number and granularity of the phases that are considered. Usually, adjustments of the most popular models are created to meet specific needs and interpretations.

The simplified model of the typical Value Chain in Manufacturing that has been specifically created and adopted in Road4FAME, is graphically represented below.

[4] Foresight (2013) The Future of Manufacturing – A new era of opportunity and challenge for the UK Summary Report – The Government Office for Science, London

Figure 3: Value Chain model applied in Road4FAME

Its major steps are:

- **Market Analysis**: includes activities for monitoring of the market, analyzing trends and demand fluctuations,
- **Product and Service Research**: includes all the Research activities on material, technologies and processes whose results are transferred to the product and services design and development.
- **Product Design and Development**: includes all activities for the conception and design of products and services and the detail engineering.
- **Product and Service Acquisition**: includes the activities for creating and activating the Supply Chain, providing availability of necessary materials and services for the production phase through commercial and cooperation agreements with partners.
- **Manufacturing**: includes all activities for the actual production, starting from the engineering information, delivery production plans and monitoring of the actual production.
- **Logistics:** includes all activities for the warehousing and delivery of products, including the selection of service suppliers if the logistics is outsourced.
- **Sales**: activities for order acquisition and product/service delivery to the final customers.
- **After Sales**: activities for monitoring the consumption of products and services and for supporting the final customers in using and maintaining the products/services

3.4.2 IDC Value Chains Classification System

As an example of Value Chain-focused classification of the manufacturing firms, the following introduces the one used by the IDC consultancy firm to develop the *Manufacturing Insights* reports.

The basic idea is to avoid the too dispersive classifications based on the actual products, services or production processes of a company, but rather to understand which are the "business drivers" having a huge impact on the value chain of a company.

Four main typologies of value chains, each one characterised by a different driver, have been identified by IDC:

- **Engineering** Oriented Value Chain (EOVC)
- **Brand** Oriented Value Chain (BOVC)
- **Asset** Oriented Value Chain (AOVC)
- **Technology** Oriented Value Chain (TOVC)

EOVC: **ENGINEERING** ORIENTED VALUE CHAIN

DRIVER: ENGINEERING OF PRODUCTS

This value chain is characterised by the production of complex products, for which the engineering phase as a dominant importance.

Examples of industries are: Automotive, Aerospace, Industrial Machinery and other discrete manufacturing categories.

BOVC: BRAND ORIENTED VALUE CHAIN

DRIVER: **COMMERCIAL BRAND DEVELOPMENT & MAINTENANCE**

This value chain is characterised by the focus on the brand creation and maintenance.

Examples of industries are: Food & Beverage, Personnel Goods, Health & Beauty, Apparel, Textile, Toys, Music Instruments.

AOVC: ASSET ORIENTED VALUE CHAIN

DRIVER: **ASSET**

This value chain groups those companies having very complex factories, whose management requires high effort and costs.

Examples of industries are: Chemicals, Pharmaceutical, Pulp & Paper, Metal.

TOVC: TECHNOLOGY ORIENTED VALUE CHAIN

DRIVER: **TECHNOLOGICAL INNOVATION OF THE PRODUCTS**

This value chain is characterised by the high degree of technological innovation provided by the products.

Examples of these industries are: High Tech, Semi-conductors and electronics.

4 Classification based on ICT adoption

Since the Road4FAME roadmapping activities are centred on the adoption of ICT Technologies (in particular, IT architecture and services), the identification of those factors that make a firm more able to successfully adopt IT solutions is of primary relevance.

A study conducted by the Swiss Technology Institute compared firm-specific information on ICT use (e.g. time period of adoption of nine technology elements, share of employees using specific technologies, range of application of Internet and Intranet respectively, objectives of and obstacles to the adoption of ICT, etc) with characteristics of the firm (size, industry affiliation, human resources, etc.) and other variables to properly identify the factors influencing the decision of adopting ICT.

The interest for that specific study is in the applied methodology rather than on the specific results, being it limited to the Swiss scenario and related to the past period, thus requiring considerable updates.

Particularly relevant for this deliverable is the analysis of which are **a)** the benefits that firms expect from the ICT adoption and also of **b)** which factors representing barriers to it.

a) Potential benefits can be grouped into 3 main categories:

- **MARKET:** Benefits related to the revenues and to the improvement in sales; in this context, ICT is expected for example to improve quality and variety of products, on supporting the development of services and improving customer orientation
- **COST REDUCTION:** Benefits related to the reduction of costs in general; here ICT can improve the internal communication, the decision making and the optimization of the production process
- **INPUT:** Benefits derived by the improvement of external relationships on the input side (labour market, co-operation with suppliers and other actors in the value chain) and on the technology side.

Expected Benefits of IT adoption	MARKET*	COST REDU**	INPUT***
Improving product quality and variety	X		
Improving presence on the product market	X		
Increasing sales	X		
Improving customer-orientation	X		
Complementing products by new features (on-line payment, etc.)	X		
Optimisation of production process		X	
Improving decision making		X	
Improving internal communication		X	
Reducing costs		X	
Improving attractiveness on the labour market			X
Monitoring performance of employees			X
Improving the technological position	X		X
Improving supplier-relationships	X		X

(*) MARKET: Improving market position
(**) COST REDU: Reducing production costs
(***) INPUT: Improving position on the input side: labour, technology, material/components

Table 4: Expected Benefits of IT adoption

b) The main **obstacles** to the adoption of ICT within the firm can be grouped accordingly to 4 main macro-categories:

- **INVCOST:** Obstacles related to problems with financing ICT investments. Technology is too expensive, investment volume to large, lack of finance.

- **KNOWHOW**: Obstacles related to the lack of competences necessary to accept and benefit from ICT technologies. For example: lack of ICT personnel, information and management problems.
- **TECH**: Obstacles related to technological problems, such as: Technological uncertainties, performance of ICT not sufficient, etc.
- **COMPAT**: Obstacles related to compatibility issues with existing systems and additional costs for adoption of new solutions; examples are: Insufficient compatibility with existing ICT and work organization.

Perceived Obstacles to IT adoption	INVCOST*	KNOWHOW**	TECH***	COMPAT****
Investment volume too large	X			
Technology too expensive	X			
Current costs too high	X			
Lack of finance	X			
Resistance to new technology within the firm		X		
ICT-related information problems		X		
Lack of qualified personnel		X		
Insufficient attention of the management		X		
Technology not yet developed far enough			X	
Insufficient performance of ICT			X	
Insufficient compatibility with existing ICT systems				X
Required adjustments of work organisation too large				X

(*) INVCOST: High investment costs
(**) KNOWHOW: Qualification and know-how problems
(***) TECH: Technological problems
(****) COMPAT: Compatibility problems

Table 5: Obstacles to IT Adoption

This methodology will be used to perform an analysis of the ICT intensity within each one of the Manufacturing Business Settings that will be created and evaluated in WP2, with the objective of assessing how companies are mature to implement IT solutions based on architectures and services.

5 Value-chain based characterization system in Road4FAME

The firm classifications presented in Sections 3.2, 3.3 and 3.4 are widely and intensively used by consultancies, governments, public organizations when a clear way to position firms into different compartments is necessary. However, for the purpose of the Road4FAME project, these classifications tend to be too rigid and insufficient to put the needs and requirements of manufacturing companies into a useful perspective. This section introduces the system for the characterization of manufacturing companies elaborated in Road4FAME.

The approach we adopt is to concentrate on the identification of those factors or characteristics that differentiate or associate manufacturing firms, in terms of needs and requirements that can be supported or mitigated by the adoption of ICT solutions.

Among the characteristics selected in Road4FAME some describe overall business factors, such as the dimension and the image of the company, the overall degree of outsourcing of activities and the location of production sites. Beyond this, the characterization system devised in Road4FAME is largely value-chain based, inspired by some well-known examples presented in the previous systems. Thus, many characteristics relate to questions of how companies conceive and generate value from their products and services.

The classification factors have been identified by answering questions such as:

- Which are the most critical phases of the value chain?
- How companies implement these phases?

As we have seen above, the IDC classification follows a similar approach, where the most relevant key factors driving the whole value chain have been identified and companies classified accordingly. However, a more thoroughly identification of distinguishing factors, with focus on those that might be affected by the IT adoption, was necessary.

The picture below graphically represents those factors that have been identified in a preliminary analysis in Road4FAME. The resulting system of characteristics is not expected to be exhaustive as several additional characteristics will be probably identified as useful along the project evolution; moreover, not all these characteristics are expected to be equally relevant when comparing companies. Also, while certain factors will significantly drive the needs to manufacturing IT (specifically services / architectures) others will be less influential.

Figure 4: Value chain based characterization system for manufacturing firms devised in Road4FAME

Of particular relevance are, for example:

- **Market**: the influence of the market on the firm's value chain can be analysed taking into account, for example:
  - **Market geographical dimension**: Firm can address a local or a global market.
  - **Market acceptance criteria**: Demand from customers can be driven by the Price of the product/service, by its quality and functional characteristics, by the possibility to personalize it, by the brand they are buying, etc.
  - **Market Dimension:** Firm's offer can be conceived for the large market, or for very specific target groups of consumers.
  - **Demand Variation:** Demand from the market can be stable along the year, or vary from one season to the others; products can have a long or short lifecycle, and consequently their demand can be stable or subject to peaks**.**
- **Supply Chain**:
  - **Dimension**: the geographical distribution of the production. It could be: local, global supply or multi-local.[5]
  - **Stability**: Describes the stability of the composition (in terms of suppliers) of the supply chain along time. It is relevant to distinguish among volatile and stable supply chain.
  - **Cooperation degree**: Cooperation among actors in the supply chain can vary from the pure competition to a full cooperation.
- **Product and Service Design**
  - **Product customisation:** It is important to distinguish among fully customized products, mass customized products and mass product**.**
  - **Offer: Servitisation degree:** A firm's offer can be product-cantered or consisting of added value services completing the product.
  - **Product complexity:** Complexity can derive from the high number of components, wide variety of materials used in the production, in the complex geometry of the product, etc.
  - **Product "intelligence":** Products can interact with the external world, collect, receive and offer data thanks to the presence of sensors, actuators or embedded software.
- **Production**
  - **Volumes**: Distinguishing among production of Big Volumes, typically for mass product, or production of small lots or even single items, usually for fully customized products.

[5] multilocal design, supply and support. Companies are shifting from a centralized model, where these functions support global markets, to a regionalized approach, where capabilities are placed locally, but architected globally.

- **Production scheduling**: Production can be done on demand, or based on forecasting algorithms.
- **Automation**: The production process can be performed mostly by robots and machines, by robots and humans controlling machines or manually by humans.
- **Production Process complexity:** Complexity of production is associated with the number of relevant steps to be executed, by the interdependencies among these steps, by the technologies to be used; another important aspect is the level of re-configurability of the production process.
- **Blue collar Workers**: Production can require workers with high and specific skills or be rather independent from worker's skill.
- **Sustainability**: Production sustainability can affect both the production process (with optimization of the energy, water and raw material consumption, re-usage of materials consumed in production) and the design of the product (based on sub-components that can be reused after the end of the product lifecycle and on the usage of eco-compatible materials).

- **Selling:** In case of production for final consumers (B2C), it is important to distinguish among firms selling in the traditional way, within shops, and those that are offering on-line purchasing experience to the customers.
- **Post-sale:**
  - **Customer:** The offer of post-sale services to the customers can be in terms of (technical) support on the usage and maintenance of the product and of collection of feedbacks to better profile customers and improve product offer.
  - **Reuse of materials and Products:** Solutions for reverse logistics covering also the post-sale phase allow to recapture value from the used products and materials and to reduce environmental impact of product disposal.

Remark: In the context of the Road4FAME project, only companies in the domain of **discrete manufacturing** will be considered, in line with the scope of the Factories of the Future PPP; however, for the sake of completeness the system devised in Road4FAME to characterize manufacturing businesses is suitable to describe both discrete and process manufacturing scenarios.

5.1.1 How to position industries

A first validation exercise of the above characterisation has been done by applying it to several different manufacturing industries, with the two-fold objective of checking the completeness of the tree structure of characteristics in Figure 4, i.e. checking if relevant aspects of the value chain are not described in the classification, and to provide an example of how the classification could be used.

The companies that have been characterised in this exercise belong to the following sectors:

- Aerospace
- Automotive (car producer and components supplier)
- Apparel
- Medical technologies
- Semiconductors
- Electronics
- Heavy Engineering
- Industrial automation

For each one of them, a characterisation has been done by:

- Short description: e.g. strong brand company in the fashion market.
- Selection of the most relevant criteria from the above map.
- Values (with short explanation when necessary) for the selected criteria

The exercise confirmed that all analyzed companies can be sufficiently well described with regard to the characteristics included in the tree even if, depending on the case, some of them are of little relevance or even not applicable.

Furthermore, as already anticipated, the set of factors depicted above will likely not exhaustively cover all specific aspects that may be relevant for a full characterization of a company. Rather, it is expected to support the identification of macro-differences among companies. The proposed tree structure is flexible and expandable thus, depending on the specific case and on the specific objectives of the characterization; new factors and values can be added whenever it will be necessary to further detail specific aspects.

Two of the performed characterisations are reported in the following. The full list is available in Appendix 1.

Case 1: Aerospace

Short description of the considered company
Manufacturing company producing and selling helicopters and training services all over the world

General Criteria	*Value/description*
Product Necessity	*Consumer Discretionary*
Company Dimension	*Large Enterprise*
Degree of outsourcing	*Medium: product design and development are insourced; production of components is outsourced; quality check, assembling and testing are insourced)*
Company Image	*Strong Brand*

"Value Chain" selected criteria	*Values or description*
Market geographical dimension	*Global Market*
Demand variation/ In time	*Continuous demand*
Demand variation/ In product	*Long product lifecycle*
Market Analysis	*Trends/needs detection; brand perception*
Target Consumer	*End users and businesses (service stations)*
Market acceptance criteria	*Quality, functionality*
Product and Service Design	*Mass Customisation*
Servitation degree	*Product-centred but with services*
Product complexity	*High*
Product "intelligence"	*High*
Product and Service Acquisition/Supply Chain Stability	*Stable*
Supply Chain Geographical Coverage	*Multi-Local Supply Network*
Supply Chain Cooperation Degree	*Ad hoc cooperation*
Product and Service Research	*Both high-level research (for example for new green engines or for new vehicle concepts) and product-specific research are conducted*
Post Sale/Customer Support	*Maintenance Support, Customer training*
Post Sale/Reuse of materials	*not relevant*

Case 3: Automotive supplier

Short description of the considered company
Automotive supplier producing control devices for cars

General Criteria	*Value/description*
Product Necessity	*Consumer Discretionary (but does not sell directly to consumers)*
Company Dimension	*Large Enterprise*
Degree of outsourcing	*Low (product design and development are insourced; production of components is outsourced; production of core components and final assembly is insourced; quality check and packaging is insourced)*
Company Image	*Strong Brand (but does not play a large role)*

"Value Chain" selected criteria	*Values or description*
Market geographical dimension	*Global Market*
Market variation	*Product Lifecycles (3-5 years, many updates and adaptions of products)*
Market Analysis	Demand oriented
Market Dimension	Mass market
Target Consumer	Other Industry (car manufacturer)
Market acceptance criteria	Price, Lead Time, Functionality
Product and Service Design	Mass Production
Servitation degree	Product-centred
Product complexity	Medium (compared to the whole car), development closely coupled to specific customer requirements
Product "intelligence"	High (control device whose main features are based on ICT)
Product and Service Acquisition/Supply Chain Stability	Stable (per product, suppliers can join the network only after certain audits)
Supply Chain Geographical Coverage	Global Supply Network
Supply Chain Cooperation Degree	Mainly Competitive
Product and Service Research	Tightly coupled (Research is typically on new control features and hardware to be controlled)
Production Characteristics	High volume production; Forecasting based; high level of automation; Medium production process complexity; Blue collar workers partially highly skilled
Sustainability/Production Process Optimisation	Reduction of resource usage as long as it leads to cost savings.
Logistics	Availability of materials by means of managed inventories and buffer strategies.
Selling/order acquisition	B2B
Post-sale	No reuse, customer support in case of problems

5.1.2 Potential Manufacturing Business Settings

As anticipated in Section 2 at the beginning of the requirements elicitation phase, a set of four manufacturing business settings, each describing a set of characteristics of companies sharing the same or similar needs and ICT requirements will be used for a tentative earmarking of experts and companies.

The needs and requirements elicitation and description will be done in the same way for all the industries, ignoring in the first instance, any mapping into manufacturing business settings; before the requirements analysis phase, the meaningfulness of the selected business settings will be verified and, if necessary, adapted to better represent the natural clustering of companies around sets of common expectations and needs. In the following, 4 business settings are described by valorising set of factors that characterize a relevant group of companies, selected from the tree described above.

During the roadmapping activity of the project, it will be important to be able to anticipate and model how most of the factors selected for a business setting will be subject to a rapid and important evolution and will be the key elements in the characterization of the manufacturing companies of the future.

By trying to anticipate a vision of manufacturing industry evolution in the next future, it is possible to imagine how the factor-based characterization of an ideal company can change.

Below it is reported an example of characterisation of a company as it is now ("AS-IS") and as it is expected to be ("TO-BE") in the future.

The example is focused on a large company selling heavy, highly engineered items (such as water pumps), produced with a global supply chain. The firm presently is producing both standard products for a mass market as well as single customized items with specific characteristics. In the future, production will be shifted to customised-only pumps, and production will be done trying to reach the optimal mix between the need of bringing production back to the mother country of the company (thus keeping production and quality control more close to the research and design) and to produce close to the customer (thus improving lead time and reducing delivery costs). Furthermore, future products will be offered to the customers with a set of services that will allow to support maintenance and to monitor working conditions of the pump.

Orange cells report values that will likely change in the future (new values highlighted in green)

The business settings presented below are used to represent typologies of companies with the same characteristics; one of the main objectives of the roadmapping activity is to propose a vision of manufacturing, thus it will describe how the characteristics of a business setting will change in the next future.

Criteria	**Classification of AS IS**	**Classification of TO BE**
Description	Large Company providing standard and customised complex product (e.g.: big water pump)	Large Company providing complex fully customised product (e.g.: big water pump)
Company dimension	Large Company	Large Company
Company location	Industrial Zone	City area

Degree of outsourcing	Product design, final assembly and test/quality check are in house; components are partially outsourced and partially produced in house	Product design, final assembly and test/quality check are in house; components are partially outsourced and partially produced in house
Product Necessity	N.A.	N.A.
Market Analysis	Demand distribution analysis as a factor influencing global production planning No co-design	Demand distribution analysis as a factor influencing global production planning Co-design with customer
Market Variety	Continuous demand Long product lifecycles of core components, individualised overall products	Continuous demand; Lifecycle reduced: need to manage product and service Life Cycles Long product lifecycles of core components, individualised overall products
Geographical dimension	Global/International	Global/International
Market dimension	specialised market	specialised market
Target customers	Other Industries	Other Industries
Acceptance criteria	Functionality, quality	Functionality, quality, personalisation
R&D intensity	Resarch focused on materials and functionalities of the product	Resarch focused on new added-value services
R&D coupling with product and production development	close	R&D coupled with servitation and product-service co-evolution
Product Customisation	Mix of standard and fully customised products	Mix of standard and fully customised products
Servitisation Degree	Product-centred	Service-centred
Product complexity	high	high
Product "intelligence"	Low	High
Supply Chain stability	Stable	Stable
SC geographical coverage	global	global
SC cooperation degree	Ad-hoc cooperation	Full cooperation; symbiotic cooperation with other industry for improved sustainability of production
Production Volumes	Large series & lot size 1	Lot size 1
Production Scheduling	on demand	on demand
Production Automation	High	High
Production Process complexity	high	high
Workers	highly skilled	highly skilled

Sustainability	not considered	Production process optimisation for reduction of energy consumption and footprint
Selling	B2B	B2B
Post-sale	No reuse of materials	Reverse Logistic

Further to the development of the classification and its preliminary usage and validation on examples, we have exploited it to sketch what we imagine will be future Business Settings of interest for the Roadmapping activity.

In the selection of criteria to characterize the business settings, the attention has been put only on the ones that, combined together, represent the innovation of such business.

Business Setting 1: "The Demand-driven Enterprise"

Description of the Type of Company: This is an SME specialized in production of special equipment, e.g. highly technological and highly customised components for factories.

Main Foreseen Challenges: The company's strategic plan is to be able to anticipate changes in demand from the customers, keeping the pace of technological progress in the sector and to improve the product offer with regard to lead times (production, delivery, and commissioning at customers' sites), and new services that make the manufactured equipment "intelligent" and thus able to provide information to humans and cooperate with other factory's element more easy and efficiently.

This will require a strong investment in research and product development performed by the SME, while only the production of some subcomponents will be outsourced.

Example for possible IT support: Event-based architectures could support this enterprise in collecting information provided by the intelligent objects from the manufacturing phase to the sale and usage by the consumer. A cloud-based infrastructure allows performing analysis of the collected data to detect customer trends.

Characteristic	Description of characteristic
Description	SME providing special equipment for factories
Company dimension	SME
Company location	High-wage country, close to market
Company Image	Strong
In-/outsourcing strategy	High internal added value, outsourcing of non-complex and standard components production and supporting processes
Product Necessity	discretionary

Market Analysis	Trend/needs detection
Market Variety	Demand depending on economic trends; Long product lifecycles of core components, individualised overall products
Geographical dimension	mainly local / national
Market dimension	specialised market
Target customers	Industry (manufacturing companies)
Acceptance criteria	Functionality, lead time, quality, price
R&D intensity	Medium
R&D coupling with product and production development	Close
Product Customisation	fully customised products
Servitisation Degree	service-centred
Product complexity	High
Product "intelligence"	High
Supply Chain stability	unstable (regarding partners and time)
SC geographical coverage	Global
SC cooperation degree	Ad-hoc cooperation
Production Volumes	Small series / lot size 1
Production Scheduling	on demand
Production Automation	low (goal is increase it?)
Production Process complexity	High
Workers	highly skilled
Sustainability	not considered
Logistics	On-demand ordering & managed inventories
Selling	B2B, easy order acquisition on-line
Post-sale	Customer support / service provision

Business Setting 2: “The Collaborative Enterprise”

Description of the Type of Company: A company which is supplier of a great number of different industries, over a medium-longer term or just ad-hoc. It produces specialised components, supplying different firms and it frequently faces requests of high volume of pieces to be provided in short term.

For example, it could be an SME that produces certain sensors to be integrated into consumer electronics. It has to provide its products over a medium or longer term or just ad-hoc and frequently faces request of high volume of pieces to be delivered in short term. The geometries of the product have to be slightly adapted for each new customer’s end-product, to which the sensors have to be integrated.

To customers and suppliers, the company establishes strategic partnerships for close cooperation in order to exchange information about new orders, product types to be delivered etc. as fast as possible.

Main Foreseen Challenges: The company needs to be able to quickly reconfigure its production, to establish strategic partnerships and close information exchange, i.e. integrate with other businesses and enter into business agreements, and cooperate with the new partners in order to fulfil new orders appropriately.

The level of automation is high in the plant, and the customisation of production requires re-programming of machines and frequent updates of information to the workers who need to be skilled and also frequently re-trained.

Example for possible IT support: IT-enabled solutions allow reconfiguring production plants to meet changing demands: being connected with other actors in the supply chain, it can exchange information and receive continuously updated data about incoming orders and the overall status of production. Workers can be continuously updated about new production procedures, quality checks of specific products or about how to re-programme machines and robots.

Characteristic	Description of characteristic
Description	SME providing sensor components with various variations to the consumer electronics industry
Company size	SME or Large
Supply chain stability	Unstable
Market dimension	specialised market
Target customers	Other Industry
Supply chain geographical coverage	multi-local
Supply chain cooperation degree	full cooperation + ad-hoc
Product customization	Mass Production for each customer-adapted product
Production volumes	Very high
Production scheduling	On demand, aligned with production scheduling of customers
Blue Collar Workers	Highly skilled, need to be frequently re-trained
Stocking	on demand
Automation	High
Post-sale	no re-use
Product life cycle duration	Short

Business Setting 3: “The Virtual Enterprise”

Description of the Type of Company The virtual enterprise is an association of SMEs that cooperates to jointly identify and exploit new market opportunities (new requests from the market, but also complex tenders, etc.), to innovate products and to minimize costs for approaching new markets with new products. The SME association is focusing on delivering customised products to a niche market. For the fulfilment of each order, a subset of members with the needed capabilities and capacities is selected.

Main Foreseen Challenges: The main challenge is to join forces effectively, i.e. to really form one business out of many, as well as the management of ad-hoc orders for customised products.

Thus make research together, to innovate together, to learn together, to create a common brand and be able to offer competences on a varying, difficult market with a common effort. Design of products will focus on sustainability, to create a "Green Brand"

Example for possible IT support: IT architectures will provide the backbone for the Virtual Enterprise, whose elements can exchange data and knowledge: For example, IT services will support cooperative design of products, will provide assessment of sustainability of products; new market opportunities can be captured by analysing data over the web and reputation management solutions will allow to create and maintain a strong brand.

Characteristic	Description of characteristic
Description	Association of SMEs which are jointly providing customised products to better exploit their market potential (implement the virtual enterprise concept)
Company dimension	Trend/needs detection
Company location	High-wage country, close to market
Company Image	not well-known to potential customers
In-/outsourcing strategy	Mostly insourced within the virtual enterprise association
Product Necessity	Discretionary
Market Analysis	Trend/needs detection
Market Variety	Continuous demand, long product life cycles (frequent introduction of new products is intended)
Geographical dimension	mainly local / national
Market dimension	specialised market
Target customers	Consumers
Acceptance criteria	Functionality, lead time, quality, price
R&D intensity	High
R&D coupling with product and production development	Close
Product Customisation	variant based products
Servitisation Degree	service-centred
Product complexity	Medium
Product "intelligence"	Medium
Supply Chain stability	Stable
SC geographical coverage	mainly local / national
SC cooperation degree	Full / strategic cooperation of core partners; ad-hoc cooperation (competitive) for further suppliers
Production Volumes	Small series / lot size 1
Production Scheduling	on demand
Production Automation	High
Production Process complexity	High
Workers	highly skilled
Sustainability	Energy and Raw material consumption reduced to save costs Sustainability of the product to improve image
Logistics	On-demand ordering & managed inventories
Selling	B2C via retailers / product specialists
Post-sale	Customer support / service provision

Business Setting 4: "The Green Enterprise"

Description of the Type of Company: This is a large company, providing large volumes of sustainable and recyclable products (e.g. fashion articles) to the market, willing to shift to a fully-customised production with acceptable costs and lead time.

Main Foreseen Challenges: In the next future, the company plans to engage consumers in the co-design of products. Furthermore, to reduce costs, lead time and footprint, production will be as close as possible to the market. For the company, the design of recyclable products is strategic, both to reduce the overall costs and to make the brand recognized on the market as a green one.

Example for possible IT support: A SoA-based architecture will make available to the firm, but also to consumers, a shared environment where they can exchange ideas, product information and feedback, and co-design new products. LCA services can compare the full range of environmental effects assignable to products and services during all the phases of their life, from components assembly, to packaging, delivery, selling etc.

Characteristic	Description of characteristic
Description	Large company providing "green products"
Company size	Large
Outsourcing Degree	Full (most of production is outsourced)
Supply chain stability	Unstable, however new partners have to be certified etc.
Market dimension	mass market
Target customers	Final consumers
Acceptance criteria	Price, lead time
R&D intensity	Low
R&D coupling with product and production development	Medium
Product Customisation	Full customisation
Servitisation Degree	Low (product-cantered)
Supply chain geographical coverage	Multi-local
Supply chain cooperation degree	competition
Production volumes	Small lots/single item
Stocking	forecasting-based raw material stocking
Automation	High
Sustainability	Product design optimization for usage of eco materials and re-usage of components
Post-sale	reverse logistics
Product life cycle duration	Long lifecycle

6 Final manufacturing scenarios

Based on the *initial manufacturing business settings* presented in section 5.1.2, an evolution has taken place towards final manufacturing business settings, referred to as *manufacturing scenarios*. This section outlines the iterations toward these final manufacturing scenarios. Below, the final manufacturing scenario descriptions are presented.

The final four manufacturing scenarios have been refined in a way so they are a) more clearly described, and b) do not overlap. Furthermore, they have been refined to be more c) challenging and d) more visionary i.e. of a certain visionary nature in the sense that, in most industries, they cannot be observed today.

This further development of the initial scenarios involved:

- Discussions with the Road4FAME consortium: Scenario descriptions were iteratively refined following discussions within the consortium.
- Discussion with the Road4FAME Core Group: In a conference call of 90 minutes duration on February 26, 2014, members of the Road4FAME Core Group were asked i) how challenging they would rate each scenario and ii) how visionary they would rate each scenario. Furthermore, they were asked if they thought iii) a scenario was missing important aspects and also iv) if they thought a scenario was entirely missing and if a fifth scenario should be added. Lastly, they were asked to make suggestions to v) refine the scenario descriptions further, especially to make them *more visionary* and *more challenging*.

  The general opinion was that the scenarios were well selected and sufficiently challenging. No need for additional scenarios was identified. Valuable feedback was received to refine the scenario descriptions. It was considered advantageous that the scenarios have a visionary touch but are still reasonable enough so industry would identify with them.
- Discussion of scenarios with Road4FAME Experts Group: At the first Road4FAME Experts Workshop in Brussels on March 6, 2014, the workshop participants were involved in a 1.5h session to further refine the scenarios. They were confronted with the same questions which had been posed to the Road4FAME Core Group in February.

  Again, the general opinion was that the scenarios were well selected and sufficiently challenging. No need for additional scenarios was identified. Again, good feedback was received to refine the scenario descriptions.

The final scenario descriptions can be found below. They were first applied to identify the needs of manufacturing companies in about 40 interviews with industry (see D2.2) and subsequently in the first roadmapping workshop on May 23, 2014, in Porto. In the interviews with industry and the roadmapping workshop, they proved to be a useful tool to elicit needs. In the interviews with industry and the roadmapping workshop, it was observed that they are indeed sufficiently independent in the sense that each scenario is tied to very specific needs. Nevertheless, overarching needs were identified which are relevant across scenarios. These experiences with the manufacturing scenarios show that they are suitably defined and that they are indeed a useful tool to identify a wide variety needs.

Scenario: The Virtual Enterprise

The virtual enterprise is an association of companies that cooperate ad-hoc to react to market opportunities, to do research together, innovate products and to minimize costs and risks for approaching new markets with new products. The involved companies have to join forces effectively to really form one business out of many.

For the fulfilment of each order, a subset of members with the needed capabilities and capacities is selected to execute the order. As capabilities might replicate capacity in multiple partners, they will need to bid internally for selection. The virtual enterprise would be established ad-hoc around a short term request and dissolve after the satisfaction of the request.

A virtual enterprise consisting e.g. of SMEs would enable them to complement each other's strengths or to attain the capacities of large enterprises. A virtual enterprise consisting of both large and small companies enables to combine strengths, i.e. the large companies bring in their capacity, and the small companies bring in their flexibility and innovation power. Also, the virtual enterprise enables a much broader product and service portfolio than any individual company could provider alone.

Scenario: The Green Enterprise

This scenario describes a company to which environmental awareness is an important part of the company image. But the company's goal is to go beyond a mere "green washing" of its image and products to really introducing environmental sustainability as a key parameter in all steps of the product life-cycle, including sourcing and recycling. Based on the consideration of data from a large number of sources, real-time information about the footprint of manufacturing processes is available to steer production towards minimal environmental impact.

Keeping record of the origin and history of raw materials as additional aspect of environmental awareness is used as a marketing advantage. Buyback of products for recycling or product rental and return to recycle policies are strategic, increasing sustainability on sourcing and creating stronger bonds with customer.

The environmental footprint of ordered, customized products is available to customers in the customization step, so the footprint generated along the value-chain is transparent to the customer and environmentally aware buying decisions can be made. To the manufacturer and the customer, the environmental footprint is available and can be taken into account as an actual decision parameter. The environmental implications of design decisions, process decisions, and buying decisions become completely transparent.

With a certain customer segment increasingly demanding such transparency, the competitiveness of the company increasingly depends on the degree of transparency it is able to provide, and the level of environmental sustainability it can demonstrate. Thus, its capability to be "green" translates into tangible economic value.

Remark:

- Many challenges and needs relevant for this scenario are increasingly relevant for companies even outside the green manufacturing scenario.

Scenario: The Manufacturing-as-a-Service Enterprise

The MaaS enterprise does not sell products, but offers manufacturing as a service. The manufactured goods are complex and fully customized. It frequently faces short-notice requests of high volume. The considered MaaS needs to be able to quickly reconfigure and scale up its production, to establish close information exchange with customers, i.e. integrate with other businesses and enter into business agreements, and cooperate with the new partners in order to fulfil new orders appropriately.

The range of offered services goes beyond pure manufacturing process, extending over all the value chain e.g.: product design, after sales support, product maintenance.

The company offers its services globally and is strongly dependant on an efficient mechanism for service provision. The company's strategic plan is to be able to anticipate changes in demand from the customers, keeping the pace of technological progress in the sector and to improve the companies' ability to take orders ad-hoc. Predicting trends on demand will require using data mining on a variety of data coming from many sources e.g. social networks.

Remarks:

- In certain industries, like the highly automated semiconductor industry, MaaS is a well-established business model already whereas other industries perceive this still as rather challenging.
- As manufacturing is becoming more technology-intensive and thus manufacturing equipment becomes more expensive, the MaaS concept is likely to gain relevance in the future. Instead of investing in costly manufacturing equipment, the manufacturing capacity would be bought as a service.
- A MaaS can also be a part of a virtual enterprise, in the role of a provider of manufacturing capacity or even taking over a coordinating role for the virtual enterprise.

Scenario: The High-Volume Production Enterprise

This scenario describes a company which produces very-high volumes of goods and increasingly faces the challenge of shorter product life-cycles. To remain competitive, it also needs to be capable of offering an increasing degree of customization, despite the high volumes produced (mass customization). The supply network the company is embedded in comprises some long-term cooperation but also ad-hoc cooperation.

The level of automation is high in the plant, and the customisation of production requires short reconfiguration cycles, including tests / experimental production, fast re-programming of machines and frequent updates of information to the workers who need to be skilled and also frequently re-trained, as well as short ramp-up and scale-up cycles. To do so, context-awareness of production facilities is helpful in order to adapt production to current product specifications, react to and schedule order execution appropriately, also according to specific customer relations.

The fact that a company has to react to an increasingly dynamic market entails also that the individual worker has to keep this pace, by acquiring relevant knowledge fast enough. With the half-life of relevant knowledge decreasing, the rate of human knowledge acquisition threatens to become the limiting factor for companies to keep pace with technological progress. Appropriate IT support has to be provided to the human who is embedded in the digital factory, in the form of context-relevant information and on-the-fly knowledge provision supported by, e.g., knowledge based decision support systems or self-learning systems supported by cooperation between humans, machine and data.

7 Conclusions and Next Steps

Remark: This document was updated as of 2014-06-19 (version 1.2) to include the final version of the four manufacturing scenarios used in Road4FAME. These are presented in section 6. All other sections remain unchanged by this update and equate to the version originally submitted to the EC on 2013-11-29 (version 1.11)

Among the objectives of WP2 of the Road4FAME project is to establish a sound overview of the *needs* of manufacturing businesses, to then see into what requirements these translate with regards to future architectures and services. In the introductory section of this document, we have described that these needs can be expected to depend strongly on the considered scenario: The business environment the particular manufacturing company is embedded in (e.g. served market, competition) but also, for instance, the degree of automation, the scale of production, etc. The entirety of these ***characteristics*** we have been referring to as ***Manufacturing Business Setting***. The respective Manufacturing Business Setting, then, will likely influence the needs for IT services, and determine the most promising IT architectures.

In this document, we have described our search for suitable existing typologies or classification systems that would allow us to usefully distinguish and describe manufacturing businesses for our purposes. Several classification systems that are used for statistical and certification purposes, economic analysis and trends detections, have been analysed. As expected, neither the code-based classifications, nor the other examined ones resulted to serve the expectations of WP2. Indeed, the classifications created for statistical purposes aim to be exhaustive and to provide an automatic way to map every company into a single category, mostly depending on the final product thus from an "external" observation of the company; this approach does not allow to capture those differences among companies that emerges by analysing how they do business and how they create value associated to their offer. Other considered classifications resulted to be of limited utility for the WP2 purposes, as they focus on specific factors, such as technology intensity, relation between R&D and production, etc.

Value-chain-based systems have been found to be widely used for purposes similar to Road4FAME and are considered useful for the purposes of Road4FAME. Accordingly, a value-chain based characterization system for manufacturing companies has been devised for the use in Road4FAME. It is expected that the needs and requirements that will be collected in task T2.2 will vary considerably depending on certain characteristics included in the devised characterization system. Therefore, the characterization system in T2.1 is expected to be useful to put these needs and requirements into perspective.

Based on these characteristics, an initial set of four manufacturing business settings has been suggested in this document, each representing a group of similarly characterized manufacturing companies, likely facing similar challenges, and likely having similar needs and requirements regarding manufacturing IT.

Both results from T2.1, the system of characteristics and the set of manufacturing business settings, provides a basis for other tasks in WP2 and the roadmap development in WP3. And both the system

of characteristics and the set of manufacturing business settings will likely have to be adjusted and sharpened over the course of the project.

The intention of considering Manufacturing Business Settings is to suitably distinguish manufacturing businesses with respect to their differing needs. Since these needs will be iteratively identified in the course of the project, and a complete picture will only be available post the roadmapping process, it is reasonable to evolve and adjust the Manufacturing Business Settings as we learn more about the needs. Only doing so will yield Manufacturing Business Settings that offer indeed a useful distinction of manufacturing businesses based on their needs. This implies that the set of Manufacturing Business Settings will evolve, and only be final once a complete picture of needs is available. We refer to this way of scoping the Manufacturing Business Settings as the **ex-post approach**.

This approach has slight implications on upcoming tasks in WP2 and WP3, rendering them more flexible and goal-oriented:

- In **Task 2.2**, interviews are foreseen involving around 40 experts. While it has initially been planned to conduct 10 interviews with representatives from each of the four manufacturing business settings, it has been decided to not strictly separate them ex-ante. While the system of characteristics will be used to describe the companies to which the contacted experts belong, experts will be "open-mindedly" interviewed for their needs and challenges. Only later, *ex-post*, will we analyze if reported needs cluster according to the proposed manufacturing business settings. An *ex-post* revision of the manufacturing business settings may become necessary to ensure that these settings really represent groups of companies sharing same needs and requirements for IT architecture and services.
- In **Task 2.3**, a workshop to analyze common needs across the Manufacturing Business Settings is foreseen. It will be primarily a validation exercise for needs identified in T2.2 (and other findings from WP1).
- In **Task 3.2**, it was foreseen to develop four initial roadmaps reflecting the established push perspective (WP1 findings) and pull perspective (WP2 findings). Since the WP2 findings will be to some degree specific to the Manufacturing Business Setting, is was foreseen to develop four roadmaps with each of them including the WP2 findings specific to the respective Manufacturing Business Setting. These four roadmaps were intended to be consolidated into a single final roadmap further on in the roadmapping process. Instead, it has been decided to maintain a single comprehensive roadmap from the very beginning, to certain filters – or "views" – can be applied, one view for each Manufacturing Business Setting. Having profiled, or "earmarked" any participating expert prior the workshops according to the characterization system, it will be possible to trace his/her articulated needs. This information then provides the possibility to filter the roadmap content ex-post. Again, an *ex-post* revision of the manufacturing business settings may become necessary to ensure that these settings really represent groups of companies sharing same needs and requirements for IT architecture and services.

Appendix 1 – Classifications of manufacturing businesses

Case 1: Aerospace

Short description of a typical company
Manufacturing company producing and selling helicopters and training services all over the world

General Criteria	***Value/description***
Product Necessity	*Consumer Discretionary*
Company Dimension	*Large Enterprise*
Degree of outsourcing	*Medium: product design and development are insourced; production of components is outsourced; quality check, assembling and testing are insourced)*
Company Image	*Strong Brand*

"Value Chain" selected criteria	***Values or description***
Market geographical dimension	*Global Market*
Demand variation/ In time	*Continuous demand*
Demand variation/ In product	*Long product lifecycle*
Market Analysis	*Trends/needs detection; brand perception*
Target Consumer	*End users and businesses (service stations)*
Market acceptance criteria	*Quality, functionality*
Product and Service Design	*Mass Customisation*
Servitation degree	*Product-centred*
Product complexity	*High*
Product "intelligence"	*High*
Product and Service Acquisition/Supply Chain Stability	*Stable*
Supply Chain Geographical Coverage	*Multi-Local Supply Network*
Supply Chain Cooperation Degree	*Ad hoc cooperation*
Product and Service Research	*Both high-level research (for example for new green engines or for new vehicle concepts) and product-specific research are conducted*
Sustainability/Production Process Optimisation	*Reduction of energy, water or raw material consumption*
Post Sale/Customer Support	*Maintenance Support, Customer training*
Post Sale/Reuse of materials	*not relevant*

Case 2: Automotive

Short description of a typical company
Car manufacturer producing high-value and high-volume series of cars

General Criteria	*Value/description*
Product Necessity	*Consumer Discretionary*
Company Dimension	*Large Enterprise*
Degree of outsourcing	*High (product design and development are insourced; production of the very most components is outsourced; core components and final assembly is insourced, added value of 20% within the company)*
Company Image	*Strong Brand*

"Value Chain" selected criteria	*Values or description*
Market geographical dimension	*Global Market*
Market variation	*Light seasonal trends, product lifecycles of 3-5 years*
Market Analysis	*Trend and demand driven*
Market Dimension	*Mass Market*
Target Consumer	*End user*
Market acceptance criteria	*Functionality, Quality, Brand, Personalisation*
Product and Service Design	*Mass Customisation*
Servitation degree	*Product-centred, trend to involve more and more service aspects*
Product complexity	*High (number of components & materials used, geometries, etc.)*
Product "intelligence"	*High (various control devices, user interfaces, etc.)*
Product and Service Acquisition/Supply Chain Stability	*Stable (per product, suppliers can join the network only after certain audits)*
Supply Chain Geographical Coverage	*Global Supply Network*
Supply Chain Cooperation Degree	*Strategic cooperations (e.g. for engines) but also Competitive (for standard components)*
Product and Service Research	*High intensity, on various topics (future product features, materials to be used, service integration etc.)*
Production Characteristics	*High volumes but customised products; on-demand manufacturing; all processes at least semi-automated; High number of process steps; blue-collar workers partially high-skilled*
Sustainability/Production Process Optimisation	*Reduction of resource usage as long as it leads to cost savings. For products, sustainability is more focussed*
Logistics	*Just in time arrival of materials; delivery network optimised based on costs*
Selling/order acquisition	*Point of Sale (own and retailers)*
Post-sale	*Customer support (warranties, maintenance, repair, etc.)*

Case 3: Automotive supplier

Short description of a typical company
Automotive supplier producing control devices for cars

General Criteria	*Value/description*
Product Necessity	*Consumer Discretionary (but does not sell directly to consumers)*
Company Dimension	*Large Enterprise*
Degree of outsourcing	*Low (product design and development are insourced; production of components is outsourced; production of core components and final assembly is insourced; quality check and packaging is insourced)*
Company Image	*Strong Brand (but does not play a large role)*

"Value Chain" selected criteria	*Values or description*
Market geographical dimension	*Global Market*
Market variation	*Product Lifecycles (3-5 years, many updates and adaptions of products)*
Market Analysis	*Demand oriented*
Market Dimension	*Mass market*
Target Consumer	*Other Industry (car manufacturer)*
Market acceptance criteria	*Price, Lead Time, Functionality*
Product and Service Design	*Mass Production*
Servitation degree	*Product-centred*
Product complexity	*Medium (compared to the whole car), development closely coupled to specific customer requirements*
Product "intelligence"	*High (control device whose main features are based on ICT)*
Product and Service Acquisition/Supply Chain Stability	*Stable (per product, suppliers can join the network only after certain audits)*
Supply Chain Geographical Coverage	*Global Supply Network*
Supply Chain Cooperation Degree	*Mainly Competitive*
Product and Service Research	*Tightly coupled (Research is typically on new control features and hardware to be controlled)*
Production Characteristics	*High volume production; Forecasting based; high level of automation; Medium production process complexity; Blue collar workers partially highly skilled*
Sustainability/Production Process Optimisation	*Reduction of resource usage as long as it leads to cost savings.*
Logistics	*Availability of materials by means of managed inventories and buffer strategies.*
Selling/order acquisition	*B2B*
Post-sale	*No reuse, customer support in case of problems*

Case 4: Apparel industry

Short description of a typical company
Fashion firm with strong brand producing high quality clothing sold at global level.

General Criteria	*Value/description*
Product Necessity	*Consumer Discretionary*
Company Dimension	*Large Enterprise*
Degree of outsourcing	*High (product design and development are insourced; production is outsourced; quality check and packaging is insourced)*
Company Image	*Strong Brand*

"Value Chain" selected criteria	*Values or description*
Market geographical dimension	*Global Market*
Market variation	*Seasonal Demand*
Market Analysis	*Trend analysis*
Global market	
Target Consumer	*End user*
Market acceptance criteria	*Quality, Brand*
Product and Service Design	*Mass Customisation*
Servitation degree	*Product-centred*
Product complexity	*Low*
Product "intelligence"	*Low (barcodes for item tracking)*
Product and Service Acquisition/Supply Chain Stability	*Unstable*
Supply Chain Geographical Coverage	*Multi-Local Supply Network*
Supply Chain Cooperation Degree	*Ad hoc cooperation*
Product and Service Research	*Tightly coupled (Research is typically on materials to be used in production)*
Sustainability/Production Process Optimisation	*Reduction of energy, water or raw material consumption*
Selling/order acquisition	*In-Shop & On-line*
Selling/Point of Sale	*Retailers & Own points of sale*

Case 5: Medical Technologies

Short description of a typical company
Small manufacturer of cardiovascular measurement technology (pacemakers, defibrillators, pulse oximeters, etc.)

General Criteria	***Value/description***
Product Necessity	*(not relevant / applicable)*
Company Dimension	*SME*
Degree of outsourcing	*high*
Company Image	*(not relevant / applicable)*
Company location	*(not relevant / applicable)*

"Value Chain" selected criteria	***Values or description***
Market geographical dimension	*Global*
Market variation	*Continuous demand / long product life cycle*
Market Analysis	*trend/need detection*
Market Dimension	*mass market*
Target Consumer	*Business*
Market acceptance criteria	*Price, functionality, brand image*
Product and Service Design	*mass production*
Servitation degree	*product-centred*
Product complexity	*medium number of components, complex interaction of materials, simple geometry*
Product "intelligence"	*Contains sensors, interfaces and embedded software.*
Product and Service Acquisition/Supply Chain Stability	*Stable*
Supply Chain Geographical Coverage	*Global*
Supply Chain Cooperation Degree	*full cooperation*
Product and Service Research	*High R&D intensity, tightly coupled R&D and product development*
Production Characteristics	*big volume, forecasting-based, semi-automated, high number of process steps, low interdependency, good predictability, high number of critical parameters, highly skilled workers*
Sustainability/Production Process Optimisation	*Production process not optimized; product design optimized for recycling*
Logistics	*buffer strategies; based on cost*
Selling/order acquisition	*B2B*
Post-sale	*customer feedback, no re-use*

Case 6: Semiconductors

Short description of a typical company
Multinational semiconductor company providing solutions for automotive and industrial electronics and chip card and security applications

General Criteria	***Value/description***
Product Necessity	*Consumer Discretionary*
Production	*Discrete Manufacturing*
Company Dimension	*Large Enterprise*
Company location	*Industrialized Zones*
Company Image	*Strong Brand*
Degree of outsourcing	*Medium (some parts of the production process, e.g. Test, or BE assembly are often outsourced)*

"Value Chain" selected criteria	***Values or description***
Market geographical dimension	*Global Market*
Market variation/In Time	*Continuous demand*
Market dimension	*Mass market (although through retailers ...)*
Target Consumer	*Other industries*
Market acceptance criteria	*Price, quality and functionality mix*
R&D investments	*High R&D intensity*
R&D and product development	*Tightly coupled*
Product customization	*Mass production*
Servitation degree	*Product-centred*
Product complexity	*High*
Product and Service Acquisition/Supply Chain Stability	*Stable*
Supply Chain Geographical Coverage	*Global supply network*
Supply Chain Cooperation Degree	*Competition*
Production Volumes	*Big Volumes*
Production Scheduling	*On-demand*
Production Automation	*High Automation (very relevant dimension for ICT)*
Production process complexity	*Complex production tech*
Blue colar workers	*Highly skilled*
Sustainability/Production Process Optimisation	*Reduction of energy, or raw material consumption*
Selling	*B2B*
Post-sale	*Technical support*

Case 7: Electronics

Short description of a typical company
Leading OEM supplier of innovative flat panel display products and solutions, specializing in the design, development and manufacturing of a broad range of specialty display products targeted at commercial, outdoor monitor, interactive, and custom industrial markets.

General Criteria	*Value/description*
Product Necessity	*Consumer Discretionary*
Company Dimension	*OEM*
Degree of outsourcing	*Low*
Company Image	*No/"weak" brand*
Company Location	*Industrialized zone*

"Value Chain" selected criteria	*Values or description*
Market geographical dimension	*Local Market*
Market variation	*Stable demand*
Market Analysis	*Trend/needs detection*
Market Dimension	*Mass market*
Target Consumer	*end users*
Market acceptance criteria	*Price, Quality*
Product and Service Design	*Mass Production*
Servitation degree	*Product-centered*
Product complexity	*High*
Product "intelligence"	*Embedded Software, interfaces*
Product and Service Acquisition/Supply Chain Stability	*Stable*
Supply Chain Geographical Coverage	*Multi-Local Supply Network*
Supply Chain Cooperation Degree	*Competition*
Product and Service Research	*Tightly coupled*
Sustainability/Production Process Optimisation	*Reduction of energy, water or raw material consumption*
Selling/order acquisition	*In-Shop & On-line*
Selling/Point of Sale	*Retailers*

Case 8: Heavy Engineering

Short description of a typical company
Manufacturer of heavy engineering equipment

General Criteria	*Value/description*
Product Necessity	*Consumer Discretionary*
Company Dimension	*Large Enterprise*
Degree of outsourcing	*Low*
Company Image	*Strong brand*
Production	*Discrete manufacturing*
Company location	*Widespread geographically*

"Value Chain" selected criteria	*Values or description*
Market geographical dimension	*Global market*
Market variation	*Continuous demand Long product lifecycle*
Market dimension	*Niche market*
Target Consumer	*Other industry*
Market acceptance criteria	*Functionality/Price/Quality*
Product and Service Design	*Mass*
Servitation degree	*Product-centred, but changing to service*
Product complexity	*High*
Product "intelligence"	*High*
Product and Service Acquisition/Supply Chain Stability	*Reasonably stable*
Supply Chain Geographical Coverage	*Multi- global supply network*
Supply Chain Cooperation Degree	*Ad hoc cooperation*
Product and Service Research	*High R&D intensity Tightly coupled*
Sustainability/Production Process Optimisation	*Reduction of energy, or raw material consumption*
Selling/order acquisition	*B2B*
Post-sale	*Service support*

Case 9: Industrial automation

Short description of a typical company
Manufacturer of specialist industrial alternators and drive systems

General Criteria	*Value/description*
Product Necessity	*Consumer Discretionary*
Company Dimension	*Large Enterprise*
Degree of outsourcing	*Medium (product design and development in-house; sub-assemblies outsourced, main assembly in-house)*
Company Image	*Strong brand*
Production	*Discrete manufacturing*
Company location	*Industrialised zone*

"Value Chain" selected criteria	*Values or description*

Market geographical dimension	*Global market*
Market variation	*Continuous demand Long product lifecycle*
Market dimension	*Niche market*
Target Consumer	*Other industry*
Market acceptance criteria	*Functionality/Price/Quality*
Product and Service Design	*Mass customisation*
Servitation degree	*Product-centred*
Product complexity	*High*
Product "intelligence"	*High*
Product and Service Acquisition/Supply Chain Stability	*Reasonably stable*
Supply Chain Geographical Coverage	*Multi- global supply network*
Supply Chain Cooperation Degree	*Ad hoc cooperation*
Product and Service Research	*High R&D intensity* *Tightly coupled*
Sustainability/Production Process Optimisation	*Reduction of energy, or raw material consumption*
Selling/order acquisition	*B2B*
Post-sale	*Service support*

Case 10: Solar industry

Short description of a typical company
Local solar company with two production facilities, one a product development and the other a mass production facility, producing solar modules using an innovative and patented solar cell technology.

General Criteria	***Value/description***
Product Necessity	*Consumer Discretionary*
Company Dimension	*SME*
Degree of outsourcing	*None*
Company Image	*No/"weak" brand*
Company Location	*Industrialized zone*
Production	*Discrete Manufacturing*
"Value Chain" selected criteria	***Values or description***
Market geographical dimension	*Local Market*
Market variation	*Continuous demand*
Market Analysis	*Demand Analysis*
Market Dimension	*Mass market*
Target Consumer	*Other industry*
Market acceptance criteria	*Price, Efficiency*
Product and Service Design	*Mass Production*
Servitation degree	*Product-centred*

Product complexity	*Medium*
Product "intelligence"	*Low (barcodes for item tracking)*
Product and Service Acquisition/Supply Chain Stability	Stable
Supply Chain Geographical Coverage	Multi-Local Supply Network
Supply Chain Cooperation Degree	Competition
Product and Service Research	Tightly coupled
Sustainability/Production Process Optimisation	Reduction of energy, water or raw material consumption
Selling/order acquisition	B2B