D2.2
FITMAN Verification & Validation Business and Technical Indicators Definition

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VERSION HISTORY

VERSION	DATE	NOTES AND COMMENTS
0.1	24/04/2013	INITIAL TABLE OF CONTENTS AND ASSIGNMENTS
0.2	23/05/13	BASED ON WP2 HELSINKI MEETING, MODIFICATION OF THE TOC
0.61	14/06/2013	DEVELOPMENT OF DEFINITIONS AND STATE OF THE ART FOR BPI METHODS
0.62	23/06/2013	SUPPLEMENTARY DEFINITIONS AND BPI METHODS AND POLIMI INPUTS
0.7	02/07/2013	MODIFICATION OF PLAN
0.72	03/07/2013	INPUTS FROM NTUA ON TECHNICAL INDICATOR AND FROM VTT ON VERSATILITY
0.78	05/07/2013	ADD TRIALS DESCRIPTIONS
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1.3	02/10/13	FINAL VERSION

DELIVERABLE PEER REVIEW SUMMARY

ID	Comments	Addressed (✓) Answered (A)
1	No specific comment or remark concerning the content of the document at scientific and technological level. Also, the global structure of the document is clear, and suitable to present what is planned to be delivered. The document needs to have the text fully revised, for a clear and easier understanding of its contents in terms of phrasing and the logical sequence of the text.	We have taken in consideration the comments and performed the corrections coming from both reviewers.
2	I will use the Review/Track changes capabilities of WORD, to put my comments/remarks along the text.	

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Executive Summary

The goal of the WP 2 "FITMAN Verification & Validation (V&V) Method" is

"to develop a method for the evaluation and assessment of the FITMAN Trials, regarding various aspects".

The deliverable D 2.2 reports on the identification and the definition of Business Performance Indicators (BPI) and Technical Indicators (TI) for the "FITMAN Verification & Validation Method".

On the one side, we have to evaluate the Generic Enablers (GE), Specific Enablers (SE), Trial Specific Components (TSC) and also the various platforms developed in FITMAN derived from their orchestration. The nature of the systems is "Technologic", hence the criteria for evaluation (Technical Indicators TI) are more oriented to the technical performance. This selection is reported in D2.1 "*FITMAN Verification & Validation Method and Criteria".*

On the other side we have to evaluate the performance of a "Business System": the Trials. This System has a different behavior and the criteria for evaluation are different. We have to combine Economic, Social and Human behaviors with Technical ones. This evaluation is based on Business Performance Indicators (BPI).

The two evaluations using BPI and TI are complementary and influencing each other. If the technical performances of the IT system are not satisfying, the global business performances of the Trial will not reach the defined objectives, determining the failure of the whole Trial. On the other hand, a perfect IT system which is not enabling the Business System to achieve its objectives is mostly useless.

The main results of this deliverable are the following:

- Definition of **concepts** connected with Business Performance Indicators and Technical Indicators.
  - For Performance Indicators we defined the following concepts: Criterion, Performance, Performance Indicators (PIs), Key Performance Indicators (KPIs), Key Success Factors, Objectives, Mission, Vision, Strategy, Process, Decision Variable and Action Variables, Constraints;
  - For Technical indicators we defined Validation andVerification.

- Concerning Business Performance Indicators, thirty methods were analysed and classified in four categories:
  - methods with a basic architecture of performance measurements (A),
  - methods to define directly a Performance Indicators System (B),
  - methods with diagnosis for improvement (C),
  - methods based on organisational models to support the selection of performance dimensions (D),

  From this survey, four approaches have been selected: BSC (Balanced Score Card) (A), ECOGRAI (B), TOPP SYSTEM (C), ENAPS (D),

  The possibility of SCOR/VCOR have been finally analysed, and also the work developed by the ECOLEAD project in the domain of Performance measurement.

In a second analysis, BSC and ECOGRAI were shortlisted as most promising methods for FITMAN. These two methods are widely used and have some common characteristics. Due to the fact that BSC is limited to the definition of KPIs at the strategic level, we propose ECOGRAI which instead covers all the levels: strategic, tactical and operational. This is a necessary precondition for FITMAN Trials which are to be conducted and monitored at operational level.

In the last part of the deliverable, a list of TI and BPI have been proposed.

1. Introduction

The goal of the WP 2 “FITMAN Verification & Validation (V&V) Method” is:

“to develop a method for the evaluation and assessment of the FITMAN Trials, regarding the following aspects:

- *to identify existing V&V methods, integrate them and depict the criteria to follow in the Trials*
- *to describe functional and non-functional technical indicators for evaluating openness and versatility of FI-WARE in FITMAN trials*
- *to describe business indicators and social-technological-economical-environmental-political (STEEP) sustainability criteria for evaluating the business benefits in the trial after the adoption of FI-WARE Generic Enablers*
- *to integrate technical and business indicators in a generic V&V assessment package for FI-WARE evaluation in manufacturing smart-digital-virtual factories of the future*
- *to instantiate the generic V&V package into the chosen Use Case Trials and application domains”.*

The WP 2 is organized round 4 tasks:

- Task 2.1 *“FITMAN V&V Generic Method and Criteria Identification”* which has the objective to provide a general and extended Verification and Validation (V&V) framework, which can be applied to all FITMAN’s needs.
- **Task 2.2 *“FITMAN V&V Business and Technical Indicators Definition”* which has the objective to identify and define a selection of business and technical indicators to be used in the FITMAN Verification & Validation Method.**
- Task 2.3 *“FITMAN V&V Assessment Package”* which has the objective to consolidate the developed V&V Generic Method, assessment criteria, technical and business *indicators into a generic package,*
- Task 2.4 *“Instantiation of V&V Assessment Package per Use Case Trial”* which has the objective to adapt the V&V assessment package to each Use Case Trial taking in accounts the scope and specific requirements and environment conditions that will affect each instantiation of the package.

Deliverable D2.2 reports on task 2.2.

1.1 Objectives of task 2.2

The objective of task 2.2 is to identify **the methods** to determine **Technical Indicators** on one side and **Business Performance Indicators** on the other side to be used in the FITMAN project.
Based on these two methods a selection of Business Performance Indicators and Technical Indicators will be performed.
The Technical Indicators are identified and defined for the assessment of openness and versatility of FI-WARE generic enablers used in the manufacturing domain and in agreement with the defined objectives. The task will set benchmarking values for indicators, if feasible and meaningful reference values can be defined.

The Business Performance Indicators are identified to evaluate the performances of the trials according several domains based on STEEP(Social, Technical, Economic, Environmental, Political).

1.2 Methodological Approach

It is obvious that there are two domains which need evaluation.

The first one is the technical evaluation for the various technical components that will be developed in FITMAN project: Generic Enablers (GE), Specific Enablers (SE), Trial Specific Components (TSC) and also the various platforms developed based on GEs and SEs. These platforms will be coherent with the Generic and Specific Architectures developed for the three types of Trials (Smart, Digital, Virtual Manufacturing) but also for the specific platforms of each trials.

The second one is the evaluation of the global performance of the Trial. We are more in the evaluation of a system which are not only Technical characteristics but also Economic, Social,… We propose to use the classical approach to evaluate the performance of an enterprise or a technical-economic system: Performance Indicators.

These relations between the two types of evaluation will be analysed by the tasks T 2.1 and T 2.2.

So the methodology we propose is:

- To design or to choose a method to determine Technical Indicators (described in D2.1),
- To determine a set of example of Technical Indicators,
- To design or to choose a method to determine Business Performance Indicators,
- To determine a set of example of Business Performance Indicators.

1.3 Structure of the Document

In agreement with the previous paragraphs presented, the document is structured as follows:

In chapter 2 collects, based on literature analysis, the definition of the main concepts connected with Business Performance Indicators and with Technical Indicators: Criterion, Performance, Performance Indicators (PIs), Key Performance Indicators (KPIs), Key Success Factors, Objectives, Mission, Vision, Strategy, Process, Decision Variable and Action Variable, Constraints,

Chapter 3 concentrates on the state of the art analysis for the methods used for Business Performance Indicators developed since the last 20 years in order to choose one or to adapt one.

Chapter 4 gives a list of Technical and Business Performance Indicators.

A conclusion and future directions are introduced at the end of the document.

2. Definition of the Concepts connected with Business Performance Indicators (BPIs) and Technical Indicators

In this section we give the definitions of the main concepts which are usually used to describe the Business Performance Indicators. We have also introduced in a second part the main definitions concerning Verification and Validation

2.1 Definition of Concepts connected with Business Performance Indicators

The definitions below have been taken after an analysis of state of the art of each concept.
The definitions proposed are in accordance with the actual Business Performance concepts.
When it is possible we have adopted the same structure: state of the art, comments, definition.

Key Term	Analysis
Criterion	A standard on which a judgment or decision both at business and at IT level may be based. Each criterion should be clearly defined to avoid ambiguity in understanding and prioritizing the differing views that affect a decision or an assessment. In D2.1, a criterion reflects the diverse parameters that are involved and influence the V&V activities of the trials. In D2.2, a criterion allows to choose the right variable for measuring the performance of a system.
Performance	*State of the art:* • Performances in the enterprise are the results of actions which contribute to reach the strategic objectives [Lorino, 1996] • It results of the animation of a dynamic of generalized progress, lying on the deployment of an indicators system associated with objectives and levers enabling in a continual and systematic way to apprehend the situation of the moment, to visualize the layers and to light the way to be traversed and finally to evolve while measuring the performed progress [CPC (Club Production and Competitivity),1997] • Performance is what the organization hires one to do, and do well but only actions which can be scaled, i.e. measured, are considered to constitute performance [Campbell et al., 1993] • The ability of an entity, such as a person, group or organization, to make results in relation to specific and determined objectives (Laitinen, 2002; Lebas and Euske, 2004). *Comments:* From these definitions, the performance is always associated with objectives, actions and its results to make evolve a system (enterprise of Trial) towards the objectives achievement. *Definition:* The performance of an organization (enterprise, system, trial) measures the evolution of this organisation towards the objectives, under the influence of external or internal factors

<table>
<tr><td>Performance Indicators</td><td><u>State of the art:</u>
A quantified data which measures the effectiveness and/or efficiency of all or part of a process or system in comparison to a standard or a plan or a determined objective and accepted in the frame of an enterprise strategy [AFGI (Association Française de Gestion Industrielle),1992]
Information that must help an actor, individual or more a group of actors, to define actions towards an objective achievement and must allow him to evaluate the results [Lorino, 1997].
A PI (Performance Indicator) is a quantified data which measure the efficiency the action variables or the decision variables of the decision makers and the degree of their objectives achievement in the frame of the strategy of the enterprise [Doumeingts, 1998].
Which anticipates and measures condition changes or specific situation [CARNEIRO, 2005].
<u>Comments:</u>
Three elements are very important to define a PI. The first element is the system (Enterprise, Trials) in which we will define the PIs. The second element is the objective assign to this system, and the last element is the action variable (or decision variable) to reach the objective.

<u>Definition:</u>
PI (Performance Indicator) is a quantified data which measures the efficiency of action variables or decision variables, in the frame of the achievement of an objectives defined for this system</td></tr>
<tr><td>Key Performance Indicators (KPIs)</td><td><u>State of the art:</u>
Indicators show what needs to be done in an internal operative perspective. These KPI´s focus on the parts of an organization’s performance that are the most critical to success, both for present time and future. A good KPI affects a number of critical success factors. It also affects other KPI´s in a positive manner [Parmenter, 2007]
<u>Definition:</u>
A KPI is a Performance Indicator which allows to define the Performances of a system (Enterprise or trial) at the strategic level. The companies used the expression Key Performance Indicators (KPIs) because these PIs evaluate the global situation. They can be used to evaluate the KSF (Key Success Factor).</td></tr>
</table>

Objectives	*State of the art:* • The objectives reflect the mission of the organization and the finalities which concretize the mission [Mélèse, 1972]. • An objective is the result or the target that has to achieve the system (Enterprise or Trial) controlled by the decision-maker [Marcotte, 1995] • An objective translates the intention of the decision-maker, in a given decision-making frame, to pass from the state of existing performance to the state of wished performance for the controlled system. Thus, it constitutes a proactive representation of the performance to be reached [Kromm, 1997]. *Comments:* These definitions emphasize the relation between the objective, the mission, and the performances and the controlled system *Definition:* Objectives allow to define the results that the global company, or a part of the company (trials) must reach. In fact for a company a set of objectives will be defined according the functions, the processes or the services of the organization. In such case, it is very important to check the coherence of the various objectives in order that the global performance will be improved. Each objective must contribute to the achievement of the global objectives.
Mission	*State of the art:* • A Mission of an organization characterizes and identifies the reasons for existence [J.Camillus, 1997] • A Mission captures the overriding purpose of an organization in line with the values and expectations of stakeholders and should typically answer the questions: “what business are we in?” [Johnson et al., 2008] and “what is our business for?” [Drucker, 1973]. • A Mission is the nature of function or task to which a company must assume or achieve as organizational entity (Ex: service delivery activity).[P.Iribarne, 2006] • A Mission is the primary business or purpose of an organization. It describes what an organization does, for whom, and its benefit. The mission of an organization is not a time-bound objective.[L.P.Gates, 2010] *Comments:* These definitions refer to the nature of the purpose, the activity or function of an organization which justify its existence. Generally, the mission is invariant throughout the life cycle of the organization. *Definition:* A Mission is the primary business or purpose of an organization. It describes what an organization does, for whom, and its benefit

Vision	*State of the art:* • a view of a realistic, credible, attractive future for the organization, a condition that is better in some important way than what now exists [W.Bennis, B.Nanus, 1997] • it defines the expected position by the organization in the long term for a well determined time that is necessary to specify and quantify [P.Iribarne, 2006] • An ideal situation that an organization intends to pursue. It links the organization to the future by articulating instantiations of successful execution of the mission. It might, in fact, describe what can be achieved in a broader environment if the organization and others are successful in achieving their individual missions. [L.P.Gates, 2010] *Comments:* All these definitions of vision refer to future state. *Definition:* The vision is an ideal state that managerial staff imagines in the future for the organization according to its activity by taking account of the opportunities and threats of the environment.
Strategy	*State of the art:* • it refers to the plans, investments, and actions taken to achieve sustainable competitive advantage and both superior economic and social performance [B. Husted, D.Allen,2001] • it consists in fixing objectives according to the environment (external constraints) and available resources in the organization, then in assigning these resources to obtain a sustainable competitive advantage [F. Leroy, 2005] • it defines the general policy axes chosen to reach the vision. It aims of obtaining a profitable and sustainable position relating to the strengths and constraints that define the sector competitive structure [P.Iribarne, 2006] • It is a derived approach to achieving the mission, goals, and objectives of an organization. It supports the organizational vision, takes into account organizational enablers and barriers, and upholds its guiding principles [L.P. Gates, 2010] *Comments:* From theses definitions, the strategy is linked with actions, resources, objectives and vision. *Definition:* The strategy is linked with the mission and the vision. It combines the choice of the actions with available resources to achieve the organizational goals, in the frame of the mission and the concretization of the vision. It needs a plan to be effective for ensuring that the entire organization is focused on a shared purpose and vision.

Key Success Factors	*State of the art:* • They are the strategic elements that an organization must control to be maintained in the competition. They focus on the changes that the organization must follow according to the change of the external environment. [P.Iribare, 2006] • they represent the stakes in success especially with the clientele [Garibaldi, 2001] *Definition:* The Key Success Factors (KSF) are internal or external actions that an organization can control to reach its objectives. They can relate to products (quality), organization (skill), customers (satisfaction) etc.
Process	*State of the art:* • A process is a set of correlated or interactive activities which transform input elements in output elements [ISO 9000] (International Standard for Standardization) *Definition:* A process is a set of correlated or interactive or parallel dynamic activities which transform input elements in output elements. Time is an important element.
Decision variable (DV) Action variable (AV)	*Proposition* • A Decision variable is an element usually used by a decision maker for reaching the objectives. The DV modifies the states of the controlled system**.** • An Action variable is the inductor of performance, a variable which influences the performance of an activity or a whole process on which we can act to develop the process to reach the goal better [El Mahmedi et al., 2005]. *Definition:* A Decision Variable (DV) is a decision taken by a decision maker in order that the system he/she controls reach its objective An Action Variable (AV) is an action taken by the owner of a system in order that the system reach its objectives
Constraints	*Definition:* The constraints are the limitation on DV or AV to reach the objectives. Example: number of hours that an employee is authorized to perform according the social law.

Table 1: Definition of concepts linked with BPIs

2.2 Definition of concepts connected with Technical indicators

Key Term	Definition
Validation	The process of providing evidence that the software and its associated products satisfy system requirements allocated to software at the end of each life cycle activity, solve the right problem (e.g., correctly model physical laws, implement business rules, use the proper system assumptions), and satisfy intended use and user needs.
Verification	The process of providing objective evidence that the software and its associated products conform to requirements (e.g., for correctness, completeness, consistency, accuracy) for all life cycle activities during each life cycle process (acquisition, supply, development, operation, and maintenance); satisfy standards, practices, and conventions during life cycle processes; and successfully complete each life cycle activity and satisfy all the criteria for initiating succeeding life cycle activities (e.g., building the software correctly).

Table 2: Definition of concepts linked with TIs

3. Determination of Business Performance Indicators Methods for FITMAN

This paragraph is divided in two parts. The first part categorizes and classifies the 37 most currents Business Performance Indicator Methods (BPIM). In the second part, a description of four methods belonging to each category is carried out.

3.1 Business Performance Indicators Methods

Numerous methods dedicated to the Business Performance evaluation proposed by researchers and practitioners abound in the literature devoted to the performance area. The objective consists to categorize a few current performance measurement methods among which some are more known and used than others according to their design and their mode of presentation (see Table: 1).

The methods will be categorized in 4 (not exclusive) A, B, C, D categories based on their dominant design characteristics. The term “not exclusive” is used because some methods can belong to 2 or 3 categories.

a) Methods with a basic architecture of performance measurements (A)

They present a structure comprising internal and external dimensions of predetermined performance indicators that will be implemented. They help the managers and employees to focus on these essential independent performance factors. Generally the approaches are balanced. Ex: BSC (Balanced Score Card) [Kaplan and Norton, 1992, 2000]; PPMMatrix [Keegan and al., 1989]; SMART Pyramid [Lynch and Cross, 1991]; etc.

b) Methods with a methodology for Performance Indicators System design and implementation (B)

They provide well-structured methodologies with explicit guide lines and step by step procedure comprising processes for choosing the indicators and the PIs implementation. Ex: ECOGRAI [Bitton, Doumeingts, Ducq, 1990], GIMSI [Fernandez, 2003], IPMF [Medori and Steeple, 2000]; etc.

c) Methods with diagnosis for improvement (C).

They use audits to find the domains of performance which require improvements. They help the decision makers to determine dimensions and elements that require improvements and the criteria on which the company must concentrate its improvement efforts to maintain durably its success. Ex: PMQ [Dixon and al. 1990]; TOPP [Moseng and Bredrup, 1993]; IDPMS [Ghalayini and al. 1997]; etc.

d) Methods based on organisation models to support the selection of performance dimensions (D)

They help to choose PIs according to the structures of the company or the organization the domains of performance to be focused on which the indicators must be assigned. Ex: ENAPS [Bradley,1999]; EFQM [1998]; SCOR [SCC, 2008]; etc.

Classification of BPIs methods according to the type of framework

A framework is built and referring to many recommendations elaborated by some authors as [Globerson, 1985; Maskell, 1989; Brown, 1996; Neely and al., 1998; etc.] relating to the PIs and the PIS definition process.

These recommendations contain guides and rules for designing Performance Indicators System (PIS). They help in the process of PIS construction by clarifying the limit of performance evaluation measurement, specifying the dimensions or goals and their relations. There are two typologies of framework: structural and procedural [Folan and Browne, 2005].

a) Structural Frameworks:

These frameworks specify domains, dimensions, and criteria to define the indicators. These approaches don't supply procedure nor guideline to help in the identification and the implementation of indicators. The approaches of categories (A) and (D) can be integrated in this typology

b) Procedural Framework:

These frameworks provide methodologies based on processes and generally tools to help in defining and implementing PIs development. The methods of categories (B) and (C) can be integrated in this typology

Classification of the existing approaches:

Red for category "A", Yellow for category "B", Green for category "C" Blue for category "D".

For more details, see Annex II

Categories / Classes Methods	REFERENCES	Structural		Procedural	
		(A)	(D)	(B)	(C)
Tableau de Bord (FR)	[around 1950]		■		
Dupont Pyramid.	[Chandler, 1977]		■		
MBNQA (Malcom Baldrige Nationality Quality Award)	(1987)		■		
ABC/ABM	[Johnson & Kaplan, 1987]	■			
Performance Measurement MATRIX	[Keegan & al., 1989]	■			
Sink and Tuttle	[Sink & Tuttle 1989]	■			
ECOGRAI	[Bitton & al. 1990]			■	
PMQ (Performance Measurement Questionnaire)	[Dixon & al., 1990]				■
TdC (Théorie des Contraintes)	[Goldratt, 1990]	■			
PMSSI (Performance Measurement System for Service Industries)	[Fitzgerald & al., 1991]	■			
ProMES (Productivity Measurement and Enhancement System)	[Pritchard, 1990]	■			
PPS (Performance Pyramid System)	[Lynch & Cross, 1991]	■			
TBC (Time Based Competition)	[Azzone & al., 1991]	■			
BSC (The Balanced Scorecard)	[Kaplan & Norton, 1992,]	■			
TOPP System	[SINTEF, 1992, & al.…]	■			■
PBSCW (Putting the Balanced Scorecard to Work)	[Kaplan & Norton, 1993]	■		■	
Skandia Navigators	[Edvinsson & al. , 1994]	■			

Methods \ Categories / Classes	REFERENCES	Structural		Procedural	
		(A)	(D)	(B)	(C)
Getting the Measures of your Business	[Neely & al.,1994]			■	
SMM (Strathclyde's Modelling Methodology)	[Bititci, 1995]		■		
CPMS* (Consistent Performance Measurement System)	[Flapper & al. , 1996]			■	
Macro Process.Measurement	[Brown, 1996]		■		
AMBITE (Advanced Manufacturing Business Implementation Tool for Europe)	[Bradley, 1996]		■		
Stakeholders Approach.	Atkinson & al. , 1997]	■			
EFQM (European Foundation for Quality Management)	[1998]		■		
SCOR Supply Chain Operations Reference	[SCC, 1996, 2008]		■		
IDPMS (Integrated Dynamic Performance Measurement System)	[Ghalayini & al., 1997]				■
QMPMS (Quantitative Model for Performance Measurement System)	[Bititci &Carrie, 1998]				■
IPMS (Integrated Performance Measurement System)	[Bititci & al, 1997, 2000]		■		
ENAPS (European Network for Advanced Performance Studies)	[Brown & Delvin, 1998]		■		
PPMS* (Process Performance Measurement System)	[Kueng & Krahn, 1999]			■	
GIMSI*	[A. Fernandez, 03, 06]			■	
IPMF* (Integrated Performance Measurement Framework)	[Medori & Stepple, 2000]			■	
Strategy Map	[Kaplan & Norton, 2000]	■			
Performance PRISM	[Neely & al., 2001]		■		
MSDP (Measurement System and Development Process)	[Rentes & al., 2002]			■	
DPMS for SME (Dynamic for Performance Measurement System)	[Laitinen, 2002]			■	
Ref.Mod. forSME* (Reference Model for PMM framework and measures)	[Taticchi & al., 2008]			■	

(*) – Can be integrated with structural and procedural (not exclusive of categorization)

Table 3: Categorization and classification of Performance Measurement Approaches

3.2 Description of representative method for each category

This part is devoted to the description of four methods belonging to each category of reference. They are: Balanced Score Card (A), ECOGRAI method (B), TOPP system (C) and ENAPS System (D).
These methods were chosen because:

- Balanced Score Card is the most known and used by many organizations.
- ECOGRAI method has a specific approach and is based on the model of the organization. ECOGRAI has some links with BSC.
- TOPP system by its originality approach using many questionnaires.
- ENAPS because it is established on a basis of other approaches.

The goal of this paragraph is to perform a deeper analysis to choose one method among the four selected.

3.2.1 The Balanced Scorecard (BSC) (Category A)

The concept of the Balanced Scorecard (BSC) was introduced by Kaplan and Norton in 1992 [Kaplan 1992]. It focuses on the strategy and the vision rather than on the control. It provides the means to translate the vision into a list of objectives. For that, the strategy is translated into a system of performance measures according to four perspectives:

- **Financial** (relating to the shareholders)
- **Customers** (to generate the turnover for the fulfillment of the financial objectives)
- **Internal Processes** (to satisfy the customers and to guarantee the financial output)
- **Innovation and Learning** (to develop the enterprise capacities to improve for its viability)

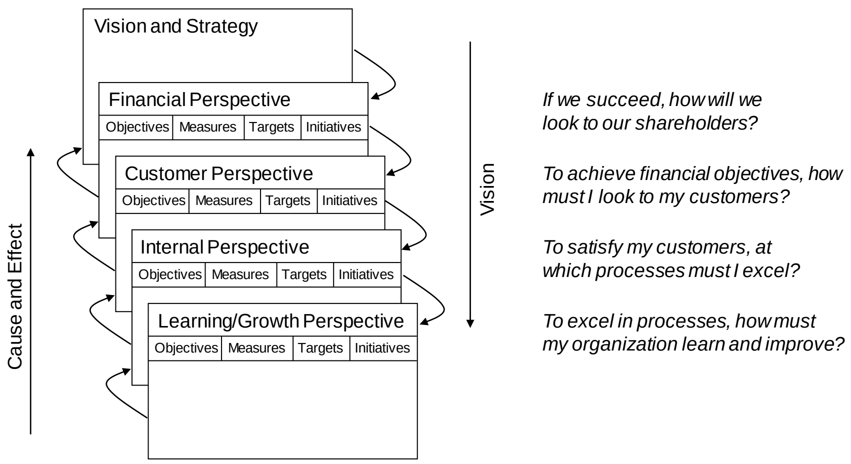

Figure 1: Perspectives of Balanced Scorecard

The process to the performance measurement consists in:

- the development of performance indicators into line with the strategy,
- the communication of the strategy by the deployment of the performance indicators,
- the strategic objectives measurement,
- the focusing on the key success factors,
- the consideration of the causal relationship between the four perspectives and the performance indicators (the real keys of the BSC)

The BSC contains a mix of lag and lead indicators. Performance measures that represent the consequences of actions previously taken are referred to as lag indicators or as key results indicators. They may focus on results at the end of a time period and characterize historical performance. Leading Indicators are considered the "drivers" of lagging indicators. There is

an assumed relationship between the two which suggests that improved performance in a leading indicator will drive better performance in the lagging indicator. For example:
Leading PI: Number of adjusted or changed parts in the products
Lagging PI: % of drop of customer's complaints or decrease of the Numbers of products returns.

Conclusion on BSC:

Strengths:

- It provides the means to define the performance indicators directly relating to the strategy and the vision
- The fundamental respect of the balance between the 4 perspectives.

Weaknesses:

- It is conceived as a tool intended for the direction (management) to observe the global performance and that it is not applicable to the operational levels [Ghalayni et al.,1997].
- It is a tool for control rather than a tool of continuous improvement.
- The limited number of stakeholders which are restricted to the customers [Maisel, 1992 ; Lingle et Schieman, 1996 ; Brown, 1996]
- The lack procedure and guidelines to help the user in its implementation

3.2.2 ECOGRAI [Bitton, G Doumeingts, Y. Ducq 1990] (Category B)

It is a method to design and to implement **P**erformances **I**ndicators **S**ystems in any kind of Application Domains and is applied with the implication of the decision makers of the Production Management Systems (it is a participative method)

Objective: It seeks to find a number of customized and limited indicators in agreement with the objectives of decision makers

Main characteristics*:*

- a logical process of analysis / design using a top-down approach, and allowing to decompose the objectives of the strategic levels into objectives for tactical and operational levels
- a concrete participative process for the design and the implementation , creating a dialogue between the various levels of the hierarchy, and favouring the identification of indicators by the future users involved in the study : it is a bottom-up implementation
- the use of a number of tools and graphic supports : GRAI grids, GRAI nets, splitting up diagrams, coherence panels, specification sheets
- a coherent distribution of Performances Indicators covering the various functions and the various decision levels (strategic / tactical / operational)

The different phases of the method*:*
The logical structured approach of the method consists of six phases decomposed into 2 main steps (design and implementation)

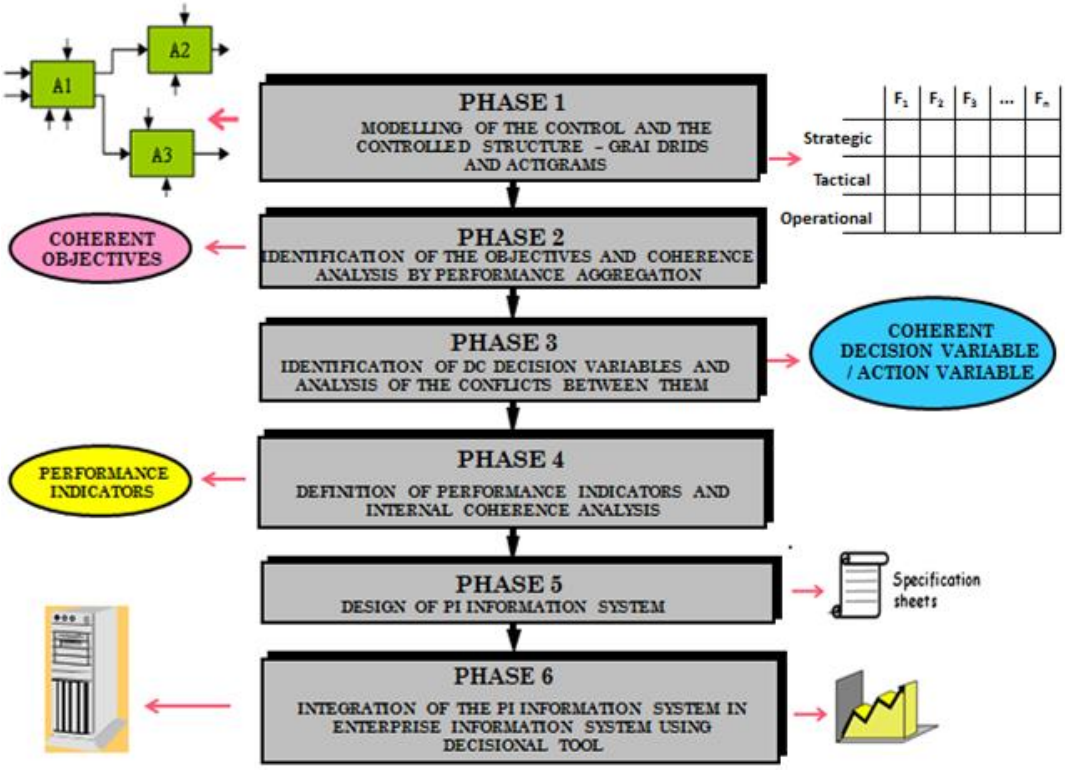

Figure 2: The six phases of the structured approach of ECOGRAI

The first phase: the modelling of the control system and the physical system (controlled part) of the Enterprise (or a part of the enterprise, for example the Trials).Then determination of the decision centres in which the Performances Indicators will be defined. This phase requires the use of GRAI grid allowing to identify the set of decision centres, as well as their links and the GRAI net aiming at describing in details all the activities identified inside each decision centre. It is also necessary to model the physical system by the processes to define performance indicators at operational level.

The second phase: the identification of the Decision Centre objectives and coherence analysis by a top-down approach:

a) Identifying the Enterprise System objectives
b) Identifying the global objectives of each function belonging to the enterprise
c) Defining the objectives of each Decision Centre inside the functions

These identifications are based on the notion of contribution: each objective must contribute to the achievement of the objectives identified at a upper level.

The third phase: The identification of the DC Drivers (Decision Variable (DV) or Action Variable (AV)) and analysis of the conflicts. It consists in the drivers identification corresponding to each objective of Decision Centres .This identification must be interpreted as one of the steps leading to the building of the triplets {Objectives / Drivers / Performances Indicators}. This notion of triplet expresses the controllability principle.

The fourth phase: Identification of the DC Performances Indicators and internal coherence analysis: it consists in the identification of the Performances Indicators which is validated only by an internal coherence analysis inside each Decision Centre in terms of triplet {Objectives / Drivers / Performances Indicators}. A triplet is coherent if :

- it is composed of one objective, one or several drivers and one or several performances indicators,
- the performance indicators allow to measure the efficiency of an activity or a set of activities of the considered function in the process to reach the objective, and are influenced by actions on the drivers.

In order to verify this coherence, coherence panels are built. They allow to identify the various links between the elements of the DC as well as their weight.

The fifth phase: Design of Performances Indicators information system: it consists in the specification of each performance indicator. It means to define clearly each indicator with fundamental parameters. The tool which guides these definitions is the specification sheet for each indicator which contains:

- the identification of the indicator (name, decision center, horizon, period),
- the objectives and the drivers related to the indicator,
- the perverse effects which have been identified,
- the identification of the data required for the implementation of the indicator,
- the definition of the associated processing,
- finally, the way of representing the indicators, determined by the future users (using graphics for most of the time).

The sixth phase: Integration of the Performances Indicators information system inside the Production information system: this integration is developed using an EIS tool (EIS: Executive Information System) or a Decision Tool. The processing and the visualisation choices to exploit the Performances Indicators are then specified into the EIS or Decision tool. This work is performed from the specification sheet.

Conclusion on ECOGRAI:

<u>The strengths:</u>

- It proposes generic concepts and generic method to define Performance Indicators in any kinds of domain.
- It offers a guideline, a procedure step by step to help the users for its implementation.
- The possibility to use methodological tools (GRAI grid, coherence table) to determine the various elements needed for PIS design.
- The link established between the three basics concepts: Objective, Decision Variable (DV) or Action Variable (AV), Performance Indicators.
- Its top-down approach for the deployment of objectives and the bottom-up for the aggregation of the performance indicators.
- It is compatible with the use of any generic objectives and performance indicators defined in other methods.

Strength and originality:

The main advantage of ECOGRAI is to limit the number of Performance Indicators. Usually the Performance Indicators are defined directly from the objectives (arrow number 2 on figure 3). The result is a large number of PI. In such situation it is difficult to follow all the PIs and more to determine which DV or AV must be activated to improve the situation. In ECOGRAI, the starting point is the search of DV or AV to reach the objectives (Arrow 1 between Objectives and DA), then the PIs characterise the result of DV or AV in reaching the objectives (arrow 1 between PI and DV or AV).

In such situation it is possible to determine rapidly where it is necessary to act to improve the situation.

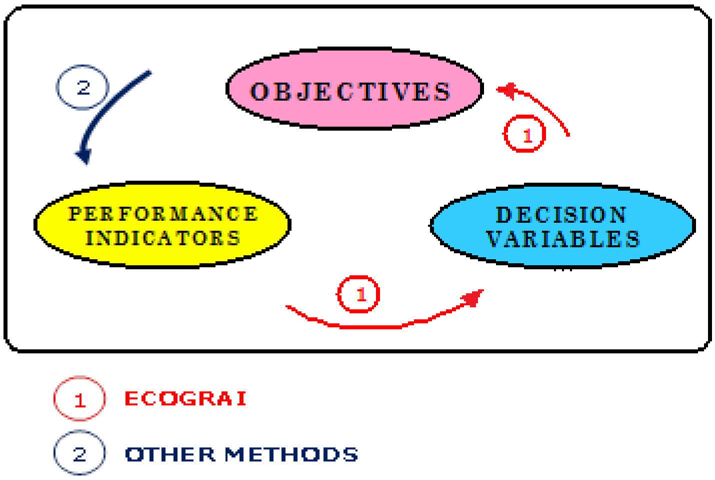

Figure 3: Principle of ECOGRAI

<u>The weakness:</u>

- The obligation to customize the method to the chosen domain.
  This can take some time but after it is possible to reuse the customized method for all the use cases in the same domain

3.2.3 The TOPP System [SINTEF, 1992; Moseng and Bredrup, 1993] (Category C)

The System was elaborated by [SINTEF, 1992; Moseng, Bredrup, 1993] in collaboration with the Norwegian Institute of Technology (NTH) and Norwegian Federation of Engineering Industries (TBL) as well as 56 other enterprises.
It includes four methods: self-audit (questionnaires), experts' audit, self-assessment (continue improvement), benchmarking.

TOPP is a set of generic questionnaires focusing on the current and expected enterprise situation for 2 years relating to the domains of performance in the whole company including especially its environment constituted by the stakeholders as the essential factor which influences the enterprise competitiveness and productivity.
To assess the performance and deduce the PIs from it, all the questionnaires are related to three dimensions (axes) defined by [Moseng and Bredrup, 1993]:

- The effectiveness: oriented to customers 'needs
- The efficiency: the optimal and economic use of the enterprise resources
- The flexibility: the adaptability with the changes, the strategic knowledge to control the internal and external changes

The questionnaires sequence is done into three parts:

- The first is put to obtain a global view of the enterprise.
- The second is done to know and to understand the actions, operations carry out by the enterprise
- The third is devoted to the 20 specific areas of the enterprise which need a continuous improvement as: product development, marketing, information technology, production control, financial, resources, improvement processes etc.

The answers to each question are qualitative and graduated from 1 to 7 which means respectively (**bad or poor**) and **excellent.** For the competitiveness, the answers are classified respectively: **not or less important, important and very important.**

Conclusion on TOPP System:

The strengths:

- Questionnaires are very precise . They can lead companies to think about the domains of production which they consider less important
- One of the points hardly of the system is the focusing on the current situation and that of expected future
- The benchmarking which allows the company to compare with those who use these questionnaires.
- The generic questionnaires are adaptable for any company

The weaknesses:

- The questionnaires are very long and takes time to fill them (60 pages with 20 questionnaires per page) with 3 classifications: current state, future state and the relative importance
- The questionnaires are generic and aren't relate to the strategy. It constitutes a handicap for the determination of the PIs of the company
- The hierarchic relationships of the measures are ignored.
- Because the questionnaires are qualitative and based on individual evaluations,the answers can be distorted
- Though the company measures, it tends to improve especially the areas with mention term: very important.

(These comments have been formulated by J.Brown, J.Devlin, A.Rolstadas et B.Andersen, 1998)

3.2.4 ENAPS (European Network Advanced Performance Studies) [Brown, 1999] (Category D)

The model ENAPS was developed by five partners in the project (SINTEF, CIMRU (University of Ireland at Galway, BIBA, GRAI (previous name of Manufacturing Engineering Group of IMS laboratory, University Bordeaux 1) and five industrial partners)

The approach: It describes the vision on the manufacturing business which takes into account all the operations including the design activities until the use of the final products via recycling. It combines 2 performance measurements approaches: TOPP system [SINTEF, 1992] for its generic performance indicators and AMBITE system [Bradley, 1996] for its top-down and process oriented approaches while based on a business model.

Objective: Using ENAPS performance measurement to test a permanent network for advanced business process performance studies in Europe industry and to develop a generic set of performance indicators to be used for it purpose.

Originality: ENAPS has **117** generic performance *(Annex III)* measures used in calculating the performance indicators. These performance indicators are defined according to 3 hierarchical levels with their number:

- Enterprise level: (**16**) performance indicators suitable for any manufacturing enterprise.
- Process level containing 2 processes:
  - Business processes: the value adding processes involved in the creation and production of a product and its sale and transfer to a buyer. The processes are: customer service (**6**), customer commitments (**13**), orders realisation (**26**), product development (**16**).

- Two Secondary processes: the non-value adding processes which are:
  - Support processes (**10**) which support the business and evolution processes while providing the resources and infrastructure necessary to perform these processes.
  - Evolution processes (**8**) which provide means to achieve the enterprise long term strategic objectives through the management and the planning of the evolution of the enterprise and its environment.

These Process level performance indicators were developed from Function level performance indicators that are used to determine the performance of the functions which are associated with them.

- Function level: No performance indicators are given because they are deemed to be too specific for comparison purposes.

The generic performance measures and indicators for each process and function were developed according to six dimensions: time, coast, quality, volume, flexibility and environment.

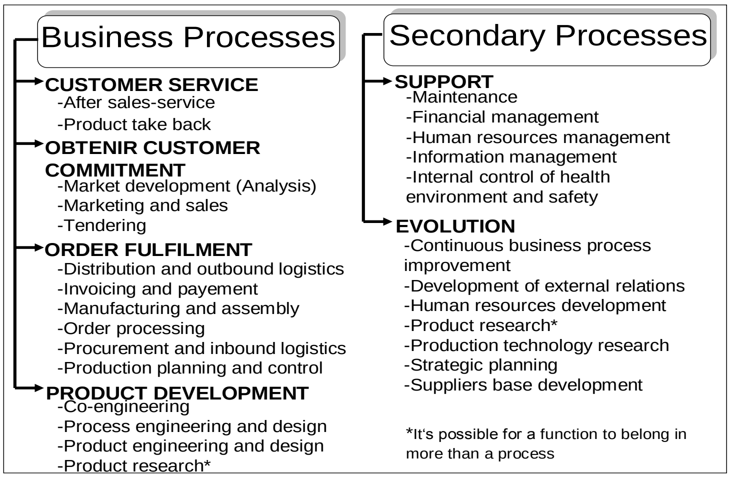

Figure 4: The ENAPS Generic Framework

Conclusion on ENAPS:

<u>Strengths:</u>

- It is inheritors of the known BPI methods which were previously developed by various authors,
- It has a generic set of performance indicators usable for any organization which use a process oriented approach.
- It uses a top-down approach while taking as base a business model to develop the indicators.
- I gives a very interesting list of PIs that could be reused with ECOGRAI.

<u>Weaknesses:</u>

- The links and the relations between the measures and the indicators are ignored.
- The lack of guidelines, procedures to help the users.
- The measures and the indicators are not linked to the specific strategies of the organization

3.3 Others methods and initiatives

In this paragraph we will describe

- one method which is applicable in the domain of Supply Chain,

- the approach developed by the ECOLEAD project for Performance Measurement,
- One method of cost evaluation which is well adapted to the new evaluation of cost activities in the modern manufacturing.

3.3.1 SCOR-VCOR methods

3.3.1.1 SCOR

The SCOR-model (Supply Chain Operations Reference Model Strategy, Methodology and Measures) has been developed to describe the business activities associated with all phases of satisfying a customer’s demand.
The Supply-Chain Operations Reference model (SCOR®) is the product of the Supply-Chain Council (SCC) a global non-profit consortium whose methodology, diagnostic and benchmarking tools help organizations make dramatic and rapid improvements in supply-chain processes. SCC established the SCOR process reference model for evaluating and comparing supply-chain activities and performance.
The Model itself contains several sections and is organized around the five primary management processes of Plan, Source, Make, Deliver, and Return (shown in Figure 5). By describing supply chains using these process building blocks, the Model can be used to describe supply chains that are very simple or very complex using a common set of definitions. As a result, disparate industries can be linked to describe the depth and breadth of virtually any supply chain. The Model has been able to successfully describe and provide a basis for supply chain improvement for global projects as well as site-specific projects. [1]

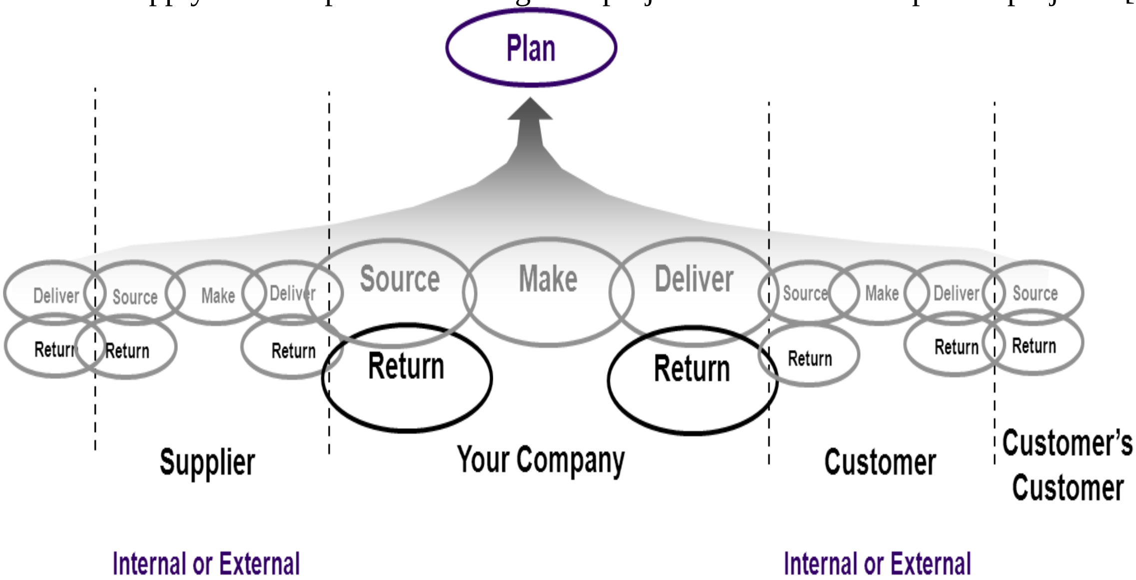

Figure 5: SCOR Model

Here following the key characteristics of SCOR Approach:

- Provides common language for supply chain
- Provides visibility through globally recognized standards in supply chain
- Define different strategies for each supply chain
- Provides structure for supply chain performance measurement across chain
- Balanced approach to measuring performance
- Evaluate and analyze supply chain holistically avoiding sub-optimization

As mentioned above SCOR model is built around 5 key processes: Plan, Source, Make, Deliver, and Return at top level, able to cover a broad range of specific cases, specifically the key 5 processes cover the following areas [2]:

- PLAN - Demand/Supply Planning and Management Balance resources with requirements and establish/communicate plans for the whole supply chain, including Return, and the execution processes of Source, Make, and Deliver. Management of business rules, supply chain performance, data collection, inventory, capital assets, transportation, planning configuration, and regulatory requirements and compliance. Align the supply chain unit plan with the financial plan.
- SOURCE - Sourcing Stocked, Make-to-Order and Engineer-to-Order Product Schedule deliveries; receive, verify, and transfer product; and authorize supplier payments. Identify and select supply sources when not predetermined, as for engineer-to-order product. Manage business rules, assess supplier performance, and maintain data. Manage inventory, capital assets, incoming product, supplier network, import/export requirements, and supplier agreements.
- MAKE - Make-to-Stock, Make-to-Order, and Engineer-to-Order Production Execution Schedule production activities, issue product, produce and test, package, stage product, and release product to deliver. Finalize engineering for engineer-to-order product. Manage rules, performance, data, in-process products (WIP), equipment and facilities, transportation, production network, and regulatory compliance for production.
- DELIVER - Order, Warehouse, Transportation, and Installation Management for Stocked, Make-to-Order, and Engineer-to-Order Product. All order management steps from processing customer inquiries and quotes to routing shipments and selecting carriers. Warehouse management from receiving and picking product to load and ship product. Receive and verify product at customer site and install, if necessary. Invoicing customer. Manage Deliver business rules, performance, information, finished product inventories, capital assets, transportation, product life cycle, and import/export requirements.
- RETURN - Return of Raw Materials and Receipt of Returns of Finished Goods All Return Defective Product steps from source – identify product condition, disposition product, request product return authorization, schedule product shipment, and return defective product – and deliver – authorized product return, schedule return receipt, receive product, and transfer defective product. All Return Maintenance, Repair, and Overhaul product steps from source – identify product condition, disposition product, request product return authorization, schedule product shipment. All Return Excess Product steps from source – identify product condition, disposition product, request product return authorization, schedule product shipment, and return excess product – and deliver – authorize product return, schedule return receipt, receive product, and transfer excess product

As shown in Figure 6, the Model is designed and maintained to support supply chains of various complexities and across multiple industries. The basic approach focus three process levels in a standard way. Every organization that implements supply chain improvements using the SCOR-mode will need to extend the Model, at least to Level 4, using organization-specific processes, systems, and practice to model the operational aspects defining the structure of each process/system component (see figure 7.)

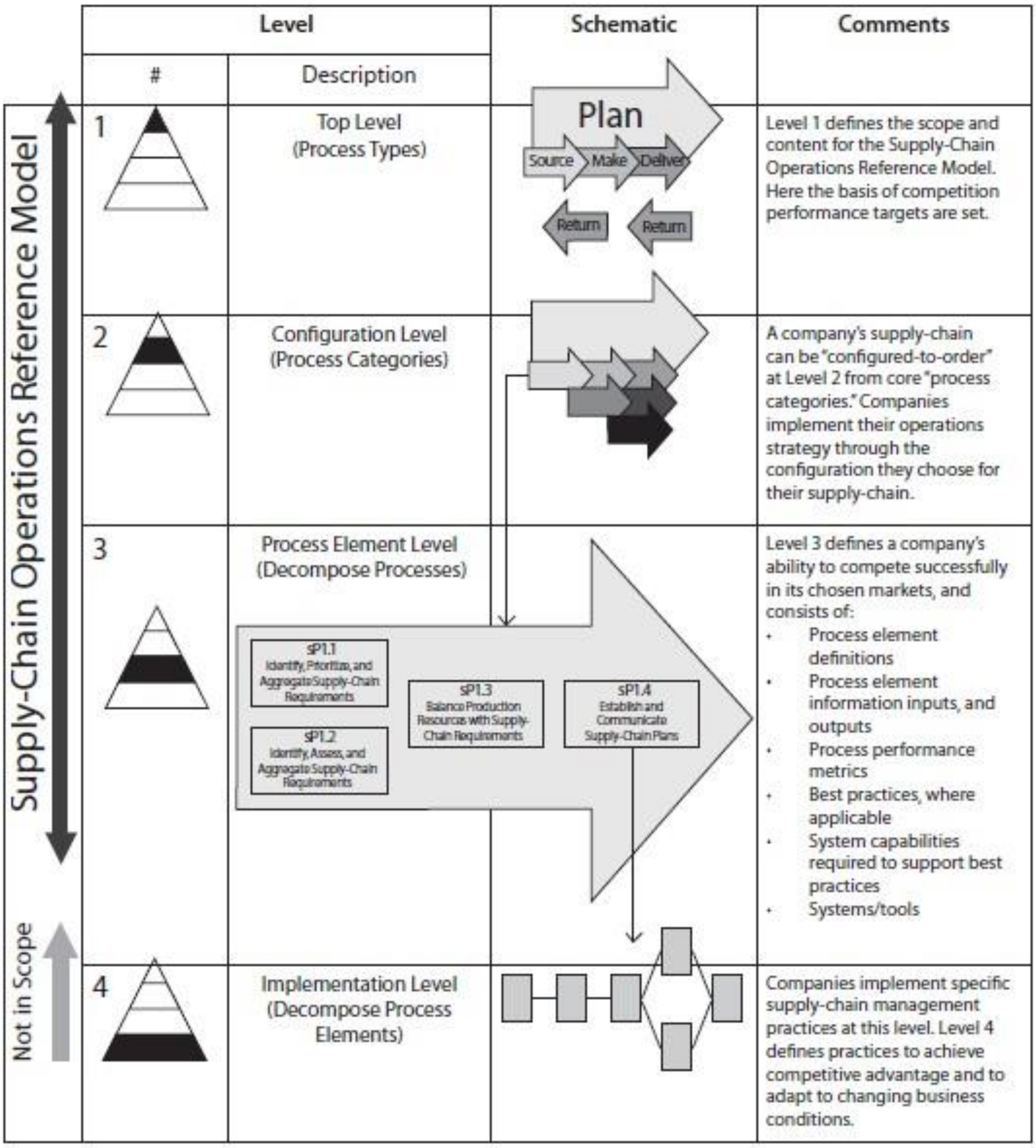

Figure 6: SCOR Hierarchical Model

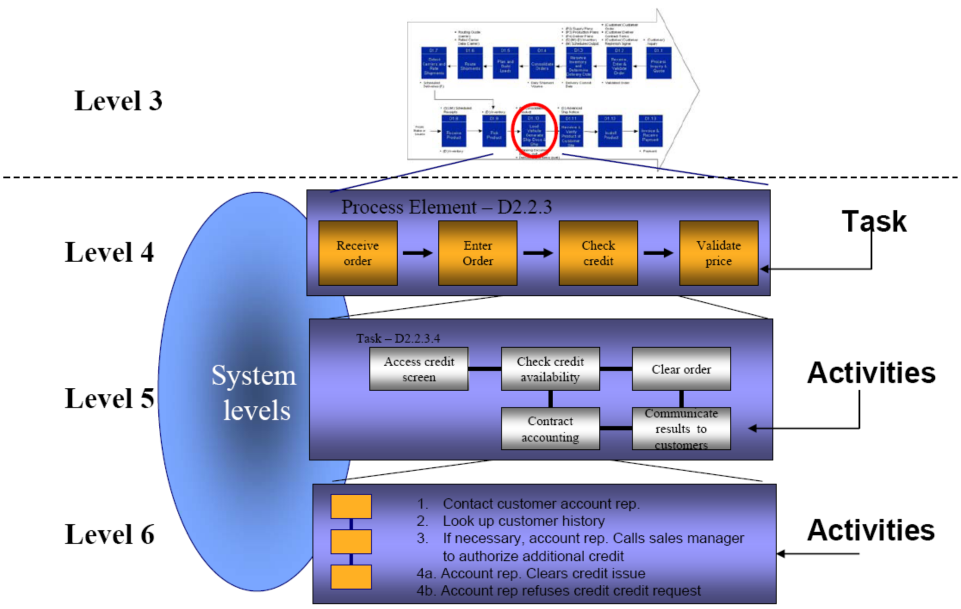

Figure 7: SCOR application on subprocess/system level

Once the specific process has been modeled, a BPR (Business Process Reengineering) initiative can be undertaken implementing the Process Reference Model. Process reference models integrate the well-known concepts of business process reengineering, benchmarking, and process measurement into a cross-functional framework. The following steps take place in this approach, Capture the "as-is" state of a process and derive the desired "to-be" future state, state, Quantify the operational performance of similar companies and establish internal targets based on "best-in-class"results, Characterize the management practices and software solutions that result in "best-in-class" performance.
Indicators, Objectives and Quantitative Targets can be eventually implemented and monitored utilizing Balanced Scorecard strategic tool (see **Error! Reference source not found. Error! Reference source not found.**)

3.3.1.2 VCOR

VCOR (Value Chain Operation Reference) model is based on Value Reference Model, a framework designed to improve Value-Chain performance. The VRM provides a common terminology and standard process descriptions to order and understand the activities that make up the value chain. It contains fully connected inputs and outputs to/from every activity, a metrics glossary, benchmarks and a collection of suggested practices.
By configuring a VRM scenario, organizations see their entire value chain in a form to compare with other companies across multiple industries. The model also helps companies use benchmarking and best-practice information to prioritize their improvements, quantify the benefits of implementing change, and to pursue specific competitive advantages discovered in the process.
VCOR intend extend the SCOR approach to the complete Value Chain (see Figure kkk)

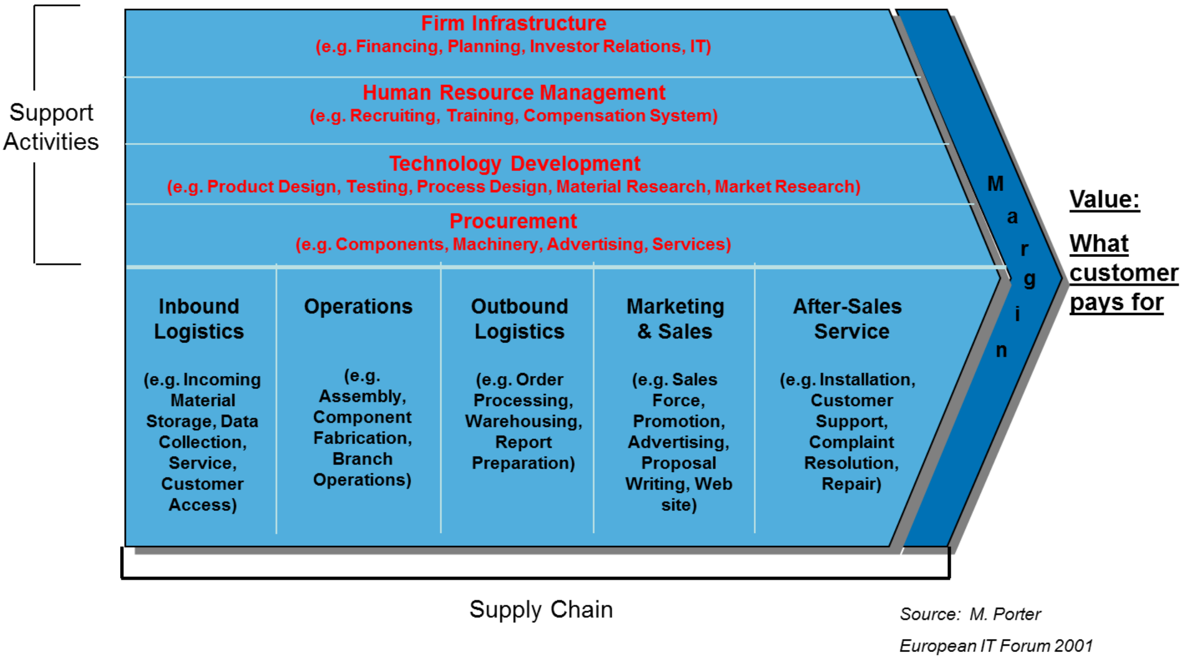

Figure 8: Value Chain [Porter 2001]

The Porter model represents the complete integration of business functions (core and support) concurring to the generation of "value".
It introduces the concept of value, perceived value and paid value by the customer.
So customer focalization has led to focus not only on Supply Chain, but also to other processes providing value to the customer. Nowadays a specific attention is paid to Customer Relationship Management (CRM), Product/Service Lifecycle Management (PSLM) and Energy Efficiency/Environmental Sustainability. All this aspects are addressed with an holistic approach according to the SCOR approach (see 3.3.1.1 SCO)

3.3.2 ECOLEAD approach – Collaboration performance

In EU/FP6 project ECOLEAD methods, concepts and tools were developed to support inter-enterprise collaboration [Camarinha-Matos et al. 2008]. As part of the developments performance measurement, supporting collaborative activities in the so called Virtual Organizations was developed. The term Virtual Organization (VO) refers to short term or temporary collaborative organizations which are created for a specific value adding task, for example to deliver a product or a service to a customer, and which are dissolved after the task is finished.

One aim of the VOPM (VO Performance Measurement) is to support the VO management, i.e. managing the collaborative activities in order to achieve the objective of the VO within the required time-, costs- and quality frame. In addition to VO management, the virtual organization breeding environment (VBE), referring to the long-term collaboration form, would benefit from information about the success factors and partners' performance. Such information is essential also in the creation of new VOs.

In ECOLEAD both measurement for the strategic (long term) and the operational (short term) purposes was considered [Westphal et al. 2008]. In the VO environment strategic level means measuring the performance for conclusions that are made in the Breeding environment / Network level and in the partner companies. Correspondingly, the operational VO performance aims to measurements that support the management of the VO during its operation. At the operational level thus the measurements should support VO creation, monitoring of progress, identification of deviations or other problems and defining the management actions.

The strategic level considers the general plan and policy to achieve the purposes of the VO. As in ECOLEAD the VO is built out of a VBE these purposes are not only derived from a specific business opportunity but also from the requirements of the VBE. According to ECOLEAD the following data is needed for the strategic level:

- Performance of partners in the VO for future decisions regarding the compilation of partners for a certain VO. .
- Effectiveness of the VO in total and the corresponding VO Management approaches as a basis for continuous improvement.
- Achievement of strategic objectives that should be supported by the VO even if the realisation of the objective exceeds its lifetime.

The operational level (VO) considers set-up, implementation and operation of the VOPM. The VOPM has to provide the following data for the operational level:

- Overall Performance of the whole VO in fulfilling the given task and objectives for
- performance control and improvement.
- Performance of the VO partners in contributing to the given task and objectives for
- Performance control and improvement as well as for the allocation of resources and benefits. In some cases the data is also used to decide if a partner has to be replaced.
- Overall collaboration performance of the whole VO as in input for VO management.
- Collaboration performance of the VO partners for improvement and the allocation of resources and benefits.

In addition to typical performance measures related to costs, time and quality also collaboration performance was in the interest both at the partner and VO level. The development towards measuring collaboration performance was the main novelty in ECOLEAD VOPM.

Collaboration performance of partners may have a significant impact on the VO performance. If there are conflicts, misunderstandings and disinterest for the common goal the VO operation may become inefficient and require high coordination. That's why there has been interest to develop measures for collaboration performance, also "soft" measures of collaboration [Westphal et. al. 2008]. Additionally, to support the short term endeavours (VO management), qualitative monitoring of VO status, based on the "feelings" and attitudes of the VO participants has been developed [Karvonen et al. 2008].
The following metrics have been developed to support measurement of collaboration performance:

- Reliability
- Flexibility
- Responsiveness
- Commitment
- Communication

They are described in more detail in [Westphal et al. 2008]. These metrics are of course "soft"; for example to measure responsiveness more than one indicator may be needed. Some measuring objects for these aspects are proposed in [Westphal et al.2008].

In FITMAN context the collaboration performance may be relevant for some specific trials in which the aim of FI implementation is to support collaboration with other companies. It is clear that FI implementation may make the inter-enterprise processes more efficient in time and costs. However, it may be difficult to directly evaluate how the FI tools can support the soft issues, like reliability or commitment, even if improved communication, information exchange and possibility for changes can affect the flexibility and trust between the collaboration partners. The soft issues will be considered depending on the objectives of the trials.

3.3.3 Transaction Cost approach and Activity Based Costing

Transaction cost analysis (TCA) represents one possible approach to understand and evaluate supply chain management and has the potential to be combined in an interdisciplinary setting with the insights provided by the marketing, logistics and organizational behaviour literatures [Hobbs 1996]. According to Rao [2003], transaction costs are "costs of undertaking a transaction, including search and information costs, bargaining costs and monitoring-enforcement costs of implementing a transaction; and the opportunity costs of non-fulfilment of an efficient transaction". Transaction costs can be divided into *ex ante* costs and *ex post* costs. Ex ante costs comprise the costs of actions before making the actual contract, e.g. negotiating and forming a contract or agreement. Ex post costs include monitoring and enforcing a contract or agreement [Rao 2003]. One common classification for transaction costs is 1) negotiation, 2) coordination and 3) monitoring costs.

A transaction cost is a cost incurred in making an economic exchange. The "father" of the core idea of transaction costs is Ronald Coase. He used the idea to develop a theoretical framework for predicting when certain economic tasks would be performed by firms, and when they would be performed on the market. Transaction cost reasoning became most widely known through Oliver E. Williamson's *Transaction Cost Economics*. Today, transaction cost economics is used to explain a number of different behaviors. According to Williamson, the determinants of transaction costs are frequency, specificity, uncertainty, limited rationality, and opportunistic behavior [Williamson 1985].

Activity-based costing (**ABC**) is a costing methodology that identifies activities in an organization and assigns the cost of each activity with resources to all products and services according to the actual consumption by each. This model assigns more indirect costs (overhead) into direct costs compared to conventional costing.

Although the activity based costing basically includes calculation of indirect costs and their assignment to activities, there is still a possibility to estimate the indirect costs based on more general data. This can be done in cases where the actual focus is not on the indirect costs but on impact on other cost components. Especially in transaction costs the labour costs are most significant cost elements, and the transaction costs can be calculated with enough precision with the help of labour costs. This makes it possible to use transaction cost analysis and activity based costing also in FITMAN. As in every other measurement, the focus has to be kept in the most significant elements and the measurement as a whole has to be as simple as possible.

3.4 Description of STEEP

The framework STEEP, an acronym for Social, Technological, Economic, Environmental, and Political, is a tool that looks on the external business environment (AWARE, 2012).
Using STEEP, it is possible to identify and to monitor the various external factors that cause change in business, organization, or the global environment. Furthermore, STEEP analysis points out the information that should be used by decision makers to improve existing strategic plans. That is why the tool is used as an environmental scanning component in the futurology as well as in strategic management.
Following the draft “STEEP analysis output”, the STEEP analysis is based on the 3 circles model of Colin Eden and Kees van der Heijden which describes three aspects of an organizations business environment - the internal organization environment, the external transactional environment and the wider contextual environment (GCVSDPA Futures Group, 2009, p. 2).

3.5 Choice of Business Performance Indicator for FITMAN

Finally we have preselected several methods in the previous paragraph. Now we will select one, the most adapted to FITMAN project.

Concerning SCOR and VCOR it is adapted to the context of Supply Chain systems. If we consider the FITMAN Trials, except perhaps in the domain of Virtual Manufacturing, the two others domains are not connected with Supply Chain environment.
ECOLEAD has produced a method VOPM (Virtual Organisation Performance Measurement) adapted to Virtual Organisation which is not the case of the FITMAN Trials.

Activity Based Costing is an appropriate method to calculate the cost of the activity taking in account not only the cost of Manufacturing but all the costs which must be associated to the realization of the product as design, evaluation of quality, marketing , commercial…. This method cannot be used to determine the BPI but could be associated to calculate the value of BPIs.

Then we have to take in consideration the four BPI methods: the most used in industrial environment are BSC and ECOGRAI.

We must notice that there is a link between BSC and ECOGRAI: at the origin Kaplan has developed some cooperation with the authors of ECOGRAI. BSC is oriented to the determination of KPI at the strategic level of the enterprise, ECOGRAI can be used at all level of the decisional structure of a manufacturing system: Strategic Tactical and Operational.
We have seen also that ECOGRAI links the PIs with the reaching of the objective by evaluating the effect of the DV/AV. By this link we can determine rapidly the corrections to

improve the situation. ECOGRAI is the alone method which owns this feature. The second advantage is also to limit the number of PIs.
For these reasons we propose to use ECOGRAI in FITMAN.
We notice that this recommendation is coherent with those written in the DOW.

The liaison between ECOGRAI and STEEP, is realized by taking in consideration various type of objectives linked with the nature of STEEP domains (Social, Technological, Economic, Environmental, and Political). For example if we choose a Social Objective, the PI which will evaluate the reaching of the objective on the influence of the DV/AV, will have a social meaning.

The V&V method described in D 2.1 will be used to determine the Technical Indicators.

4. FITMAN Technical (IT) and Business Performance Indicators

In this chapter we will describe the Technical Indicators and the Business Performance Indicators

4.1 Technical Indicators (TI)

The technical indicators that will be used in the FITMAN project for the Validation and the Verification of the software products that will be developed and used are described in this chapter. The indicators are based on the V&V technical criteria presented in Deliverable 2.1 and their scope is to assess the extent to which objectives are achieved both for individual software components (i.e. GEs, SEs and TSC) and for the complete software solutions that will be installed in the trials.
As opposed to the business indicators which depend on the category of the trials (smart/ digital/ virtual), the scope of the technical indicators is by default generic since they can be applied in all cases. However for each software component/system under verification or validation, the indicators that will be used depend on the testing techniques which will be selected and applied as part of the software development process.
The data to evaluate the indicators are collected by the stakeholders involved in V&V methodology and during the methodology's steps (See FITMAN D2.1. V&V Method). Some data, mostly those that concern the quantitative metrics, are extracted directly from the platforms such as analytics and others may be retrieved from users through crowd engagement methods.
In the table that follows, each V&V criterion is linked to a set of indicators which have been selected and/or developed in order to cover all the identified aspects of the V&V processes of FITMAN and to assess the quality dimensions of the examined software components and systems.

4.1.1 List of selected Technical Indicators

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
FITMAN GE/SE specific criteria	**Openness** Ensuring that specific people groups may access the software for free with specified rights (depending on the level of openness) (Rakitin, 2001) (Fahmy, Haslinda, Roslina, & Fariha, 2012)	**Openness Level** A measure of defining the level of openness (0:common understanding – 1:provision – 2:availability – 3:participation)	Level 0: Open specifications – Developers can view & study the requirements posed and implement them as they wish	High
			Level 1: Enablers as a Service – Developers can utilize software provided as a service through open interfaces	
			Level 2: Releasing code as open source - Developers can inspect, download, run and improve the open source code according to their needs.	
			Level 3: Consulting with the use cases about their needs and collaboratively contributing to the source repository, design documents, and bug reports	
	Versatility The ability to deliver consistently high performance in a very broad set of application domains, from server workloads, to desktop computing and embedded systems	**Generic Enablers Usage Index** Proportion of GEs that were used by any (at least one) trial	Number of used GEs/ number of all GEs	High
		Average Generic Enablers Usage per Trial Average number of GEs used in each trial	Sum of the amount of GEs used in each trial/ number of all GEs	High
Functionality The capability of the software to	**Correctness** The degree to which a system is	**Fault Detection** A measure of how many defects	Number of faults detected / Estimated number expected for	Medium

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
provide functions which meet the stated and implied needs of users under the specified conditions of usage	free from defects in its specification, design, and implementation. (Rakitin, 2001) (Meyer, 1997) (Wilson, 2009)	were detected in the reviewed software product. (Rakitin, 2001) (Felici, 1999)	the current development stage	
		Module fault density A measure of how many faults were identified in average per module. (Rakitin, 2001) (Felici, 1999)	Number of identified faults / Number of software modules	Medium
		Data integrity A measure of how accurate and consistent data are maintained and assured over the entire life-cycle.	Number of identified situations where data integrity constraints or rules are not respected / Reference period	Medium
	Interoperability The capability of the software to interact with other systems (Rakitin, 2001) (Fahmy, Haslinda, Roslina, & Fariha, 2012)	**Interoperability Maturity Level** A measure of how mature in terms of interoperability the software is.	Level 2: Integrated Approach (common format for all models), Level 1: Unified Approach (common format only existing at meta-level, Level 0: Federated Approach: no common format at all	Medium
	Security The capability of the software to prevent unintended access and resist deliberate attacks intended to gain unauthorized access to confidential information (Rakitin, 2001) (Fahmy, Haslinda, Roslina, &	**Authentication Mechanism Integrity** A measure of how many incidents related to authorization issues (when not licensed actions are authorized and/ or not licensed actions are authorized) were reported in a specific	Number of authorization incidents/reporting period	Medium

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
	Fariha, 2012)	period (Savola & Abie, 2009)		
Reliability The capability of the software product to maintain a specified level of performance when used under specified conditions	**Software maturity** The capability of the software to avoid failure as a result of faults in the software (Fahmy, Haslinda, Roslina, & Fariha, 2012) (ISO/ IEC, 2001)	**Software Maturity Index (SMI)** A measure of product stability based on IEEE Standard Dictionary of Measures to Produce Reliable Software (IEEE, 1988)	SMI = (M - (A + C + D)) / M where: M = number of modules in current version A = number of added modules in current version C = number of changed modules in current version D = number of deleted modules in current version compared to the previous version	Low
		Failure density against test cases A measure of how many failures were detected during a defined trial period. (ISO/ IEC, 2001)	Total number of failures that are resolved and never reoccur during the trial period / Total number of failures that were detected	Low
		Failure resolution A measure of how many failure conditions are resolved without reoccurrence. (ISO/ IEC, 2001)	Number of corrected defects / Number of actually detected defects	Low
	Fault Tolerance The capability of the software to maintain a specified level of performance in case of software faults or of infringement of its specified interface.	**Failure Avoidance** A measure of how many fault patterns were brought under control to avoid critical and serious failures. (ISO/ IEC, 2001)	Number of fault patterns that were explicitly avoided in the design and code / Number to be considered as defined by the requirements specification document	Medium

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
	(Fahmy, Haslinda, Roslina, & Fariha, 2012) (ISO/ IEC, 2001)	**Incorrect Operation Avoidance** A measure of how many functions are implemented with specific designs or code added to prevent the system from incorrect operation. (ISO/ IEC, 2001)	Number of incorrect operations that are explicitly designed to be prevented / Number of incorrect operations to be considered according to the requirements	Low
		Breakdown avoidance A measure of how often the system being tested causes the breakdown of the total production environment. (ISO/ IEC, 2001)	Number of total breakdowns of the system being tested / Number of failures of the total production environment	Low
		Failure avoidance level A measure of how many fault patterns were brought under control to avoid critical and serious failures. (ISO/ IEC, 2001)	Avoided critical and serious failure occurrences against test cases for a given fault pattern / Number of executed test cases for the fault pattern	Low
		Incorrect operation avoidance A measure of how many system functions are implemented with the ability to avoid incorrect operations or damage to data. (ISO/ IEC, 2001)	Number of test cases that pass (i.e., without any critical or serious failures) / Total number of test cases run	Low
	Recoverability The capability of the software to re-establish its level of performance and recover the	**Back up readiness on breakdown** A measure of how much time to back up in abnormal/breakdown	Time required to back up in case of breakdown	Low

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
	data directly affected in the case of a failure (Fahmy, Haslinda, Roslina, & Fariha, 2012) (ISO/ IEC, 2001)	cases is required. (Software Improvement Group, 2011)		
		Restorability A measure of how capable the system is to restore itself to full operation after an abnormal event or request. (ISO/ IEC, 2001)	Number of restoration requirements that have been implemented to meet the target restore time / Total number of requirements that have a specified target time	Low
		Availability Index (AI) A measure of how available the system is for use during a specified period of time. This is calculated by testing the system in an environment as much like production as possible, performing tests against all system functionality (ISO/ IEC, 2001)	AI = To / (To + Tr) where To is the total operation time Tr is the time the system takes to repair itself (such that the system is not available for use)	Medium
		Mean recovery time A measure of the average time it takes for the system to automatically recover after a failure occurs (ISO/ IEC, 2001)	Sum of time to recover for each failure / Number of test cases that triggered a failing condition for which recovery occurred	Low
		Restore effectiveness A measure of how effective (successful and in time) the restoration capability of the system is	Number of test cases where restoration was successfully completed within the target time / Number of test cases performed	Low

Criteria Category	**Criterion**	**Indicators**	**Indicators' Formulas**	**FITMAN priority**
		(ISO/ IEC, 2001)		
Usability The capability of the software product to be understood learned, used and attractive to the user, when used under specified conditions	**Understandability** The capability of the software product to enable the user to understand whether the software is suitable, and how it can be used for particular tasks and conditions of use. (Syahrul Fahmy et. al., 2012) (SQRL, 2013)	**Users' required IT background Level** A measure of how much understandable the system is depends on the necessary skills of a user (so as to be able to become moderately efficient without receiving training)	User background: - Novice user - Experienced IT user - IT Professional	High
	Ease of learning (learnability) The capability of the software product to enable the user to learn its applications. (Syahrul Fahmy et. al., 2012) (SQRL, 2013)	**Learning time** A measure of how much time is required for being able to use the software (Rakitin, 2001) (Batouche, 2012)	Time for a new user (to the specific product) to learn how to perform basic functions of the software	High
		Time to expertise A measure of how much time is required for becoming an expert in using the software (Rakitin, 2001) (Batouche, 2012)	Average time to master the component's functionality	High
	Operability The capability of the software product to enable the user to operate and control it (Syahrul Fahmy et. al., 2012) (SQRL, 2013)	**Operation time** A measure of how much time is required for performing typical/ usual operations (Batouche, 2012)	Time required for performing typical/ usual operations with the software	High
	Attractiveness The capability of the software	**Users' attraction level** A measure of how many users	Number of users stating that they would like to use the	High

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
	product to be liked by the user.	are willing to use the software of all the users who have tried it	software often/ Number of users who have tried the software	
		Users' engagement time A measure estimating the extent to which users are engaging with the software	Average time spent on the system/ Number of active users (those stating that they would like to use the software often)	High
		Users' satisfaction level regarding system's attractiveness: A measure of how much users find the system's use attractive	Percentage of users considering the system attractive	High
Efficiency The capability of the software product to provide appropriate performance, relative to the amount of resources used, under stated conditions	**Time Behaviour** The capability of the software to provide appropriate response and processing times and throughput rates when performing its function under stated conditions (e.g. latency) (Fahmy, Haslinda, Roslina, & Fariha, 2012)	**Internal Response time** A measure of how much time is required for a given task to be performed (ISO/ IEC, 2001)	Estimated time to perform a given task.	Low
		Internal Turnaround time A measure of how much time is required to complete a group of related tasks performing a specific job (ISO/ IEC, 2001)	Average time to complete the task/ Required mean time to response	Low
		System Response time A measure of how much time is required before the system responds to a specified operation (ISO/ IEC, 2001)	Time required before the software responds to a specified operation.	Low
		Throughput A measure of the estimated number of tasks that can be	Number of completed tasks/ Pre-defined time period	Low

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
		performed over a unit of time (ISO/ IEC, 2001)		
		System Turnaround time A measure of the waiting time the user experiences after issuing a request to start a group of related tasks until their completion. (ISO/ IEC, 2001)	Average waiting time the user experiences after issuing a request to start a group of related tasks until their completion.	Low
		Waiting time A measure of the proportion of time users spend waiting for the system to respond (ISO/ IEC, 2001)	Total time the user spent waiting/ actual task time when the system was busy	Low
	Resource Behaviour The capability of the software to use appropriate resources in an appropriate time when the software performs its function under stated condition. (Fahmy, Haslinda, Roslina, & Fariha, 2012)	**I/O utilization** A measure of how many buffers are required to complete a specified task (ISO/ IEC, 2001)	Number of buffers required (calculated or simulated)/specified task completion	Low
		I/O utilization message density A measure of how many I/O-related error messages are identified in a number of lines of code directly related to system calls (ISO/ IEC, 2001)	Number of I/O-related error messages/ number of lines of code directly related to system calls	Low
		Memory utilization A measure of how much memory is occupied in average by the software system for a	Memory size the software system occupies to complete a set of specified tasks/ number of specified tasks	Low

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
		specific task to be completed (ISO/ IEC, 2001)		
		Transmission utilization A measure of the amount of transmission resources that will likely be needed based on an estimate of the transmission volume for performing tasks. (ISO/ IEC, 2001)	Number of items related to efficiency compliance that are judged as being correctly implemented/ total number of compliance items	Low
		I/O-related errors A measure of how often the user encounters I/O type problems. (ISO/ IEC, 2001)	Number of warning messages or errors encountered/ user operating time	Low
		User waiting time of I/O devices utilization A measure of the impact of I/O utilization on the waiting time for users. (ISO/ IEC, 2001)	Waiting times required while I/O devices operate	Low
Portability The capability of the software product to be transferred from one environment to another	**Adaptability** The capability of the software to be modified for different specified environments without applying actions or means other than those provided for this purpose for the software considered. (Rakitin, 2001) (Fahmy, Haslinda, Roslina, & Fariha, 2012)	**Adaptability of data structures** A measure of how adaptable the product is to data structure changes. (ISO/ IEC, 2001)	Number of data structures that are correctly operable after adaptation / Total number of data structures needing adaptation	Low
		System software environmental adaptability A measure of how adaptable the software product is to system-software-related environmental changes.	Number of implemented functions that are capable of achieving required results in specified multiple system software environments / Total number of functions	Low

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
		(ISO/ IEC, 2001)		
		User environment adaptability (or Porting user friendliness) A measure of how easily a user can adapt software to the environment. (ISO/ IEC, 2001)	Time spent by the user to complete adaptation of the software to the user's environment when the user attempts to install or change the setup	Low
	Installability The capability of the software to be installed in a specified environment. (Rakitin, 2001)	**Installation time** A measure of how much time is required for a typical installation of the software (Rakitin, 2001)	Time required for installing the software	Low
		Ease of setup retry A measure of how easy it is expected to be to repeat the setup operation. (ISO/ IEC, 2001)	Number of implemented retry operations for setup / Total number of setup operations required	Low
		Installation effort A measure of the level of effort that will be required for installation of the system. (ISO/ IEC, 2001)	Number of automated installation steps / Total number of installation steps required	Low
		Installation flexibility A measure of how customizable the installation capability is estimated to be. (ISO/ IEC, 2001)	Number of implemented customizable installations / Total number of customizable installations required	Low
		Ease of installation A measure of how easily a user	Number of cases in which a user succeeded in changing the install	Low

Criteria Category	Criterion	Indicators	Indicators’ Formulas	FITMAN priority
		can install software to the operational environment. (ISO/ IEC, 2001)	operation for their own convenience / Total number of cases in which a user tried to change the install procedure	
	Coexistence The capability of the software to coexist with other independent software in a common environment sharing common resources (Rakitin, 2001)	**Internal coexistence** A measure of how flexible the system is expected to be in sharing its environment with other products without adverse impact on them. (ISO/ IEC, 2001)	Number of systems / products with which the product is expected to coexist / Total number of systems / products in the production environment that require such coexistence	Low
		External coexistence A measure of how often a user encounters constraints or unexpected failures when operating concurrently with other software. (ISO/ IEC, 2001)	Number of constraints or failures that occur when operating concurrently with other software / Time duration of operation	Low
	Replaceability The capability of the software to be used in place of other specified software in the environment of that software. (Rakitin, 2001)	**Continued use of data** A measure of the amount of original data that is expected to remain unchanged after replacement of the software. (ISO/ IEC, 2001)	Number of data items that remain usable after replacement / Number of old data items that are required to be usable after replacement	Low
		Function inclusiveness A measure of the number of functions expected to remain unchanged after replacement. (ISO/ IEC, 2001)	Number of functions in the new software that produce results similar to the results displayed by the same functions in the old software / Number of old functions	Low

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
		Use support functional consistency A measure of how consistent the new components are to the existing user interface. (ISO/ IEC, 2001)	Number of functions found by the user to be unacceptably inconsistent to the user's expectations in the user interface / Number of new functions	Low
	Hardware independence Degree to which the software is dependent on the underlying hardware	**Hardware Dependencies** A measure of defining the degree to which the software is dependent on the underlying hardware (Rakitin, 2001)	Number of software modules specifically dependent on underlying hardware	Low
Maintainability A set of attributes that bear on the effort needed to make specified modifications	**Analysability** The capability of the software product to be diagnosed for deficiencies or causes of failures in the software or for the parts to be modified to be identified. (ISO9126) (McCall, J. A. et al, 1977)	**Activity recording** A measure of how thoroughly the system status is recorded. (ISO/ IEC, 2001)	Number of items implemented that actually write to the activity log as specified / Number of items that should be logged as defined in the specifications	Low
		Diagnostic functions operability A measure of how many diagnostic functions are implemented and operate successfully (ISO/ IEC, 2001)	Number of diagnostic functions that have been implemented and operate successfully	Low
		Audit trail capability A measure of how easy it is for a user (or maintainer) to identify the specific operation that caused a failure. (ISO/ IEC, 2001)	Number of data items that are actually logged during the operation / Number of data items that should be recorded to sufficiently monitor status of the software during operation	Low

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
		Diagnostic function report A measure of how capable the diagnostic functions are in supporting causal analysis. In other words, can a user or maintainer identify the specific function that caused a failure? (ISO/ IEC, 2001)	Number of failures successfully analysed using the diagnostic functions / Total number of registered failures	Low
	Changeability The capability of the software product to enable a specified modification to be implemented.	**Change recordability** A measure of how completely changes to specifications and program modules are documented. (ISO/ IEC, 2001)	Number of changes that have comments or documentation / Total number of changes made	Low
		Modification complexity A measure of how easily a developer can change the software to solve a problem. (ISO/ IEC, 2001)	Sum of the work time spent to change a specific failure per change / number of changes	Low
		Software change control capability A measure of how easily a user can identify a revised version of the software. (ISO/ IEC, 2001)	Number of items actually written to the change log / Number of change log items planned such that the software changes can be fully traced	Low
	Stability The capability of the software to minimize unexpected effects from modifications of the software.	**Change impact** A measure of the frequency of adverse reactions after modification of the system. (ISO/ IEC, 2001)	Number of adverse impacts / Number of modifications made	Low

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
		Change success ratio A measure of how well the user can operate the software system after maintenance without further failures. (ISO/ IEC, 2001)	Number of cases in which the user encounters failures after the software is changed / Number of times the user encounters failures before the software is changed	Low
		Modification impact localization This is also a measure of how well the user can operate the system without further failures after maintenance. (ISO/ IEC, 2001)	Number of failures that emerged after modification of the system within a specified timeframe / Number of resolved failures	Low
	Testability The capability of the software product to enable modified software to be validated (ISO/ IEC, 2001) (McCall, J. A. et al, 1977)	**Built-in test functions** A measure of how complete any built-in test capability is (ISO/ IEC, 2001)	Number of built-in test functions implemented per software module	Low
		Autonomy of testability A measure of how independently the software system can be tested. (ISO/ IEC, 2001)	Number of dependencies that have been simulated using stubs or drivers / Total number of dependencies on other systems	Low
		Availability of built-in test function A measure of how easily a user or a developer can perform operational testing on a system without additional test facility preparation. (ISO/ IEC, 2001)	Number of cases in which the developer can use built-in test functionality / Number of test opportunities	Low

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
		Re-test efficiency A measure of how easily a user or a developer can perform operational testing and determine whether the software is ready for release or not. (ISO/ IEC, 2001)	Total time spent to make sure the system is ready for release after all failures are resolved / Number of resolved failures	Low
	Code Consistency Level of use of uniform design, implementation techniques and notation	**Cohesion ratio** A measure of how well modules fit together (Felici, 1999)	Number of modules having functional cohesion / Total number of modules	Low
	Modularity The extent to which a software product may be divided into smaller modules that are capable of serving a specified function.	**Cohesion to Coupling:** A measure of how modular the software is, in terms of how high the cohesion ratio is in contrast to how low the degree of coupling is, where: (new addition) • Cohesion refers to the degree to which the elements of a module belong together and suggests how strongly-related each piece of functionality expressed by the source code of a software module is. • Coupling is the degree of interdependence between	Cohesion ratio/ coupling degree= no of modules having functional cohesion/ no of modules interacting • Cohesion ratio= Number of modules having functional cohesion / Total number of modules • Coupling degree= Number of modules interacting / Total number of modules	Medium

Criteria Category	Criterion	Indicators	Indicators' Formulas	FITMAN priority
		modules and is the measure of the strength of association established by a connection from one module to another. The modularity indicator increases when cohesion is high and coupling is low		

4.1.2 Technical indicator for FI-WARE GE Versatility

The evaluation of the versatility criterion is proposed here after in the context of FIWARE vision.

4.1.2.1 FI-WARE vision

FI-WARE has the following vision and goal:

“The high-level goal of the FI-WARE project is to build the Core Platform of the Future Internet. This Core Platform, also referred to as the “FI-WARE Platform” or simply “FI-WARE” …, will dramatically increase he global competitiveness of the European ICT economy by introducing an innovative infrastructure for cost-effective creation and delivery of **versatile** digital services, providing high QoS and security guarantees.

Thus versatility of digital services is mentioned in the FI-WARE goal. In FI-WARE glossary versatility is not defined.

4.1.2.2 Some definitions and approaches for versatility

Versatility – general definition

As a general term versatility is defined for example in the following way (thefreedictionary):

1. *Capable of doing many things competently*.

2. *Having varied uses or serving many functions*

3. *Variable or inconstant; changeable*

4. *Biology* Capable of moving freely in all directions, as the antenna of an insect, the toe of an owl, or the loosely attached anther of a flower.

This definition is on a very general level and it requires adaptation to the FITMAN context. Of course, at the general level no metrics for versatility are available.

Versatility – example from software engineering

Versatility is often mentioned when describing the applicability of software but most often no definition for it has been presented. Filho et al. (2005) discuss the versatility of middleware / infrastructures and define it as “*the ability of a computational system to serve multiple purposes or to accommodate the requirements of different use situations*”. They define the following requirements for versatility in the context of middleware :

- Techniques for Software Evolution. These techniques allow a piece of software to incorporate changes due to (functional and non-functional) requirements evolution. Techniques in this category are focused in three main sub-areas:
  - · Extensibility (or enhancement) techniques.
  - · Programmability techniques. They allow the customization and modification of the behavior of existing software.
  - · Reuse techniques: Those techniques allow the modularization of certain aspects of software, permitting the incorporation of existing functionality, wrapped as special software pieces (or components), in the construction of new software.
- Techniques for Software Variability (or flexibility). The techniques are used to manage the contraction and expansion of software in order to support different functional and non-functional requirement sets. The techniques may be applied

statically, before the software is built and deployed, or dynamically, in the field, after the software is deployed.

- Usability Techniques for Software Engineering. In order to be useful, and fulfil its purpose, software must be usable by those who will use it.

Besides the above qualities of versatility, other essential requirements are proposed: scalability, interoperability, heterogeneity, network communication and coordination. Filho et al. (2005) analyse different middleware approaches through these characteristics. No metrics for versatility are presented.

Versatility and versatility metrics in computer architecture field

In computer architecture field an example about versatility and versatility metrics can be found (Rabbah et al. 2004). Here versatility has been defined for processors as: "*versatility, or the ability to deliver consistently high performance in a very broad set of application domains, from server workloads, to desktop computing and embedded systems*" (Rabbah et al. 2004). Rabbah et al. also define metrics for processor versatility: a *versatility index*. The main measure of processor architecture is here speedup for each application. To define the versatility index, for each application the speedup is compared to the reference speedup (best performance) and the index is derived through calculation of a geometric mean of the ratios (speedup/ reference speedup). Using a geometric mean instead of an arithmetic mean has the property that if just one of the performances of the application areas is zero, the index is zero. Thus in this case versatility requires that the processor is able to perform for all application areas.

4.1.2.3 Versatility in FITMAN context

The definitions coming from different fields (above) have been consolidated into Table 1 with the idea to identify corresponding definitions. From the software point of view points 1-2 of the general definition (many things/ varied uses) above seem to be near each other. However, in the table they have been kept separate with the interpretation that many things refer to the collection of GEs and multiple uses refer to the single GE level. Point 3 "changeable" corresponds clearly the "software evolution" requirement in the middleware approach (Filho et al. 2005). A question is if this is relevant in FITMAN context: is it expected that the FI-WARE GEs are used in their current form in FITMAN or is it expected that they are modified for the trials?

Generic definition (thefreedictionary)	**Middleware versatility** (Filho et al. 2005)	**Architecture/ processor versatility** (Rabbah et al. 2004)	**Proposal for FITMAN versatility**
1. Capable of doing many things competently	Usability (included in versatility), other requirements: scalability, interoperability, heterogeneity, network communication and coordination	High performance, speedup	*Versatility criteria: The collection of FI-WARE GEs as a whole* can be used for multiple functions. In FITMAN the software quality characteristics (like usability) are not included in versatility but they are handled through separate technical indicators.
2. Having varied	Software	Several	*At a service/ GE level*: A

uses or serving many functions	variability/ flexibility	applications	specific GE is able to perform the function for which it is developed in multiple scales, focus areas and environments.
3. Variable or inconstant; changeable	Software evolution	-	FI-WARE GEs can easily be modified for trial use – is this expected in FITMAN?

Table 4: Different definitions of versatility

4.1.2.4 Measuring versatility in FITMAN

Based on the definition above versatility may have different focuses in FITMAN:
- Versatility of the collection of FI-WARE GEs as a whole
- Versatility at a single GE level.

Additionally it would be possible to analyse versatility at the level of different FI-WARE chapters (FI-WARE wiki). The interpretations at the different levels are shown in Table 5.

Versatility focus	**Versatility interpretation**	**Potential versatility metrics**
Versatility of FI-WARE GE package	As a whole the FI-WARE GEs can be used for multiple functions.	From Fi-WARE GE package viewpoint: *Proportion of GEs that were used by some trial = number of used GEs/ number of all GEs* *Average GE usage/ trial =Sum of the numbers of GEs used in each trial/ number of all GEs* From the trial viewpoint: *Proportion of the functions in the trial that could use some GE*
Versatility of a single FI-WARE GE	A GE is able to perform its function in multiple scales and environments A GE can easily be modified by the user. Out of the scope in FITMAN?	For each GE: *Applicability in manufacturing: Number of trials that could use a single GE.* *Changeability out of the scope in FITMAN?*

Table 5: Versatility focus areas in FITMAN

To define the metrics finally, some clarifications should be needed:

- What do we mean with using a GE? Should we separate the level of GE specification and GE implementation? This is better known after the selection of the GEs for trials.
- What do we consider as a function in a trial? (trial viewpoint measure)
- Is changeability of GEs out of the scope in FITMAN?

As these questions cannot be answered yet in this phase of the project *it is recommended to keep the versatility metrics as simple and clear as possible*. Thus the following metrics are proposed (only GER package level):

Versatility_GE package usage index = Proportion of GEs that were used by any (at least one) trial =
number of used GEs/ number of all GEs:

$$\text{Versatility\_GEpackage\_index} = N_{usedforany} / N_{all}$$

Versatility_Average GE usage/ trial =Sum of the amount of GEs used in each trial/ number of all GEs:

$$\text{Versatility\_Average\_GE\_usage} = \sum^{trials} N_{usedfor\ trial} / N_{all}$$

Note: While comparing the metrics proposed in Table 2 to the versatility index of Rabbah et al. (2004) it should be noted that while Rabbah et al. use a geometric mean to evaluate over different dimensions/uses, here arithmetic mean/ average is used. The geometric mean is good if the versatility requires that the evaluated object should be able to fulfil the needs of *all* the uses. Using a geometric mean here would mean that a GE is versatile only if it can be used in all the trials (versatility index is zero if the object has no use just in one case). This is not the case in FITMAN; that's why for the average value arithmetic mean is more suitable.

To evaluate the proposed metrics, the following data is needed:

- the total number of Fi-WARE GEs available (N_{all})
- list of GEs used by each trial

The information could be collected into a table like Table 3. The column of each trial could be part of the Trial handbook.

GE_i $Trial_i$	Trial 1	Trial 2…	Trial n
GE1	x	x	
GE2…		x	
GEn	x		x

Table 6: GE usage data

4.2 Business Performance Indicators for the Trial

4.2.1 ECOGRAI simplified method

For this application we will use a simplified version of ECOGRAI with only three phases in order to, have to facilitate the application, and to be adapted to the size of trials and the duration of the project.

First Phase: Description of the system in which the performance indicators will be defined. It is impossible to determine Performance Indicators (PIs) for any kinds of activities, if we don't know in which conditions these activities are performed. So it is necessary to describe the system where these PIs will be determined.
For that we use System Modeling which was developed after the second world war in United States but also in Europe in numerous domains: Biology, Computer Sciences, Energy, Organisation, Enterprise, Economy, …etc.

To describe a system using System Modeling we need to determine:

- The elements which compose the system and the relations between these elements.
- The functions which allow to reach the objectives.
- The processes which support the dynamic transformations.
- The boundary which delimits the elements which don't belong to the system. It could be interesting to evaluate the influence of these external elements on the running of system. We recommend to list only the elements outside of the system.
- The dynamic of evolution of the system, particularly in the case of the evolution from AS IS to TO BE. In fact a system is always evolving, if not it die. The speed of evolution could be low or rapid.
- The objectives assigned to the system.

Second Phase: According to the objective of the system the owner of the system determines the potential actions to reach these objectives (called Decision Variables (DV) or Action Variables (AV)).
Third Phase: the performance indicators indicate or characterize the reaching of the objectives by using the DV/AV.

To collect the information on the trials we have used the Trials Handbook Chapters 1 and 2, available on FITMAN platform:
http://www.fitman-fi.eu/intranet/wp-folders/wp1-fitman-baseline-system/d1.1.-use-case-scenarios-and-business-requirements/chapter-1-chapter-2-data-gathering/chapters-questionaries-from-trials-data-gathering.

4.2.2 Application of ECOGRAI to SMART Factory

4.2.2.1 TRW Trial (ES)

Application of simplified ECOGRAI to TRW Trial

Phase 1- Description of the system:

Elements of the system:
- Prevention technician
- H&S coordinator
- Blue collar worker
- Information systems technician
- Manager of the company
- Operation technician
- Production line
- Wharehouse

Functions (Static) and Processes (Dynamic)
- TRW assemblies and manufactures power steering systems for passenger cars and commercial vehicles

Boundary of the system
- Customers

Dynamic, evolution of the system

Objectives for scenario 1 (given by TRW):

- Effective and consistent prevention strategy
- Optimization of prevention costs

Objectives for scenario 2 (given by TRW):

- Reduction of accidents and incidents
- Increase of the productivity

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To implement The FASyS system
- To adopt the FI-Ware technologies

Criteria:

- Quality
- Delay
- Cost
- Safety

Phase 3: Determination of Performance Indicators

Performance indicators for scenario 1:

- Decrease of events: *Reduction of the number of accidents and incidents in the factory*
- Optimization of cost of accidents and incidents: *Increase of the profitability of the investment in preventive strategy*
- Decrease of errors in the prevention strategy: *Reductions of the human errors in the design of the planning*
- Increase of the modelled risks and active preventions: *Number of risks that has been defined using the new system*

Performance indicators for scenario 2:

- Decrease of events*: Reduction of the number of accidents and incidents in the factory*
- Decrease the rate of absenteeism: *Reduction in the average number of workers sick leave*
- Increase the number of alarms and alerts*: Rise in the risk detections, alarms and warnings*
- Increase the number of H&S systems: *Rise in the deployed monitoring systems*
- Decrease the number of workers with diseases*: Reduction in occupational diseases*
- Increase the number of training sessions*: Rise in the training sessions regarding H&S*
- Increase of the productivity: *Rise in the produced units*

Example for TRW:

Objective	DV/AV	PI
Reduction of accidents and incidents	To use the FaSYS system	PI: Ratio: Number of accidents and incidents in the factory after / before the DV/AV implementation during a period*
Increase of the productivity	To use the FASyS system	PI: Ratio: Number of employees feel well after / before the implementation of the DV/AV during a period

4.2.2.2 Whirlpool Trial (IT)

Application of simplified ECOGRAI to Whirlpool Trial

Phase 1- Description of the system:

Elements of the system

- Production, assembly, delivery
- Two identical parallel production lines
- Washing Unit Line, Assembly Line, Testing and Final Assembly
- Shopfloor workers, supervisors, managers

Functions (Static) and Processes (Dynamic)

- To produce different models of washing machines (Production, assembly, delivery)

Objectives of Whirpool

- Improve the communication effectiveness along the help chain organization
- Improve the effectiveness of decision makers, their role , along the help chain

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To implement “Event driven scenario” and “Big data scenario”

Criteria:

- Quality
- Delay
- Cost

Phase 3: Determination of Performance Indicators

Performance indicators:

- First Pass Yield: *is the percentage of good product produced without any repaired defect*
- Overall Equipment Efficency: *is the total amount of time used to produce good product versos the total available time.*
- Service Incidence Rate: *amount of service call recorded in a time frame versus the total production in the same period*
- Engagement level: *a measure of how the workforce is engaged through an yearly survey*
- Conversion Cost: *Is the real cost the factory incurring to transform raw material and components to products*

Example for Whirlpool:

Objective	DV/AV	PI
Improve the communication effectiveness along the help chain	To use WHIRLPOOL trial platform	PI: Ratio: Time of reaction on a manufacturing event after / before the DV/AV implementation during a period*
Improve the effectiveness of decision makers along their role in help chain	To use WHIRLPOOL trial platform	PI: Ratio: % of good products produced without any repaired defect after/before the DV/AV implementation during a period*

4.2.2.3 COMPlus Trial (DE)

Application of simplified ECOGRAI to COMPlus Trial

Phase 1- Description of the system:

Elements of the system

- Design, production, maintenance (comment: it would be suitable to be more precise)
- Manager, Coordinator, Clients, Provider, Developer, Blue Collar Workers

Functions (Static) and Processes (Dynamic)

- To develop software for different industries and markets (Design, production, maintenance) (F)

Boundary of the system

- The external stakeholders (partners, customers, etc.)

Dynamic, evolution of the system

Objectives of COMPlus

- Reduction of the development time about 50%
- Reduction of mistakes and errors

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To use the General Enablers of the FI-Ware Platform
- To build a private cloud data center

Criteria:

- Quality
- Delay

Phase 3: Determination of Performance Indicators

Performance indicators:

- Reduction of the development time*: Reduction of the development time from 3 to 1.5 years*
- Reduction of mistakes and errors*: Reduction of mistakes and errors*
- Uniform IT landscape*: Works with uniform web applications on the network*

Example for COMPlus:

Objective	DV/AV	PI
Reduction of the product development time	To use ComPLUS trial platform	PI: Ratio: Average development time after / before the DV/AV implementation during a period*
Reduction of mistakes and errors in the product designed	To use ComPLUS trial platform	PI: Ratio: Number of mistakes and errors after / before the DV/AV implementation during a period*

4.2.2.4 Piacenza Trial (IT)

Application of simplified ECOGRAI to Piacenza Trial

Phase 1- Description of the system:

Elements of the system

- Production, delivery ,yarn dyeing, weaving (warping, weaving and raw control) and finishing (wet finishing, raising and dry finishing)
- production machineries, labour force, Raw material storage, yarn storage, Production
- manager, Production operator, Sales manager, Controller, Sales operator

Functions (Static) and Processes (Dynamic)

- To produce textile (Production, delivery ,yarn dyeing, weaving (warping, weaving and raw control) and finishing (wet finishing, raising and dry finishing))

Boundary of the system

- The external stakeholders (partners, customers, etc.)

Objectives of Piacenza

- Better exploitation of internal and external production capacity
- Improved monitoring of production capacity

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To adopt FITMAN “cloud production”
- To implement RF-ID (Radio Frequency Identification) technology

Criteria:

- Cost
- Delay

Phase 3: Determination of Performance Indicators

Performance indicators:

- Machinery exploitation: *Machine cost / produced unit*
- Production time: *Time per meter*
- Energy for supporting systems per meter: *Kwh per meter*
- Gas for supporting systems per meter: *m3 per meter*

Example for Piacenza:

Objective	DV/AV	PI
Better exploitation of internal production	To use Piacenza trial platform	PI: Ratio: Cost per produced unit after / before the DV/AV implementation during a period*
Improve monitoring of production capacity	To use Piacenza trial platform	PI: Ratio: Capacity available at equal number of machines after / before the DV/AV implementation during a period*

4.2.3 Application of ECOGRAI to DIGITAL Factory

4.2.3.1 AIDIMA Trial (ES)

Application of simplified ECOGRAI to AIDIMA Trial

Phase 1- Description of the system:

Elements of the system

- Designer,
- Trend analyst
- production,
- Quality test,
- Furniture Trends Forecasting,
- End User requirements
- Management,
- Collaborative work for product Innovation

Boundary of the system

- The external stakeholders (partners, customers, etc.)

Objectives of AIDIMA

Business scenario 1:

- Facilitate the detection and initial analysis of home trends for further product design and development

Business scenario 2:

To have access to customers latent demands and suggestions expressed as online comments and opinions for improving user-centered product development

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To use the software module (Furniture Trends Forecasting for product development)
- To use the FI-WARE GEs

Criteria:

- Quality
- Delay

Phase 3: Determination of Performance Indicators

Performance indicators for scenario 1:

- Identification of weak signals time cycle: *The process will go automatic so a dramatic reduction of the time cycle is expected*

Performance indicators for scenario 2:

- Number of ideas *: Number of ideas posted by customers or leads*
- Number of opinions *: Number of opinions on furniture pieces posted by customers or leads*
- Number of comments on furniture *: Number of comments on furniture pieces posted by customers or leads*
- Analysis Time cycle *: Time to analyze social information*

Example for AIDIMA:

Objective	DV/AV	PI
To reduce the analysis Time cycle of social information	To use the AIDIMA trial platform	PI: Ratio: Average time cycle to analyse the socials information after/before the DV/AC implementation during a period*
To improve the access to user opinions on line for improving user-centered product development	To use the AIDIMA trial platform	PI: Number of users opinions taken in account by the design department after/before the DV/AC implementation during a period*

4.2.3.2 AGUSTA WESTLAND Trial (IT)

Application of simplified ECOGRAI to AGUSTA WESTLAND Trial

<u>Phase 1- Description of the system:</u>

<u>Elements of the system</u>

- FALs (final assembly line)
- FAL plants collect parts
- Technicians at the shop floor
- Job Card
- The logbook
- Service Stations H/C maintenance
- Smart toolbox (sensor)

<u>Functions (Static) and Processes (Dynamic)</u>

- To manufacture helicopter
- To operate the helicopter maintenance

<u>Boundary of the system</u>

- Other Agusta Westland plants
- Vendors of parts
- Commercial and military customers

<u>Dynamic, evolution of the system</u>

- To create e-logbook to be archived and accessible in the system for future search.
- For each helicopter the system will create a serialized BoM that will be useful for a better control of the helicopter configuration

<u>Objectives of AGUSTA WESTLAND</u>

- Reduction of time of the preparation of the final version of logbook and relevant data
  Improvement of H/C Configuration Control
- Improved the tools tracking management
  Support and improvement FOD prevention

<u>Phase 2: Definition of AV/DV, constraints and criteria:</u>

<u>AV/DV:</u>

- To create a digital logbook (electronic version of logbook starting from its paper format)
- To develop sensors and applications to control the tools used with the Toolbox

Criteria:

- Safety
- Delay

Phase 3: Determination of Performance Indicators

Performance indicators:

- Machinery exploitation: *Machine cost / produced unit*
- Production time: *Time per meter*
- Energy for supporting systems per meter: *Kwh per meter*
- Gas for supporting systems per meter: *m3 per meter*

Example for AGUSTA WESTLAND:

Objective	DV/AV	PI
Improve the tools tracking management	To use Agusta Westland trial platform	PI: Ratio: Number of tool lost after / before the implementation of the DV/AV during a period*
Improvement of helicopter Configuration Control	To use Agusta Westland trial platform	PI 1: Ratio: Average time spent to fulfill the logbook in its final version after / before the implementation of the DV/AV during a period * PI 2: Ratio: Average consultation time of logbook to search an information after / before the implementation of the DV/AV during a period*

4.2.3.3 VOLKSWAGEN Trial (DE)

Application of simplified ECOGRAI to VOLKSWAGEN Trial

Phase 1- Description of the system:

Elements of the system

- Design
- Production
- Product concept
- production modules (press shop, body shop, paint shop, assembly shop and in-house logistics)
- Manager, Engineers, MR (Machine Repository) responsible person, MR-Coordinator, car project leads
  Recommendation: to be more precise in order to limit the domains

Functions (Static) and Processes (Dynamic)

- To produce cars VW and others brands (product design, production)

Boundary of the system

- The external stakeholders (partners, customers, etc.)

Objectives of VOLKSWAGEN

- Reduction of time needed for the assessment of product related inquiries
- Reduction of costs, spend for the assessment of product related inquiries
- Reduction of costs, spend for the management of the Machinery Repository
- Immediate accessibility of experts knowledge about production equipment

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To use FIWARE technologies to make highly automated the MR (Machinery repository) management
- To use the web service “Support Inquiries” and “Support MR management”

Criteria:

- Quality
- Cost
- Delay

Phase 3: Determination of Performance Indicators

Performance indicators:

- Reduction of costs: *(final costs of implementation) minus (planned costs of implementation)*
- MR Update effort: *Effort needed for the update of a production module within in MR. This indicator is of course driven by the accessibility of experts’ knowledge.*
- Inquiry respond effort: *Effort that an engineer spent for the processing and evaluation of an inquiry.*
- MR Update time: *Time needed for the update of a production module within in MR. This indicator is of course driven by the accessibility of experts’ knowledge.*
- Inquiry respond time: *Time needed for the processing and evaluation of an inquiry.*

Example for VOLKSWAGEN:

Objective	DV/AV	PI
Reduction of time needed for the assessment of product design related inquiries	To use VOLKSWAGEN trial platform	PI: Ratio: Average lead time to assess the product related inquiries after / before the DV/AC implementation during a period*
Reduction of costs, spend for the management of the Machinery Repository (MR)	To use VOLKSWAGEN trial platform	PI: Ratio: Total cost of engineers hours spent to update MR after / before the implementation of the DV/AC during a period*

4.2.4 Application of ECOGRAI to VIRTUAL Factory

4.2.4.1 CONSUGAL Trial (PT)

Application of simplified ECOGRAI to CONSUGAL Trial

Phase 1- Description of the system:

Elements of the system

- Design,
- Production,
- Works Contractor,
- Supervision

Functions (Static) and Processes (Dynamic)

- Design, production (F)

Boundary of the system

- The external stakeholders: customers

Dynamic, evolution of the system

- A common web platform will be developed for all the stake holders to store and retrieve information and documents generated at different stages of the work flow

Objectives of CONSUGAL

- Improving readability of the concreting zones with the combination of visual and textual
information.
- Decrease the time for access to information on concreting operations and eventually help in quick decision making
- Reduction in the use of paper
- Improve the methodology for performing test activity, recoding of test results and analysis of the test results.

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To create a collaborative workspace using standard web and storage technologies
- To tag and integrate the things to the central information system
- To use mobile and web applications
- To use FI-WARE GEs

Criteria:

- Quality
- Cost
- Delay

Phase 3: Determination of Performance Indicators

Performance indicators:

- Operation margin*: Reduction in the cost of the project management, by allowing remote participation*
- Time needed to record test result*: Reduction in the time for recoding test result for a particular cube by making use of cube identification technology*
- Time for data exchange*: Reduction in the time for exchange of information between stakeholders.*

- Use of Paper: *Reduction in use of paper for exchange of information, archival and also for test result recording*

Example for CONSUGAL:

Objective	DV/AV	PI
Improve the method to perform test activity	To use the CONSULGAL trial platform	PI: Ratio: Average time needed to record and analyze the test results after / before the DV/AV implementation during a period*
Reduction in the use of paper	To use the CONSULGAL trial platform	PI: Ratio: Average number of pages used in test activity and archival after / before the DV/AV implementation during a period*

4.2.4.2 APR Trial (FR)

Application of simplified ECOGRAI to APR Trial

Phase 1- Description of the system:

Elements of the system

- Research Department
- Sales,
- Purchasing,
- Plastic transforming,
- Quality control,
- Shipping,
- Finance,
- Production,
- Sales manager,
- Production manager,
- Procurement
- Manager

Objectives of APR

- Decrease the order processing time
- Improve the quality of the relationship
- Improve price competitiveness
- Improve the contracting facilities with partners.

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To use the Fi-Ware capabilities (GE, SE, etc.)
- Additional functionalities (business process applications, data analysis, etc (such us the integration of OCR component).

Criteria:

- Quality
- Cost
- Delay

Phase 3: Determination of Performance Indicators

Performance indicators:

- Improve service levels*: Rate for service*
- Command processing time*:*
- Gain on purchases*: Reduce purchases cost*
- Improve the quality of contracts*: Fully formalisation of contracts by It-based business rules*
- The level of the customer satisfaction*: Improve customer satisfaction*

Example for APR:

Objective	DV/AV	PI
Decrease the order processing time	To use the APR trial platform	PI: Ratio: Average order processing time after / before the DV/AV implementation during a period*
To improve the contracting facilities with partners (suppliers)	To use the APR trial platform	PI: Ratio: Average time in the procurement negotiation after /before the DV/AC implementation during a period*

4.2.4.3 TANet Trial (UK)

Application of simplified ECOGRAI to TANet Trial

Phase 1- Description of the system:

Objectives of TANet

- Faster, and more cost effective, and more reliable platform and service maintenance
- Agile, evolving service offering, adaptable to technology developments

Case 1: For SMECluster

- Improve the search capability in order to find a suitable tender opportunity for a closer match to a customer profile

Case 2 : INDUSTREWEB

- Maximise the cutting time of the drill assembly

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To exploit the FI-WARE architecture and selected GEs with FITMAN specific enablers

Criteria:

- Quality
- Cost
- Delay

Phase 3: Determination of Performance Indicators

Performance indicators:

- *No PIs given.*

Example for TANet:

Objective	DV/AV	PI
To deliver faster service maintenance	To use the TANet trial platform	PI: Ratio: Delivery maintenance time after / before the DV/AV implementation during a period*
To improve search capability for a suitable tender opportunity	To use the TANet trial platform	PI: Ratio: Total value of successful tender after / before the DV/AV implementation during a period*

4.2.4.4 GEOLOC SYSTEM Trial (FR)

Application of simplified ECOGRAI to GEOLOC SYSTEM Trial

Phase 1- Description of the system:

Elements of the system

- SharePoint
- Solidworks
- SAP Business One
- Flows of information
- Purchasing process,
- Data management,
- production process,
- accompanying
- services,
- after-sales,
- design,
- commercial

Functions (Static) and Processes (Dynamic)

- To develop special machinery for the wood industry

Objectives of GOLOC System

- Reduce quoting lead time and increase accuracy
- Reduce Call for Tender cycle
- Automate Data management Process

Phase 2: Definition of AV/DV, constraints and criteria:

AV/DV:

- To use the FITMAN platform servic

Criteria:

- Quality
- Cost
- Delay

Phase 3: Determination of Performance Indicators

Performance indicators:

- Quoting lead time *: Lead time between the customer's request and quote*
- % of quoting lead time improvement *: Ratio between new and past quoting lead time*
- Product cost and lead time*: Relative difference between estimated and real values: Measures the accuracy of quotes*

- Ratio between actual and planned product lead time*: %*
- Number of iterations in the quoting process*: Number of cycles between the company and the customer to achieve the final version of the quotation*
- Number of partners answering to the tenders*: Number of partners answering to the tenders, to measure the attractivity of the offers*
- Number of tasks in data management process*: Number of tasks in data management process to show the complexity of the process*
- Number of manual tasks in the data management process*: Number of manual tasks in the data management process, measures the degree of automation*
- Number of tasks to ensure data interoperability*: Number of tasks without added value in the data management process*
- Time to market *: Lead time between the idea of the new product validated by the CEO and the date of commercialization to the customer*

Example for GEOLOC SYSTEM:

Objective	DV/AV	PI
Reduce quoting lead time	To use Geoloc trial platform	*PI: Ratio: Average lead time for quoting after / before the implementation of the* DV/AV *during a period**
Reduce Call for Tender cycle	To use Geoloc trial platform	*PI: Ratio: Average call for tender cycle lead time after / before the implementation of the* DV/AV *during a period**

4.3 Conclusion on the application of ECOGRAI for BPI

In this first phase the goal was to demonstrate the applicability of ECOGRAI to FITMAN project.
First we have defined a simplified ECOGRAI method in order to facilitate the test. We have been able to find the necessary information in the trials handbook v1. It is clear that it will be necessary that we validate or complete the information collected by a direct discussion with the responsible persons of the trials.
On our point of view the ECOGRAI method is applicable to determine Business Performance Indicators.
This first work must be completed in two directions:

- To develop the determination of the PIs for each trial. This task will be preform during the
- To constitute a set of Performance Indicators that will be used by each trial according their needs. This set of performance indicators will be determined by the ECOGRAI method based on the ENAPS PIs List (Annex III).

5. Conclusions & Next Steps

The primary goal of the work package 2.2 is "to identify and define a selection of business and technical indicators to be used in the FITMAN Verification & Validation Method."

It was obvious that the evaluation of the various components of FITMAN is obliged to take in account the nature of these components.
On one side we have technical components composed of Generic Enablers (GEs), Specific Enablers (SEs) and also Trial Specific Components (TSC): they are essentially software. The evaluation of their performance is based on the V&V technical criteria presented in Deliverable 2.1. A list of potential indicators has been proposed. We can notice that the evaluation of these components could be common to several trials except the TSC which is specific to each trial.

On the other side the objective is to evaluate the performance of the trials on a global point of view. The nature of the trial is at least Technical, Economic and Social. In such situation, Business Performance Indicators will be used. The ECOGRAI simplified method will support the definition of BPIs. The BPIs will depend on the objectives of the Trials. If the objectives are identical for some trials, the BPIs could be identical. If the objectives are different, the BPIs will be different.
The determination of the BPIs could be connected with the STEEP method. In such cases the objectives will be Social, Technical, Economic, Environment and Political.

Finally the global performance must combine the results of TI (necessary to get a good performance) and BPI.

This initial work developed in three months must be consolidated particularly by a generalization of the method and also by the determination of a complete set of TI and BPI well adapted to the 11 trials.

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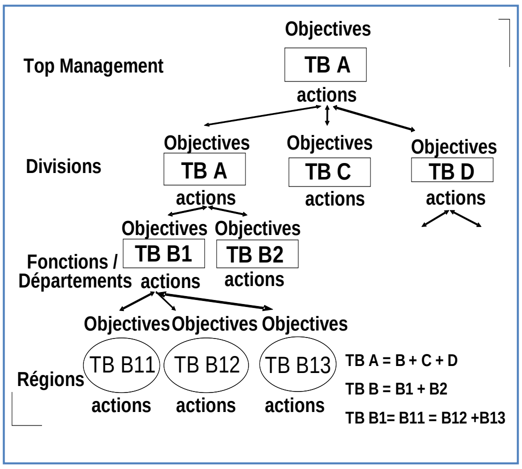
7. Annex II: Description of Business Performance Indicators methods

1. The TABLEAU DE BORD (French Dashboard) [around 1950]



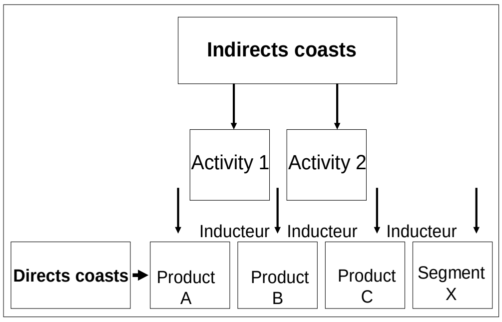
It is used as support for local decision makings thus, different integrated and inter connected TB exist at each hierarchical level. They includes results indicators, actions indicators which permit at the same time the reporting towards the upper hierarchical level the running of each unit to reach the global objectives

Figure 9: The French Dashboard

2. DuPont PYRAMID [Chandler, 1977]

It presents a pyramidal structure established on the connection and progressive aggregation of a large number of financial ratios existing in the whole functions and various organisational levels to arrive at the ROI (Return Of Investment) determination in order to ensure the viability [Chandler, 1977; Neely et al, 2000; Clivillé, 2004].

3. ABC method [Johnson and Kaplan, 1987]



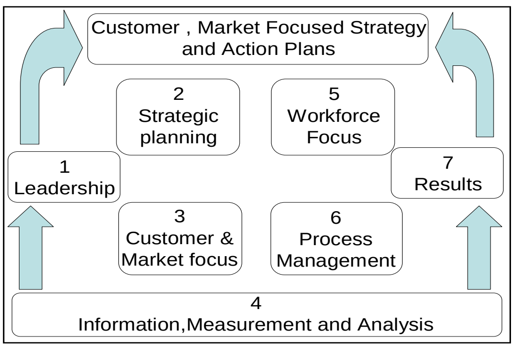
It's a costs management for each activity where all analyses are based on the single base of cost prices treated as variable costs assigned to activities. The principle consists in five steps to obtain the real costs of a product or a service [Lauras, 2004].

Figure 10: ABC method

4. The Theory of Constraints (TdC) [Goldratt, 1990]

The TdC, constituted by a procedure with 5 stages, provides on one hand the analytical tools to identify a business sector constraints and bottlenecks and on the other hand the methodology to manage them in order to improve the performances with three financial PIs: net profit, ROI and Cash-flow

5. MBNQA (Malcom Baldrige Nationality Quality Award) [1987]

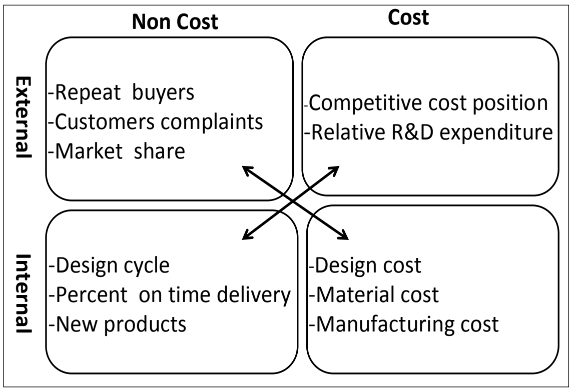


MBNQA is based on 7 criteria of reward and established to promote the total quality management especially centred on 3 inter connected processes: *the approach, the deployment* and *the results*. It is founded on the same principles as the EFQM [Neely et al., 2000].

Figure 11: The MBNQA

6. Performance Measurement Method Design [Sink and Tuttle 1989]
It's a classic approach to conceive a PIS as an interrelation between 7 criteria [Parida, 2006]: Effectiveness, Efficiency, Quality, Productivity, Quality of Work life, Innovation, Profitability/Budget.

7. Performance Measurement MATRIX [Keegan and al., 1989]



The matrix integrates four different dimensions of performance employing the generic terms: internal, external, linked with costs and non-costs generators with a great balance between measurements corresponding to these dimensions [Balachandran et al., 2007; etc

Figure 12: Performance measurement MATRIX

8. The ECOGRAI Method [Bitton, 1990; Doumeingts, 1998] (cf: 3.2.2)

9. PMQ (Performance Measurement Questionnaire) [Dixon and al, 1990]
It's a method based on a set of questionnaires relating to a list of areas that can be improved to maintain the company's viability and to assess the PIS status. The data coming from these questionnaires are evaluated according to 4 types of analysis to determine: the alignment, the congruence, the consensus, the confusion.

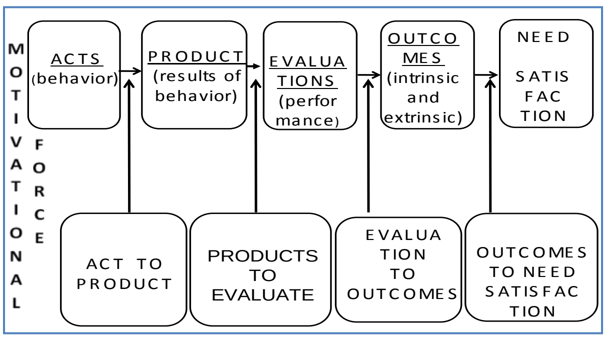
10. PMSSI (Performance Measurement System for Service Industries) [Fitzgerald and al, 1991]

RESULTS	Competitiveness
	Financial performance
DETERMINANTS	Quality of service
	Flexibility
	Ressource utilisation
	Innovation

The method known as the "Results and Determinants Framework" comprises six axes of performance grouped in two main distinct categories: **results (**competitiveness, financial performance) and **determinants (**service quality, flexibility, the use of the resources and the innovation) with the concept of causality between them. It's the ahead of "leading" and "lagging" indicators concept.

Figure 13: PPMSI

11. ProMES (Productivity Measurement and Enhancement System) [Pritchard and al., 1990]



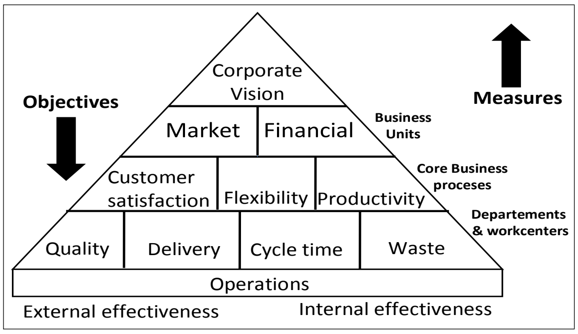
It's a participative management method of the performance constituted of 7 processes centred on the organisational productivity and built around the "motivational strength" concept.

Figure 14: The ProMES

12. PIS Design [Wisner and Fawcett, 1991]

It's a detailed process for a PIS design composed of 9 stages which consists with: the clear definition of the mission, the strategic objectives identification, the establishment of each functional area's roles in the various strategic objectives achievement, the global performance indicators definition , the strategic objectives communication to the lower levels, the consistency insurance with the strategic performance objectives used at each level, the indicators compatibility used in all functional areas, the use of the PIS to identify the competitive position and the domains with problem, to update strategic objectives, make tactical decisions and provide feedback after the decisions implementation , the periodically re-evaluation of the established PIS appropriateness.

13. PPS (Performance Pyramid System) [Lynch and Cross, 1991]



It uses a hierarchic, performance pyramid structure to represent the integration between organizational vision and operations actions. There is an interplay between external and internal orientations to improve the internal efficiency focused on the employees, processes etc. and the external effectiveness focused on the customers.

Figure 15: PPS (SMART)

14. Measures for time based competition (TBC) [Azzone and al., 1991]

It's a model with a quite detailed structure advised to be advantageous for companies focusing on competitiveness strategies based on the time (delay) as key success factor [Parida, 2006].

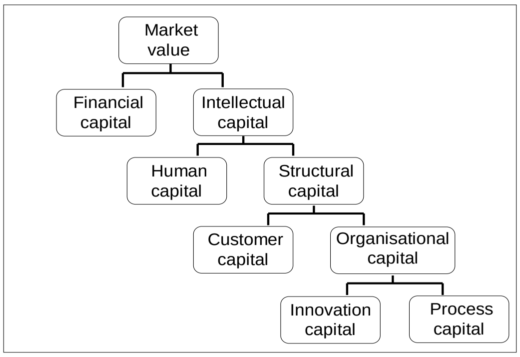
15. The BSC (Balanced Scorecard) [Kaplan and Norton, 1992] (cf: 3.2.1)

16. TOPP System [SINTEF, 1992; Moseng and Bredrup, 1993] (cf: 3.2.3)

17. Putting the Balanced Scorecard to work [Kaplan and Norton, 1993]

It's a short process description constituted of 8 stages comprising interviews to help the managers in the development of BSC. It starts by the business unit identification and ends at the periodic review of balanced PIs.

18. IC-Navigator of Skandia [Edvinsson and Malone, 1994]



It's a dashboard model constituted of five performance domains centred on finance, customer, processes, renewal and development, human capital which used to assess the intellectual capital (IC) consisted by the addition of human and structural capital.

Figure 16: The Skandia Navigator

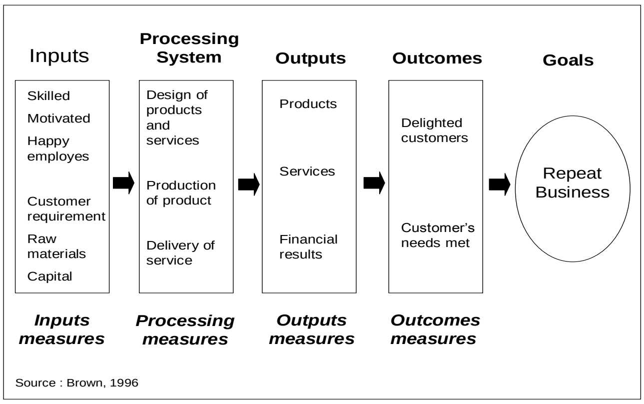
19. Getting the measures of your business [Neely and al., 1994]

It is constituted of logical stages split into 2 phases made up each of 5 activities. The first phase is dedicated to the high level PIs identification according to the customer requirements as competitiveness factors. The second concerns the deployment of these indicators through the objectives.

20. The Strathclyde's Modelling Methodology [Bititci, 1995]
It's a PIS modelling method just as the Information System (IS) by analogy with their similar structure. As (IS) can be modelled according to 3 points of view [Bititci, 1995], the PIS can be modelled in the same way in four stages by using some tools.

21. Consistent Performance Measurement System [Flapper and al., 1996]
This method is explicitly founded on the PIs relationship according to their classification based on the decision type, the aggregation level, the measure unit: physical/ monetary/dimension.

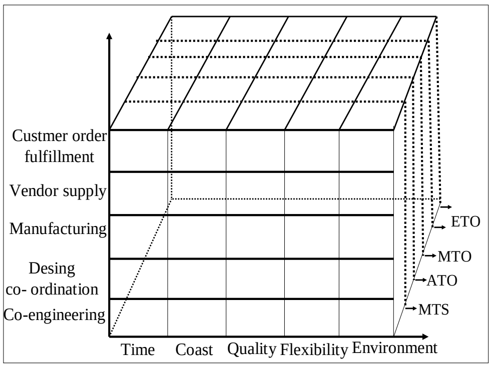
22. The Macro Process Model of the Organization [Brown, 1996]



It's an oriented-processes approach with 5 processes with their successive cause and effect relationship: the ***inputs,*** the ***processing system***, the ***output***s, the ***outcomes***, *and* the ***Goals***.

Figure 17: The Macro Process Model

23 AMBITE (Advanced Manufacturing Business Implementation Tool for Europe) [Bradley, 1996]

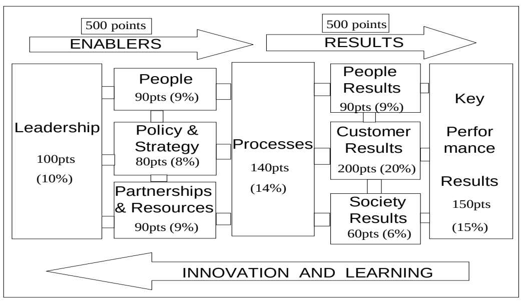


The system contains five macro processes dedicated to: the customers, the suppliers, the conceptual organization, the technical coordination, the production
(manufacturing process) to which one makes correspond macro performance measures: time (delay), quality, flexibility and environment in order to produce a set of twenty five strategic performance indicators for each manufacturing type.

Figure 18: The AMBITE

24. Stakeholder Approach to Strategic Performance Measurement [Atkinson & al., 1997]
The model is based on the stakeholders approach: the primary stakeholders (customers, owners, community) and the secondary (employees, suppliers) with their reciprocal contribution to meet their respective needs, expectations and objectives.

25. EFQM (European Foundation for Quality Management) [1998]



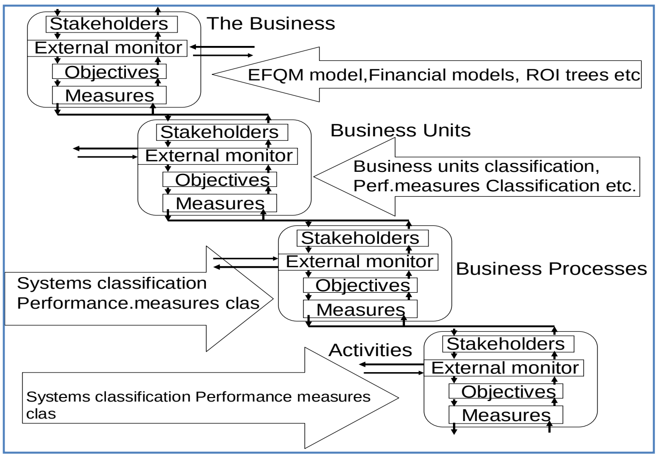
It is a management model centred on the quality with an approach based on the self-assessment principle. It consists of nine criteria among which 5 are the "**enablers**" and 4 the "**results**".
The principle is as follow: "The obtaining of excellence in the results is generated by the enablers".

Figure 19: EFQM

26. SCOR (Supply Chain Operations Reference) [Supply Chain Council, 2000, 2008] (cf. 2.2.1.1)

27. IDPMS (Integrated Dynamic Performance Measurement System) [Ghalayini and al., 1997]
The system integrates 3 primary and interactive functional: the management and the success specific areas, the team of processes improvement area and the industrial workshop.

28. IPMS (Integrated Performance Measurement System) [Bititci and Carrie, 1998]

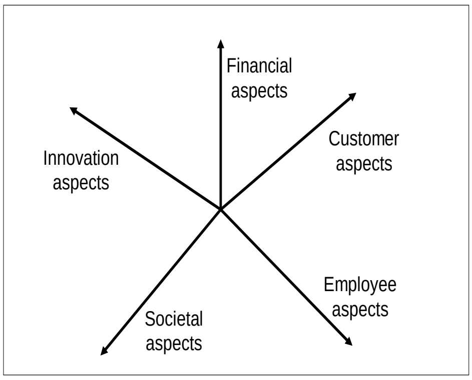


It's a reference model based one hand on Beer' S Viable System Model [Beer, 1985], and on the other hand on the BSC in a part with the four perspectives relations and inter dependences. So the IPMS restructures performance dimensions in four principal groups: business, business units, essential processes, support processes.

Figure 20: The IPMS

29 QMPMS (Quantitative Model for Performance Measurement System) [Bititci, and al., 1997]
It's a technique to model and to include the relations between the PIs in quantitative term by using suitable tools and techniques: Cognitive maps, cause with effect diagram and AHP (Analytic Hierarchy Process) [Saaty, 1980]. The quantification is made from the results of factors combination.

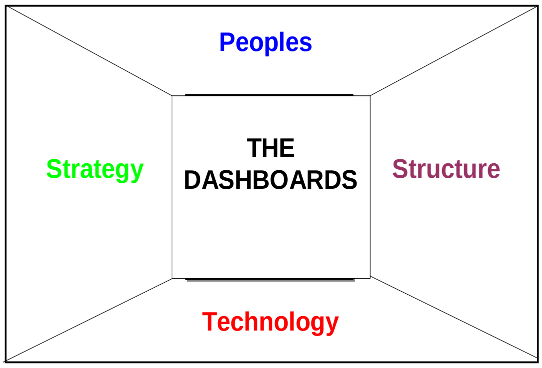
30. PPMS (Process Performance Measurement System) [P. Kueng, 1999]



It's a processes-oriented approach assisted of the TQM philosophy [Deming, 1986].The system is built in 9 steps and applies a stakeholders-oriented approach in which each group is represented by an aspect of the performance: ***financial aspect***, ***employee aspect***, ***customer aspect***, ***societal aspect***, ***innovation aspect***.

Figure 21: The PPMS

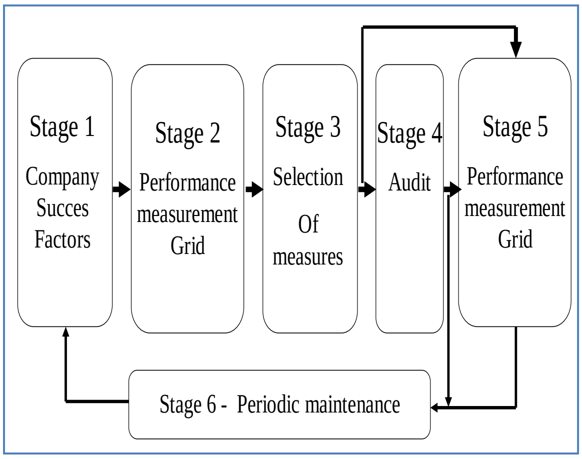
31. GIMSI [A. Hernandez, 1999, 2000, 2003]



It's a dashboard centred on the information system (IS) with the participation in group of the decision making, objectives and PIs definition. The GIMSI approach is articulated around of four axes: ***people, structure, strategy and technology***. Its development contains four principal phases constituted by 10 stages with 7 performance dimensions to be assessed.

Figure 22: GIMSI

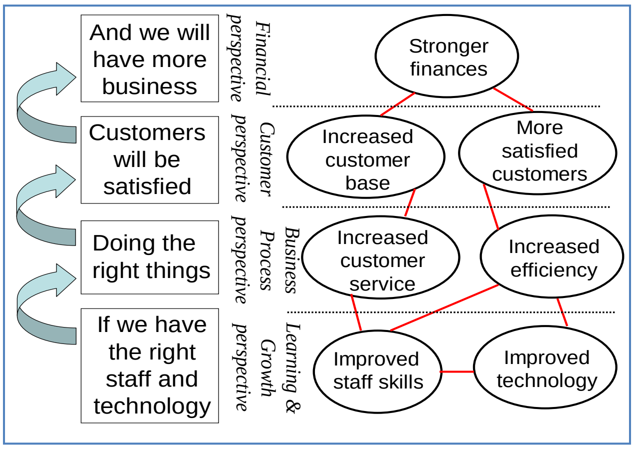
32. IPMF **(Integrated Performance Measurement Framework)** [Medori and Steeple, 2000]



This architecture is conceived for designing, auditing and enhancing the PIS by using 2 distinct interdependent documents: the manual of work containing the 6 stages for the PIS design, and the (Spectrum/Checklist) containing the IPs list (105) with their description and calculating methods according to the 6 priorities of competitiveness which are: quality, cost, flexibility, time, delivery, future growth**.** .

Figure 23: IPMF

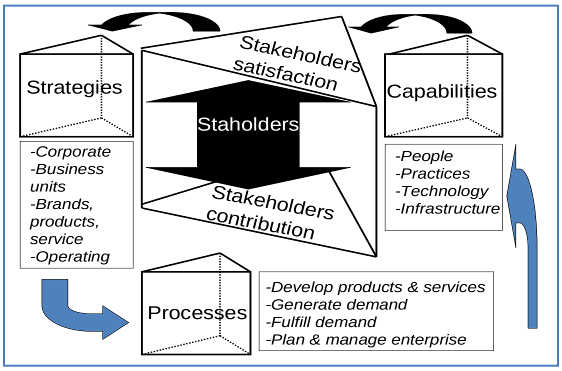
33. Strategy Map [Kaplan and Norton, 2000]



It's an improvement method of strategies implementation and execution. It presents in diagram form the value creation by connection of the strategic objectives and the causal relationship between them to facilitate the communication. It is founded on the four BSC perspectives: ***financial perspective, customer perspective, internal perspective, the growth and learning perspective.***

Figure 24: Strategy Map

34. Performance PRISM [Neely and al, 2001]



This is a scorecard based system for measuring and managing stakeholder relationships. The framework is conceived to cover stakeholder satisfaction, strategies, processes, capabilities, stakeholder contribution dimensions. The main objective of the strategic management system is to deliver stakeholder value

Figure 25: The Performance PRISM

35. MSDP **(Measurement System and Development Process)** [Rentes and al., 2002]

According to the recommendations suggested by different authors (Globerson, 1985; Neely and al. 2000; etc.), this system is a set of 7 steps for guiding the process for answering the question of what to measure and how to measure to obtain an effective PIS.

36. A dynamic PMS [Laitinen, 2002]

The method associates a hybrid system of the traditional accounting and ABC method with a repetitive causal relationship chain between 5 factors connected to the internal performance and 2 others to the external performance because each factor is the determinant of the one which precedes it.

37. Reference Model for PMM framework and measures [Taticchi and al., 2008]

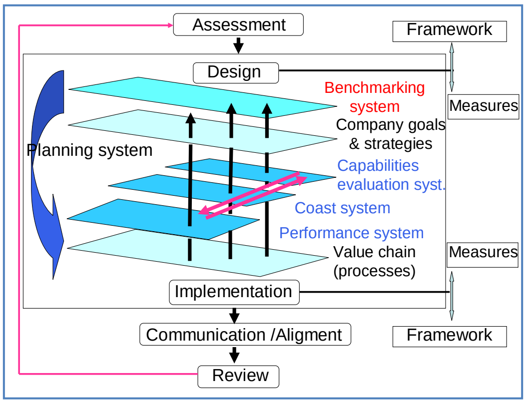


Figure 26: The Reference model for PMM framework and measures

The model proposes 5 integrated systems (performance, cost, capacity evaluation, benchmarking and planning system) which interact on multiple levels. It's completed by a reference framework (Design Reference Framework for PMM) constituted by the basic model to which are added directives for the assessment, the conception, the implantation, the communication / alignment and the system revision made by the combination of various methodologies proposed by the most known

various authors such as [Dixon and al., 1990, Bititci and al ., 2000, St-Pierre and Delisle, 2006, Kaplan and Norton, 1992, etc.]

8. Annex III: ENAPS Indicators (117)

Measure **Value** **Unit** **Definition**

Accounts:

	Measure	Value	Unit	Definition
1	Sales (Turnover)		ECU	The total amount of money received from customers during the last period.
2	Fixed assets		ECU	The present value of investment goods buildings; book value (or balance-sheet value) machines, cars, etc.; purchasing value.
3	Current assets		ECU	The present value of inventories (material value, added value NOT included), cash and other current assets.
4	Purchased material cost		ECU	The total amount of money paid to suppliers during the last period.
5	Other costs		ECU	Labour/personnel costs, rent, interest, etc. paid during the last period.
6	Equity		ECU	Shareholders Capital (Total Assets - External Capital).
7	Receivables		ECU	The present value of bills to be paid by customers.
8	Current liabilities		ECU	The present value of bills to be paid to suppliers.
9	Opening stock		ECU	Value of stock at the beginning of last period in terms of material costs only.
10	Closing stock		ECU	Value of stock at the end of last period in terms of material costs only.
11	External capital		ECU	Loans, mortgages, etc. Long term and short term.
12	Total liabilities		ECU	Current Liabilities + External Capital.
13	Profit from joint ventures		ECU	The profit made during the last period which can be attributed to joint ventures with other enterprises.

Product Development:

	Measure	Value	Unit	Definition
1	Number of active products		Number	Total number of active products where an active product is one which is listed in the product sales catalogue or any product which can currently be delivered to a customer. This should not include product variants.
2	Average new product development lead time		Months	The average time from product concept specification document until production ramp up, where "ramp up" means to reach full expected volume production, for new products launched during the last period.
3	Average planned product development lead time		Months	The average planned product development lead time (as defined above) for all new products launched last year.
4	Product engineering and design cost		ECU	The cost of product engineering and design. Includes labour and equipment but not overheads.
5	Product-related process engineering and design cost		ECU	The cost of developing a production process aimed specifically at producing a product. Includes labour and equipment costs but not overheads.
6	Product research cost		ECU	The cost associated with product research including labour and equipment. This includes both basic and applied research cost.
7	Number of new products		Number	Total number of new products that were launched during the last period where a new product is one which involves a major development effort and includes new technology or a new combination of technologies… … A product is considered "new" if it has been developed within the last three years and if it is published in the product catalogue as a new product and not simply a variant of an existing product.
8	Number of new product variants		Number	Total number of product variants or modified product models that were launched during the last period.
9	Number of unsuccessful new products		Number	The number of launched new products which had to be withdrawn earlier than planned. (Number of premature product deaths) that occurred during the last period.
10	Total number of customer complaint-related design changes		Number	The number of design changes for new products in the last period which were directly related to one or several customer complaints.
11	Engineering drawings change cost		ECU	The total cost of labour for all engineering drawing changes made during the last period.

12	Warranty costs for new products		ECU	Total cost of recalling and repairing new products covered by warranty during the last period. This includes labour, materials, transportation and administrative costs.
13	Number of products launched late in the last three years		Number	The number of products which failed to meet the initial scheduled launch date.
14	Number of patents granted in the last period		Number	The number of patents granted for technology or products developed by your enterprise in the last period.
15	Number of patents held		Number	The total number of patents being held by your enterprise at present.
16	Number of co-engineered products		Number	The number of active products which were partially designed by suppliers. This does not include consultants.
17	Number of components recycled		Number	The total number of product components that were recycled in the last period where recycled means re-used in new or second-hand products or recycled for reclamation of base materials.
18	Total number of components produced		Number	The total number of components produced in the last period across all products. This will be used to calculate the ratio of recycled components to components produced.
19	Number of part types with multiple usage		Number	Total number of part types which appear in more than one bill of materials.
20	Total number of part types		Number	The sum of all the part numbers minus the number of products. That is all part types that have potential for multiple usage.

Marketing and Sales:

1	Number of new customers		Number	The number of customers who ordered within the last period but had not ordered within the last three years.
2	Total number of customers		Number	The total number of active customers on the customer list, where an active customer is one that has placed an order within the last three years.
3	The percentage of customers accounting for 80% of sales volume in the last period		%	Sort all customers according to sales and then sum the sales per customer while counting the number of customers. When you reach 80% of total sales note the number of customers accounting for that amount and divide it by the total number of customers.
4	Market share for main product		%	The approximate market share that your main product (the product which results in most sales for your enterprise) held last period, where this market refers to the enterprise's target market which can be domestic, European or global.
5	Marketing cost		ECU	The total cost of all marketing including labour costs, advertising costs external service costs and equipment but not overheads.
6	Sales of products receiving an ecological certificate		ECU	The total value of sales of products which have received your country's "green" label or another ecological certificate. When a European standard becomes available this should be used.
7	Sales to new customers		ECU	The sum of the value of sales to new customers during the last period.
8	Sales resulting from tenders		ECU	The sum of the value of all sales resulting from tenders during the last period.
9	Tender preparation lead time		Weeks	The average tender preparation lead time.
10	Tender value		ECU	The sum of the value of each tender made during the last period.
11	Cost of preparing tenders		ECU	The sum of all costs of preparing tenders during the last period. This includes labour and equipment costs but not overheads.
12	Successful tenders		Number	The number of tenders during the last period which resulted in a customer order.
13	Number of tenders		Number	The number of tenders prepared and submitted during the last period.
14	Lost customers		Number	The number of customers who were expected to order but did not order during the last period.
15	Customer visits		Number	Total number of times that marketing personnel from your enterprise visited a customer site or that customers visited your site during the last period.
16	Number of invoices sent to customers		Number	The total number of invoices sent to customers during the last period where each invoice may contain several line items but is still just one single invoice.
17	Number of on-time customer payments		Number	The total number of customer payments received on or before the promised payment date in the last period where all items on the invoice are fully paid for.
18	Value of cancelled orders		ECU	The summed value of all cancelled orders in the last period where a cancelled order is one which appeared in your enterprises order processing system but subsequently had to be deleted before delivery due to customer request.

19	Products sold		Number	Total number of product units sold in the last period where sold implies that payment has been received.
20	Number of customer suggestions		Number	Total number of customer suggestions for product or process improvement.
21	Number of implemented customer suggestions		Number	Total number of implemented customer suggestions for product or process improvement.
22	Sales of new products		ECU	The total value of sales during the last period from new products, i.e. products which have been introduced in the last three years and include new technology or new combination of technologies.

Planning and Production

1	Number of customer orders		Number	The total number of customer orders during the last period where each customer order may contain several line items (requests for individual quantities of different products).
2	Number of on-time outgoing deliveries		Number	The total number of deliveries from your enterprise to a customer during the last period which were delivered on or not more than two days before the date specified by the customer for delivery.
3	Number of incomplete outgoing deliveries		Number	The total number of incomplete deliveries from your enterprise to a customer during the last period which contained too few items or the wrong product. A delivery may be made in two or more batches but still constitutes a single delivery.
4	Number of outgoing deliveries containing defective products		Number	The total number of deliveries from your enterprise to a customer during the last period which contained defective products. A delivery may be made in two or more batches but still constitutes a single delivery.
5	Average order fulfilment lead time		Days	The average time across all products from receipt of an order to delivery of that order to the customer and to installation where appropriate.
6	Average commercial lead time		Days	Average time taken for order processing and production planning. This begins at receipt of an order and ends when the order is released to the shop floor for production.
7	Average production and assembly lead time		Days	Average time for production of an order starting at release of an order to the shop floor until that order has been fully produced and transferred to outgoing stock. This includes waiting times + production time + internal transport.
8	Average distribution lead time		Days	Average time for distribution of an order from arrival of the order at outgoing stock until the delivery (and installation where appropriate) to the customer site. This includes packaging + storage + transport to customer.
9	Commercial costs for order fulfilment		ECU	The cost of order processing and production planning. The costs incurred by all the activities from receipt of an order to release of the order to the shop floor for production.
10	Total production cost		ECU	The cost of production in terms of direct labour costs, equipment and maintenance but not overheads.
11	Inventory costs		ECU	The total of all costs related to the storage of inventory including materials and finished products.
12	Distribution costs		ECU	The cost of distributing finished products including labour and transport costs.
13	Average cost of work in progress		ECU	The value of work in progress (in terms of materials and semi-finished product) at the beginning of the period + the value of work in progress at the end of the period divided by 2.
14	Total production hours		Number	The total number of person-hours during the last period spent on production. This includes production effort and time spent on internal transport.
15	Cost of scrap material		ECU	The total value of the material and components scrapped in the last period where the value is measured in terms of the purchase value of the materials or components.
16	Re-work hours		Number	The total number of person-hours spent re-working products or components in the last period.
17	CO_2 production		$Metre^3$	The volume of CO_2 produced by your enterprise in the last period.
18	Mass environmentally unfriendly material produced		Kilograms	Environmentally-unfriendly material can be classified according to the current country standards (Standard not available yet: When standard becomes available this measure may be used).
19	Mass of product produced		Kilograms	The total mass of material in the products and packaging produced by your enterprise.
20	Cost of energy		ECU	The total cost of energy used by production in the last period. This includes the cost of gas, electricity or oil.

Customer Service:

1	Number of products received back due to faults		Number	The total number of product units received back during the last period by your enterprise due to faults in the product. These products may be recalled by your enterprise or returned by a customer.
2	Number of product units taken back for recycling or re-manufacture		Number	The total number of complete product units taken back during the last period by your enterprise for recycling.
3	Cost of product takeback		ECU	Total cost of product takeback during the last period where products are taken back for recycling or re-manufacturing. The costs include labour (including disassembly), equipment and transportation.
4	Product takeback revenue		ECU	Total revenue generated from product takeback during the last period.
5	Income from after-sales service		ECU	The total income generated by after-sales services in the last period. After-sales service is defined as service activities following receipt of payment for the initial sale.
6	Average complaint response time		Days	The average time taken from when a customer complaint is received to when the complaint is acknowledged by your enterprise. To respond within the same day means a value of 1, to respond the next day means a value of 2 etc. The maximum performance is 1.
7	Average complaint resolution time		Days	The average time taken from when a customer makes a complaint to when the problem that the customer is complaining about is fully resolved and the customer is satisfied.
8	Number of customer complaints		Number	Total number of customer complaints during the last period.

Purchasing

1	Number of active suppliers		Number	The total number of suppliers which are currently supplying your enterprise or having supplied your enterprise within the last three years.
2	Certified suppliers		Number	Total number of active suppliers with quality system certification. Acceptable are: ISO-9000, BS 5750.
3	Number of purchase orders		Number	The total number of purchase orders issued during the last period where each purchase order may include several line items but still represents one single purchase order.
4	Number of incoming deliveries		Number	The total number of deliveries to your enterprise by suppliers in the last period.
5	Number of complete incoming deliveries		Number	The number of deliveries that have the exact amount of material as requested on the Purchase Order.
6	Number of incoming deliveries received on time		Number	The number of deliveries that are received on or before the day specified on the Purchase Order.
7	Number of incoming deliveries containing defective parts		Number	The total number of deliveries from suppliers which contained defective material or parts.
8	Average material procurement lead time		Days	This starts from the determination of material requirements until the material is on the shop floor in the location required to be ready for production. Includes material planning and procurement + transportation + receipt check and store + picking.
9	Purchase value of parts rejected at incoming inspection		ECU	The sum of the value of all parts (material or components) rejected at incoming inspection.
10	Number of suppliers visited		Number	The number of suppliers to whom employees of your enterprise visited during last period.
11	Number of on-time payments to suppliers		Number	The total number of payments to suppliers which were received by the supplier on or before the promised date.

Personnel

1	Average number of employees		Number	Average number of full-time equivalent employees, regardless of the contract over the last period.
2	Total wages		ECU	The total cost of wages, salaries and benefits (pensions, insurance etc.) for all employees in the last period.
3	Number of person-days lost due to absenteeism		Number	The total number of person-days lost during the last period due to absenteeism.
4	Maximum person-days available		Number	The maximum possible number of person-days available during the last period (excluding overtime). Total average number of employees multiplied by the number of person-days per employee.
5	Number of departed employees		Number	The total number of employees who left the enterprise for any reason other than retirement during the last period.
6	Number of new employees		Number	The total number of new employees who joined the enterprise during the last period.
7	Overtime cost		ECU	The total labour cost of overtime for the enterprise during the last period.
8	Average number of employees involved in product research and development		Number	The average number of employees directly involved in product development projects within your enterprise during the last period.
9	Average number employees involved in marketing		Number	The average number of employees directly involved in marketing and obtaining customer commitment within your enterprise over the last period.
10	Average number of employees involved in project teams		Number	The average number of employees who at some time during last period were involved in an improvement project.
11	Training and educational cost		ECU	The total number of ECU's spent on training during the last period. Includes internal and external training and education.
12	Average total working days for an employee		Days	The average total working days for an employee during the last period.
13	Average time spent on training for each employee		Days	The average number of days during the period for which an employee undergoes training.
14	Cost of incentive schemes		ECU	The total cost of all incentive schemes during the last period.
15	Person-hours spent at management team meetings		Hours	The total number of person-hours spent at management team meetings during the last period.
16	Management team person-hours spent on strategy		Hours	The total number of person-hours spent on the development of enterprise strategy during the last period.

Others

1	System downtime		Hours	The total percentage of time for which the main computer system in the enterprise (network server or management information system server etc.) was unavailable in the last period.
2	Number of injuries		Number	The total number of work-related injuries in the last period.
3	Cost of preventative maintenance		ECU	The total cost of preventative maintenance of machines, computers, etc. in the last period.
4	Number of employee suggestions		Number	The total number of written employee suggestions received during last period. These suggestions may relate to process improvements, product improvements or any other improvements within the enterprise and may come from any personnel.
5	Machine downtime		Hours	The sum of all hours of downtime on critical machines during the last period where a critical machine is one which is essential to maintain full production.
6	Maximum available machine hours		Hours	The sum of the maximum possible available production machine hours during the last period. This should be calculated as the total number of hours during which the entire production facility is "open".
7	Cost of improvement projects		ECU	The total cost of investment in improvement projects and associated activities during the last period. This includes labour, services (consultancy, training etc.), equipment and software for projects aimed at improving the performance of any process.

Enterprise Level

1	Return on capital employed		%	Capital Turnover*Margin
2	Return on equity		%	Profit/Equity
3	Capital turnover		%	Sales/Total assets
4	Margin		%	Profit/Sales
5	Profit		ECU	Sales - Operating expense
6	Operating expense		ECU	Purchased materials cost + Other costs
7	Quick ratio		%	(Current assets + Receivables)/Current liabilities
8	Cash ratio		%	Current assets/Current liabilities
9	Payment capacity		ECU	Current assets - Current liabilities
10	Sales outstanding		%	(Receivables * 360)/Sales
11	Sales per employee		%	Sales/Number of employees
12	Value-added per employee		%	(Sales-Purchased material cost)/Number of employees
13	Inventory turnover		Days	Average value of stock*360/Purchased material cost
14	Debt ratio		%	External Capital/Total liabilities
15	Customer satisfaction		Ratio	Number of customer complaints/Total number of orders
16	Value of joint ventures		%	Profit made from joint ventures/Sales

Product Development

1	Average product development lead time		Weeks	The average time from product concept specification document until production ramp up, where "ramp up" means to reach full expected volume production, for new products launched during the last period.
2	Product launch target adherence		%	Number of products launched late in the last three years/Total number of new products launched in the last three years
3	Product development efficiency		Ratio	Average planned product development lead time/Average product development lead time
4	Product development cost		%	(Total product engineering and design cost + total product research cost + total product-related process engineering cost)/Sales
5	Engineering change costs		%	Cost of engineering drawing changes/Sales
6	Warranty costs of new products		%	Warranty costs of new products/Sales of new products
7	Product development reliability		%	Total number of customer complaint-related design changes/Total number of active products
8	Contribution of new products		%	Sales of New Products/Sales
9	New product introduction performance		%	Number of unsuccessful new products/Total number of new products
10	Proportion of new products		%	Number of new products developed last period/Total number of active products
11	Extent of co-engineering		%	Number of co-engineered products/Total number of new products developed
12	Patenting performance		%	Number of patents awarded last period/Total number of patents held
13	Modularity of products		%	Number of components with multiple usage/Total number of components
14	Proportion of people in product development		%	Number of people involved in product development/Total workforce
15	Product variance		%	Number of product variants/Number of active products
16	Components recycled		%	Number of produced components recycled last period/Total number of components produced last period

Obtaining Customer Commitment

1	Tender preparation lead time		Weeks	as is
2	New customer return		%	Sales to new customers/Sales
3	Tender return		%	Total cost of preparing tenders/Total sales resulting from tenders
4	Marketing cost ratio		%	The marketing cost/Sales
5	Customer base growth		%	Number of new customers/total number of customers
6	Lost customers		Ratio	Number of lost customers/Total customers
7	Market share for main product		%	as is
8	Tender efficiency		%	Total tenders value/Sales
9	Tendering hit ratio		%	Number of successful tenders/Total number of tenders
10	Customer visits		%	Number of customer visits/Number of customers
11	Value added per marketing employee		%	(Sales - Purchased material)/Number of marketing employees
12	Customer dependency		%	The percentage of customers accounting for 80% of sales volume last period.
13	Green product sales ratio		%	Sales of products receiving country's green label/sales

Customer Service:

1	Average complaint response time		Days	as is
2	Product takeback profit		%	Product takeback revenue - Product takeback cost/Sales
3	After-sales service profit		%	Income from after-sales service/Sales
4	Average complaint resolution time		Days	as is
5	Returned products ratio		%	Number of products returned because of faults/Total number of product units sold
6	Product takeback ratio		%	Number of Product units taken back/Number of product units sold

Order Fulfilment:

1	Commercial lead time ratio		%	Commercial lead lime/Order fulfilment lead time
2	Material procurement lead time ratio		%	Average material procurement lead time/Order fulfilment lead time
3	Production and assembly lead time ratio		%	Production and assembly lead time/Order fulfilment lead time
4	Distribution lead time ratio		%	Distribution lead time/Order fulfilment lead time
5	Commercial cost ratio		%	Commercial costs/Sales
6	Inventory cost ratio		%	Inventory costs/Sales
7	Distribution cost ratio		%	Distribution cost/Sales
8	Materials cost ratio		%	Purchased material costs/Sales
9	Production cost ratio		%	Production cost/Sales
10	Average order value		ECU	Sales/ Total number of customer orders
11	Work in progress		%	Cost of work in progress/(Purchased material cost + Total Production cost)
12	Value of cancelled orders		%	Value of cancelled orders/Sales
13	Outgoing delivery quality		%	Number of customer deliveries containing defective parts/Total number of customer orders
14	Outgoing delivery completeness		%	Number of complete customer orders/Total number of customer orders delivered
15	Outgoing delivery timeliness		%	Number of customer orders delivered on time/Total number of customer orders
16	Incoming delivery quality		%	Number of incoming deliveries containing defective parts/ total number of incoming deliveries
17	Incoming delivery completeness		%	Number of complete incoming deliveries/Total number of incoming deliveries
18	Incoming delivery timeliness		%	Number of incoming deliveries received on time/Total number of incoming deliveries
19	Supplier payment timelines		%	Number of on-time payments to suppliers/Total number of purchase orders
20	Customer payment timeliness		%	Number of on-time customer payments/Total number of invoices
21	Incoming rejection cost		%	Components rejected at incoming inspection/Purchased material costs
22	Percentage re-work		%	Re-work hours/Total production hours
23	Percentage scrap		%	Cost of scrap material/Purchased material cost
24	Energy cost		%	Cost of energy/Sales
25	Production process environmental-friendliness		%	Mass of environmentally-unfriendly material produced/total mass of product produced
26	CO_2 volume		M^3/ECU	Number of cubic metres of oil * CO2 ratio/Sales

Support Processes

1	Overtime cost		%	Cost of overtime/ Total wages
2	Preventative maintenance cost		%	Cost of preventative maintenance/Sales
3	System downtime		%	Number of hours the main computer system was unavailable/Total available hours
4	Employee absenteeism		%	Number of man days lost due to absenteeism/Maximum man days available
5	Employee turnover		%	Number of employees that left the enterprise/Average number of employees
6	Machine downtime		%	Sum of all machine hours of downtime/Maximum number of machine hours
7	Training investment		%	Training and educational cost/Sales
8	Time spent on training		%	Average time spent on training for each employee/Average total working time
9	Employee participation		%	Number of employee suggestions/Average number of employees
10	Health and safety		%	Number of injuries/Average number of employees