



ComVantage

284928

***Collaborative Manufacturing Network
for Competitive Advantage***

**D9.2.2 – Multidimensional Metric Set
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Executive Summary

This document presents a multidimensional metric set. The purpose of the metric set is the evaluation of the contribution of the *ComVantage* platform to the business value of implementing organizations. This document, the product of the second and final phase of the development of the metric set (the outcome of the first phase was presented in D9.2.1), is based on a thorough literature review, analysis of the system use cases, and adaption of the former to the latter. The process included data collection through questionnaires and interviews with key project stakeholders to ensure full and accurate adaptation of general supply chain performance measures to the specific context of the project. The analysis of the data gathered shows that the multi-dimensional metric set reflects the expected improvement in organizational performance. The analysis also reveals the differences in the extent to which the metrics reflect the effects of *ComVantage* across different application areas. Therefore, the final output of the process is three lists of metrics for the three application areas and a consolidated list of all metrics relevant to the project. This report depicts the process' background, methodology, results and their analysis, as well as the final outcome and the next planned steps.

Table of Contents

1	OVERVIEW.....	6
1.1	INTRODUCTION	6
1.2	SCOPE OF THIS DOCUMENT	6
1.3	RELATED DOCUMENTS.....	6
2	BACKGROUND	7
2.1	PERFORMANCE MEASURES IN SUPPLY CHAIN MANAGEMENT	7
2.2	THE STRUCTURE OF THE MULTI-DIMENSIONAL METRIC SET FOR <i>COMVANTAGE</i>	8
2.2.1	Operational Effects Dimension.....	8
2.2.2	Business Process Dimension.....	9
3	METHODOLOGY	10
4	METRIC SET ASSESSMENT.....	11
4.1	EXPECTED IMPACT OF <i>COMVANTAGE</i>	11
4.1.1	Work Package 6 – Plant Engineering and Commissioning	12
4.1.2	Work Package 7 – Customer-oriented Production.....	12
4.1.3	Work Package 8 – Mobile Maintenance.....	12
4.2	REFLECTION LEVEL OF THE PROPOSED METRIC SET.....	13
5	MULTI-DIMENSIONAL METRIC SET.....	16
5.1	MULTI-DIMENSIONAL METRIC SET – PLANT ENGINEERING AND COMMISSIONING (WP6).....	16
5.2	MULTI-DIMENSIONAL METRIC SET – CUSTOMER-ORIENTED PRODUCTION (WP7)	17
5.3	MULTI-DIMENSIONAL METRIC SET – MOBILE MAINTENANCE (WP8)	19
5.4	CONSOLIDATED MULTI-DIMENSIONAL METRIC SET	20
6	CONCLUSION AND OUTLOOK.....	24
7	REFERENCES.....	25
8	APPENDIX I: INITIAL METRIC SET.....	27
9	APPENDIX II: QUESTIONNAIRE FOR INTERVIEWEE, WP6	32
10	APPENDIX III: QUESTIONNAIRE FOR INTERVIEWEE, WP7	34
11	APPENDIX IV: QUESTIONNAIRE FOR INTERVIEWEE, WP8.....	37

List of Figures

Figure 1: Expected Impact on Operational Effects	11
Figure 2: Expected Direct Impact on Supply Chain (SC) Processes	12
Figure 3: Reflection Level of Metrics – WP6.....	13
Figure 4: Reflection Level of Metrics – WP7.....	14
Figure 5: Reflection Level of Metrics – WP8.....	14
Figure 6: Reflection Level of Metrics – Overall Project	15

List of Tables

Table 1: Operational Effects Dimension	8
Table 2: Business Processes Dimension	9
Table 3: Adapted Metric Set for Plant Engineering and Commissioning (WP6)	17
Table 4: Adapted Metric Set for Customer-oriented Production (WP7).....	19
Table 5: Adapted Metric Set for Mobile Maintenance (WP8).....	20
Table 6: Consolidated Metric Set	23

1 OVERVIEW

1.1 Introduction

This document presents the multidimensional metric set that will be the basis for the evaluation process of the *ComVantage* platform, to be developed in this project. The metric set was developed based on the evaluation framework generated in the first six months of the project, and is focuses on the operational effects of the various processes in the supply chain. Based in this framework, a unique metric of key performance indicators (KPIs) have been developed for each application area due to the significant differences among application areas in terms of logistic processes in general, and processes of interest in particular.

The structure of the document is as follows: Chapter 2 provides background on performance measures in supply chains in general and in the context of this project in particular, while Chapter 3 describes the methodology used to generate the metric set. Chapter 4 details the results gathered in the process of assessment and adaptation of the metrics generated for each application area. Chapter 5 presents the final output of this deliverable, the adapted metric set. The conclusion of the process and outlook for the next steps are depicted in Chapter 6.

1.2 Scope of this Document

This document describes the full list of key performance indicators identified, validated, and adapted for each application area, in order to measure the expected effect of the *ComVantage* platform on the business value of organizations implementing it. The metrics are categorized according to operational effects measured at supply chain process level. The document presents the results of the relevance level of the metric set for the different application areas, based on the evaluation of the business partners. The resulted metric set serves as a basis for the definition of performance metrics in the next deliverables.

1.3 Related Documents

The preliminary metric set, developed in the first phase of Task 9.2, was presented in D9.2.1. The present document (D9.2.2) is the second and final output of the development of multidimensional metric set, to be used in the evaluation process itself, as will be detailed in the next deliverables (D9.3.1, D9.3.2, D9.4.1, D9.4.2, D9.5).

The task of generating a metric set to measure the impact of *ComVantage* is part of an overall evaluation process described in D9.1 and is based on the evaluation framework presented in D9.1 and its adaption (presented in D9.2.1).

2 BACKGROUND

2.1 Performance Measures in Supply Chain Management

As stated in the *ComVantage* project document of work, *ComVantage* is designed to address the limitations of the existing manufacturing ICT infrastructure, by introducing a system that provides an Internet-based collaboration space to facilitate communication and coordination among all the stakeholders involved in industrial supply chains, including their end-customers. Supply chains have been defined as the network of organizations that are involved, through upstream and downstream linkages, in different processes and activities that produce value to the customer. It was claimed that the performance of an organization depends strongly on its ability to optimize its relations with partners, to interface or integrate its information systems and to synchronize its product flows and activities (Forme, 2007). Thus, improved inter- and intra-firm relationships were considered to be a pre-condition for an effective supply chain management (SCM) and a key to building a sustainable competitive edge (Ellinger, 2000).

Performance measurement provides the necessary assistance for performance improvement in pursuit of supply chain excellence (Beamon, 1999a). Traditionally, performance measurement is defined as the process of quantifying effectiveness and efficiency of action through the use of a set of metrics (Neely, 1995). In other words, measuring performance means transferring the complex reality of performance into a sequence of limited symbols that can be communicated and reported under similar circumstances. This set of metrics enables the measurement and monitoring of key performance indicators (KPIs) which are crucial for optimizing supply chain performance. Former approaches to performance measurement have relied mainly on financial measures (Beamon, 1999b). However, it was claimed that relying exclusively on cost indicators can produce a misleading picture of supply chain performance. In modern business management, performance measurement assumes a far more significant role than quantification and accounting. It can provide important feedback information to enable managers to monitor performance, reveal progress, enhance motivation and communication, and diagnose problems (Chan, 2003). Thus, measuring supply chain performance can facilitate a greater understanding of the supply chain, positively influence actors' behaviour, and improve its overall performance (Chen, 2004). Many metrics used in the evaluation of supply chain performance have been designed to measure operational performance, evaluate improved effectiveness, and examine strategic alignment of the whole supply chain (Beamon, 1999b). Metrics have been classified into cost and non-cost (Chen and Paulraj, 2004), strategic/operational/tactical focus (Gunasekaran et al., 2001), supply chain processes (Gunasekaran, 2004), and the nature of the source for the metrics – whether they are objective or rely on the subjective interpretations of individual actors (Beamon, 1999b). Individual measures of supply chain performance have usually been classified into four categories: quality, time, cost, and flexibility (Cai, 2009, Morgan, 2004). The time and quality categories have been claimed to reflect the ability of a supply chain to deliver a high customer service, while flexibility and innovation refer to the ability to cope with rapid changes in demand or supply (Chan, 2003). Flexibility and innovation were also considered to be important strategic drivers of supply chain development in the future (Morgan, 2004). However, since many measurement models lacked a balanced approach and systematic thinking (Beamon, 1999b), they had difficulty in systematically identifying the most appropriate metrics. To address this problem, some researchers have used the Balanced Scorecard (BSC) method to evaluate supply chain performance from different perspectives such as finance, customer, internal business process, and learning and growth (Bhagwat, 2007). Other researchers have also proposed similar balanced approaches, such as Performance Measurement Matrix, Performance Pyramid, etc. (Neely et al., 2005). From a process perspective, the Supply Chain Operations Reference (SCOR) model has been developed to facilitate construction of a systematic approach by defining metrics relating to both performance attributes and supply chain processes (Lockamy and McCormack, 2004). In addition, the model proposed by Chan and Qi (2003) can quantify the relative importance of both supply chain processes and measures with respect to supply chain strategies including input, output, and composite measures for each.

All these conceptual frameworks have their relative benefits and limitations, with the most common limitation being that little guidance is given for the actual selection and implementation of the measures

selected (Cai, 2009). It was claimed that the large number of individual measures being used in the supply chain context complicates the task of choosing the relevant measures for different supply chain participants (Shepherd and Günter, 2006). In addition, it is difficult to compare metrics and measurement systems used in different supply chains without consideration of the specific organisational and supply chain setting. Thus, in order to understand how to develop a performance measurement model in a supply chain, there is a need to capture its context, process, and content (Cuthbertson, 2011).

2.2 The Structure of the Multi-dimensional Metric Set for *ComVantage*

Prior literature has emphasized the importance of a multi-dimensional performance measurement that looks at several different perspectives of business at the same time, using metrics carefully selected to serve the needs of the organization (Mathur et al., 2011). The rationale of the multi-dimensional metric-set for *ComVantage* is based on specifying the dimensions that allow the definition of a set of metrics that quantify the performance of different organizational areas, in a structured manner. The proposed metric set is based on two classification dimensions of the evaluation framework, described in D9.2.1, namely the *operational effects* and the *business processes*. This framework provides a generic approach of developing key performance indicators (KPIs) with room for customization with respect to individual organizational needs. Both classification dimensions are guides to apply the relevant metrics for a particular situation, since they group performance metrics. The analysis of the KPIs according to these dimensions facilitates a deeper insight of the process performance from different operational aspects.

2.2.1 Operational Effects Dimension

The first classification dimension is the *operational effects* dimension. It relates to various aspects, in which performance improvements are expected to occur as a result of *ComVantage* collaborative capabilities. Collaborative capabilities have been associated with flexibility improvements, better resources utilization, shorter and controlled delays, quality improvement and competencies development (Forme, 2007). As described in D9.2.1, the empirical literature dealing with supply chain performance has been quite consistent in identifying cost, quality, delivery, and flexibility as important operational effects (Chen, 2004). Measures of cost relate to the consumption of a variety of resources, such as labor, capital, knowledge, facility etc. It indicates the effectiveness of business management and production productivity. Measures of time and quality reflect the ability of a supply chain to deliver high customer service, whilst flexibility and innovation indicate the ability to cope with rapid changes in demand or supply. Six relevant operational effects, detailed in Table 1, have been defined in the evaluation framework (see D9.2.1).

Operational Effect	Description
Cost	The costs associated with operating the organization's supply chain processes
Efficiency	The extent to which the organization's resources (e.g. time, use of facilities) are exploited
Quality	The degree to which the outcome of the process fulfils customer's needs and requirements
Flexibility	The extent to which a organization's supply chain supports changes in product or service offerings (e.g., features, volume, and speed) in response to marketplace changes (e.g., competitors, legislation, technological innovation etc.)
Innovation	The extent to which the organization introduces new processes, products, or services
Sustainability	The extent of usage of an environmental resource, so that the resource is not depleted or permanently damaged

Table 1: Operational Effects Dimension

2.2.2 Business Process Dimension

The second classification dimension is the *business process*. It relates to core business processes, in which performance improvements are expected to occur as a result of *ComVantage* collaborative capabilities.

This dimension is based on a process-based perspective, according to which core processes can be used to integrate the general processes and structures for any supply chain, and therefore can be used to identify and confine the framework of performance measurement (Chan and Qi, 2003). In accordance to this perspective, the business process dimension includes five core processes that categorize the typical function areas in supply chains within the organization and across its boundaries, including: suppliers, inbound logistics, operation, outbound logistics, and marketing and sales (including end-customer). The suppliers and inbound logistics processes, compose the upstream part of the supply chain. The supplier process assumes the functions of supplying materials and some outsourcing functions such as product design and the inbound logistics takes the role of supply base management, inbound material transportation and storage. The operation process refers to the internal part of the supply chain including manufacturing or maintenance and engineering. The outbound logistics and marketing and sales processes are part of the downstream part of the supply chain. Outbound logistics takes the part of outbound product transportation, distribution, and warehousing. Marketing and sales process takes the role of the links with customers including order processing and customer service.

The key processes identified can be further decomposed into sub-processes and activities to address their detailed performances. For example, the operation process can be decomposed into such sub-processes as internal manufacturing operations, R&D, engineering, maintenance, etc. For each sub-process, the corresponding performance indicators can be identified respectively. Then the associated measures of the sub-processes can be respectively grouped into the level of processes to and provide an effective means to analyse and measure supply chain performance, adapted to the specific processes of any organization. Table 2 describes the five core processes, and their corresponding sub-processes.

Business Process	Description	Supply Chain Part
Supplier	Includes all activities related to the procurement of products and services from suppliers to meet planned or actual demand (e.g. product design, product fabrication, product delivery, etc.)	Upstream (suppliers)
Inbound logistics	Refers to inventory management of raw materials (e.g. supply base management, materials transportation, receiving and inspection, handling and storing, etc.)	Upstream (suppliers)
Operation	Relates to all activities that are part of transforming a product or a service to its finished state to meet planned or actual demand (e.g. R&D, engineering, manufacturing/service, maintenance and storing etc.)	Internal part of the supply chain
Outbound logistics	Refers to the process of providing finished goods and services to meet planned or actual demand (e.g. product transportation management, warehousing, delivery management, etc.)	Downstream (customers)
Marketing and sales (including end-customer)	Refers to the process of managing customers and sales (e.g. customer order processing, demand management, customer services, etc.)	Downstream (customers)

Table 2: Business Processes Dimension

3 METHODOLOGY

The final metric set was developed in six steps. The first step involved the development of a preliminary metric set on the basis of the evaluation framework's dimensions (presented in D9.2.1). The second step focused on generating a full and comprehensive list of performance measures (see Appendix I), based on the preliminary metric set that was generated in the first step. This was accomplished by an extensive review of both professional and academic literature. Total of 67 metrics have been identified. The identified, relevant metrics were categorized according to the two dimensions of the evaluation framework - operational effects and business processes.

To understand the organizational context in which the metric-set is to be applied, the third step involved the analysis of the processes that are expected to change due to the implementation of *ComVantage*. This analysis focused on the scenarios defined in each of the *ComVantage* application areas (WP6 - plant engineering and commissioning, WP7 - customer-oriented production, and WP8 - mobile maintenance). On the basis of this analysis, an adapted metric set was created in the fourth step.

The fifth step aimed at receiving input from key stakeholders from the different application areas to the adapted list. The feedback was gathered via questionnaires and interviews with two key personnel from each application area (total of six interviews were conducted). Prior to the interviews, the interviewees received a questionnaire with the relevant metrics and were asked to assess, on a seven-point Likert scale, the extent to which each metric would reflect the expected change in business performance as a result of implementing *ComVantage* (see Appendices II, III, and IV). The interviewees were also asked to suggest additional, relevant metrics. In the interview, they were asked about their feedback in the questionnaire and three additional questions: 1) the most significant contribution of *ComVantage* platform to the improvement of organizational performance, 2) the extent to which the operational effects would reflect the improvement in performance due to the implementation of *ComVantage* and 3) the extent to which the core supply chain processes (upstream, internal, downstream) would reflect the improvement in performance due to the implementation of *ComVantage*.

Both input types were processed and analysed through the use of relevance matrices indicating the expected change due to the implementation of *ComVantage* in both framework's dimensions: the operational effects dimension and the business process dimension.

In the sixth and final step, all feedbacks were incorporated into a single general list of metrics to measure the expected impact of *ComVantage*, as well as three metric sets for the three application areas (see chapter 5).

4 METRIC SET ASSESSMENT

This chapter describes the results of the metric set assessment based on data collected from stakeholders in the different application areas of *ComVantage*. As described in chapter 3, the feedback from the business partners included two types of inputs. The first type refers to the identification of areas in which performance is expected to improve due to *ComVantage* and the second type refers to the reflection level of the proposed metrics. Section 4.1, is focused on the analysis of results relating to the major value adding areas of *ComVantage*. Section 4.2, is focused on the analysis of the degree to which the proposed metric set reflects the expected impact of *ComVantage*.

4.1 Expected Impact of *ComVantage*

The assessment of the expected value adding areas of *ComVantage* is based on inputs gathered through the interviews, using both qualitative (question 1 in the interview) and quantitative (questions 2 and 3 in the interview) inputs. The qualitative assessment relates to the perceived significant contributions of *ComVantage* to the improvement of organizational performance. The quantitative assessment relates to the estimated impact of *ComVantage* on the evaluation framework's dimensions, using 1-7 Likert scales, as presented in Figure 1 and Figure 2. Both figures illustrate the average score of the expected impact of *ComVantage* for the three different application areas. Figure 1 presents the impact on the operational effects dimension (including cost, quality, efficiency, flexibility, innovation, and sustainability) and Figure 2 shows the impact of *ComVantage* on the different parts of the supply chain, including: upstream supply chain processes (suppliers related) , internal supply chain processes and downstream supply chain processes (customers related). As can be drawn from the figures, the general impact of *ComVantage* on the operational performance is expected to be mainly through improved efficiency, improved innovation, and cost reduction (see Figure 1). The impact is expected in all supply chain processes, in accordance with the specific characteristics of each application area (see Figure 2).

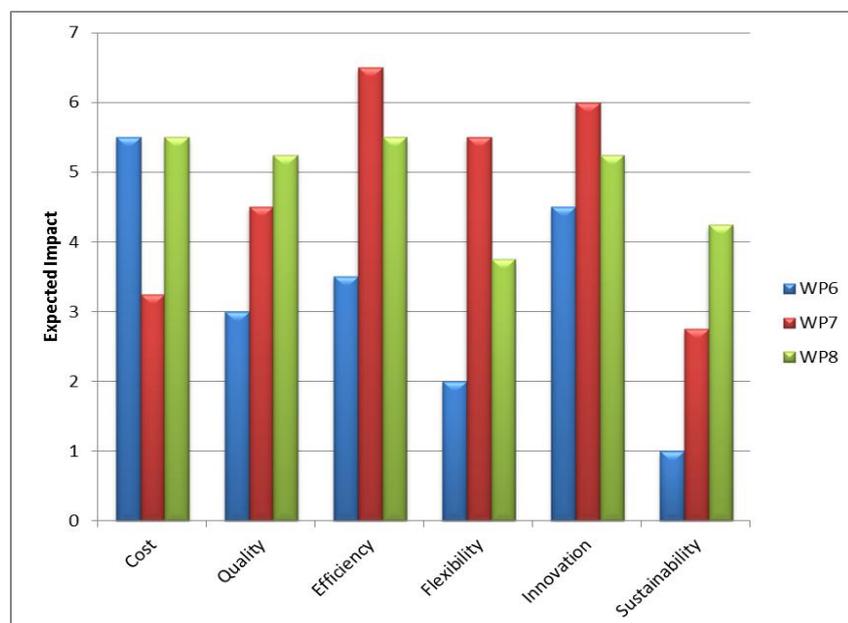


Figure 1: Expected Impact on Operational Effects

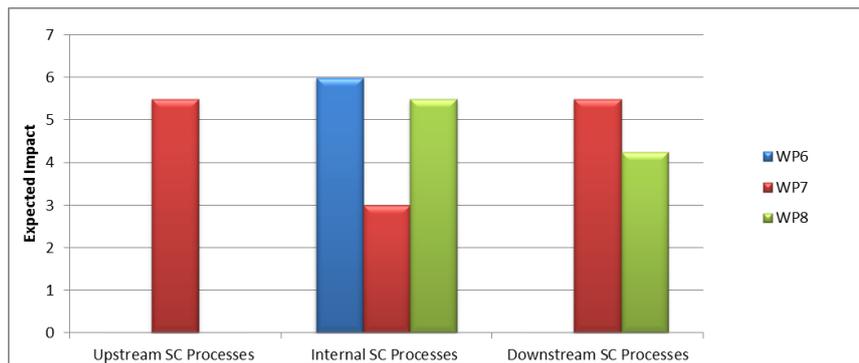


Figure 2: Expected Direct Impact on Supply Chain (SC) Processes

The next sections (4.1.1-4.1.3) refer to the results for each application area.

4.1.1 Work Package 6 – Plant Engineering and Commissioning

WP6 focuses on plant commissioning and the feedback received from stakeholders suggests that the *ComVantage* platform is expected to reduce the most crucial resource in this industry – commissioning time. This reduction is expected to be facilitated by making data from machines and experts available on demand, anywhere, via mobile devices. As a result, the most relevant operational effect to reflect the change introduced by the new platform is cost, which should drop due to more efficient internal processes. For example, problems will be detected in an earlier stage and data to identify, analyse and solve them will be accessible instantly from anywhere by any authorized personnel, making it easier to route the problem to the relevant expert supporting short response time. Innovation is also predicted to reflect the change introduced by *ComVantage* because the new capabilities will likely facilitate the inception of more innovative processes.

In terms of the framework's dimensions, the operational effects that would mostly reflect the impact of *ComVantage* include cost, innovation, and efficiency (see Figure 1); the improvement is expected in the internal processes of the supply chain (see Figure 2) since they support better collaboration between the internal functions. The upstream (suppliers related) and downstream (customers related) processes will be affected in an indirect manner.

4.1.2 Work Package 7 – Customer-oriented Production

WP7 focuses on providing the customer with a unique and customized product through the typical supply chain process. Therefore, the contribution of the *ComVantage* platform is expected mainly in the support of a unique and innovative customer-order process. In addition, a better interaction is expected with suppliers due to collaboration with various suppliers (such as textile producers and designers).

In terms of the framework's dimensions, the operational effects that would mostly reflect the impact of *ComVantage* include efficiency, innovation, and flexibility (see Figure 1); the improvement is expected in all processes of the supply chain (see Figure 2).

4.1.3 Work Package 8 – Mobile Maintenance

WP8 focuses on the provision of maintenance services to geographically-dispersed companies, and the interviewees indicated that the availability of the data from machines and experts anywhere anytime, via mobile devices and over the internet, is the key change they expect to be introduced following the implementation of the *ComVantage* platform. This availability of data is expected to reduce cost, increase efficiency, and support the creation of new services, unavailable now, due to significant improvements in internal processes.

In terms of the framework's dimensions, the operational effects that would mostly reflect the impact of *ComVantage* include efficiency, cost, and quality (see Figure 1); the improvement is expected in the internal and downstream (customers related) processes of the supply chain (see Figure 2).

4.2 Reflection Level of the Proposed Metric Set

The main challenge in defining a multi-dimensional metric set is to identify the key performance indicators (KPIs) for value-adding areas of the organization (Garcia, 2012). In practice, once the supply chain performance measures are developed adequately, managers have to identify the critical KPIs that reflect the performance aspects needed to be measured.

The analysis of the extent to which the multi-dimensional metric set reflects the impact of *ComVantage* on organizational performance was done by examining the reflection level of the metrics according to the categories that are defined by the intersection of operational effects and supply chain processes.

Specifically, this was carried out by averaging the metric scores of the respondents at the application area level and then grouping them according to their corresponding category (see appendix 1). The category score has been defined as the maximal score of all the metrics in the category. Then, the category scores were transformed into a three-level scale: High (category score ≥ 5), Medium ($2 < \text{category score} < 5$) and Low (category score ≤ 2).

The resulting scores of the categories are displayed in the following matrices for each application area (Figure 3, Figure 4, and Figure 5) and for the overall project (

Figure 6). In the figures, the colour intensity of the matrix cells indicates the reflection level of the metrics that belong to the category. Darker cells denote the existence of highly reflective metrics in the category, while lighter cells denote lower reflective metrics. White cells denote that no relevant metrics were found for the category.

Figure 3 presents the reflection level of the metrics in WP6. Considering the operational effects dimension, the results suggest that cost, efficiency, quality, and flexibility include highly reflective metrics, while innovation and sustainability include medium reflective metrics. This confirms that cost, efficiency, and innovation, which were found as value adding areas of *ComVantage* in WP6 (see Section 4.1.1), will be properly measured. With respect to the business processes dimension, the highly reflective metrics refer mainly to the operation, outbound logistics, and marketing and sales processes.

Dimension	Supplier	Inbound	Operation	Outbound	Marketing and Sales
Cost			High reflection level		
Efficiency			High reflection level		Medium reflection level (2)
Quality			High reflection level	Medium reflection level (2)	High reflection level
Flexibility				High reflection level	Medium reflection level (2)
Innovation			Medium reflection level (2)		Medium reflection level (2)
Sustainability			Medium reflection level (2)		Low reflection level (1)

Legend: 1 Low reflection level 2 Medium reflection level High reflection level

Figure 3: Reflection Level of Metrics – WP6

Figure 4 presents the expected reflection level of the metrics in WP7. Considering the operational effects dimension, the results suggest that efficiency, quality, flexibility, and innovation include highly reflective metrics. This confirms the proper measurement of the major value adding areas of *ComVantage* in WP7, including efficiency, flexibility, and innovation (see Section 4.1.2). With respect to the business processes dimension, the highly reflective metrics refer to most processes along the full supply chain.

Dimension	Supplier	Inbound	Operation	Outbound	Marketing and Sales
Cost	1	2	2	1	
Efficiency	2		2	2	2
Quality	2	2	1	2	2
Flexibility	2		2	2	
Innovation			2		2
Sustainability			2		2

Legend: 1 Low reflection level 2 Medium reflection level 2 High reflection level

Figure 4: Reflection Level of Metrics – WP7

Figure 3Figure 5 describes the expected reflection level of the metrics in WP8. Considering the operational effects dimension, the results suggest that all aspects include highly reflective metrics, which is consistent with the major value adding areas of *ComVantage* in WP8 (see Section 4.1.3). With respect to the business processes dimension, the highly reflective metrics refer mainly to the operation and marketing and sales processes, which belong to the internal and downstream parts of the supply chain.

Dimension	Supplier	Inbound	Operation	Outbound	Marketing and Sales
Cost			2		
Efficiency			2		2
Quality			2		2
Flexibility			2	2	
Innovation			2		2
Sustainability			2		2

Legend: 1 Low reflection level 2 Medium reflection level 2 High reflection level

Figure 5: Reflection Level of Metrics – WP8

Legend: 1 Low reflection level 2 Medium reflection level 2 High reflection level

Figure 6 presents the overall project view of the expected reflection level of the metrics, generated by calculating the average reflection level across all work packages. Considering the operational effects, the results suggest that all aspects include reflective metrics, while highly reflective metrics belong to cost, efficiency, quality, and innovation. With respect to the business processes, the highly reflective metrics refer mainly to the operation and marketing and sales processes.

Dimension	Supplier	Inbound	Operation	Outbound	Marketing and Sales
Cost		1	2		
Efficiency	1		2	1	2
Quality	1	1	2	1	2
Flexibility	1		2	2	1
Innovation			2		2
Sustainability			2		2

Legend:  Low reflection level  Medium reflection level  High reflection level

Figure 6: Reflection Level of Metrics – Overall Project

The final metric set lists to measure the business value of *ComVantage* for the implementing organizations are depicted next.

5 MULTI-DIMENSIONAL METRIC SET

The assessment process has resulted in an adapted metric set for each applicative work package. As explained in Chapter 2, the relevant KPIs in each application area depend on the environmental context. In accordance with these local considerations, the overall metric set has been adapted to each application area by omitting metrics that are irrelevant in the specific context and including additional KPIs proposed by application area stakeholders (marked with *). The adapted metric set for each application area is listed below (see Table 3-Table 5). Each table details the relevant KPIs, according to their corresponding dimensions, their description and reflection level (high, medium and low). Based on these work packages-specific lists, a consolidated metric set has been composed (see Table 6).

5.1 Multi-Dimensional Metric Set – Plant Engineering and Commissioning (WP6)

Table 3 presents the relevant key performance indicators (KPIs) for Plant Engineering and Commissioning (WP6).

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description	Reflection Level
Cost	Operation	Transportation cost	Aggregated cost of transportation over a specific period of time	Low
	Operation	Service cost	The cost associated with service operations over a specific period of time (e.g. receiving a customer request, examining its feasibility, performing the necessary action to fulfil the request).	High
	Operation	Cost of product design modifications	Cost of modifications that are performed to overcome errors over a specific period of time	High
Efficiency	Operation	Order processing cycle time	Time elapsed between customer order placement and delivery at the customer's location	High
	Operation	Mean time to restore (*)	Average time to repair a failed component	High
	Operation	Overall Efficiency (*)	The actual performance relative to the designed capacity, during the periods when it is scheduled to run (in terms of availability , performance efficiency and quality efficiency)	High
	Marketing and Sales	Customer query time	Time elapsed between customer query and response	Medium
Quality	Operation	Percentage of rework	Percentage of rework performed to overcome errors	High
	Operation	Percentage of erroneous services	Percentage of erroneous services provided over a specific period of time	High
	Outbound Logistics	Percentage of on-time deliveries	Percentage of orders delivered on time over a specific period of time	Medium

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description	Reflection Level
	Marketing and Sales	Customer satisfaction	Customer satisfaction as indicated by satisfaction surveys	High
Flexibility	Outbound Logistics	Service delivery lead-time flexibility	Percentage of service calls delivered promptly	High
	Marketing and Sales	Service flexibility	Percentage of special customer requests met	Medium
Innovation	Operation	Process pipeline flow	Number of new service concepts in each stage of development	Medium
	Marketing and Sales	Success rate of new services	Percentage of launched services survived over a specific period of time	Medium
Sustainability	Operation	Level of waste generated during production	Quantity of waste generated through manufacturing operations	Medium
	Marketing and Sales	Customer satisfaction with green products	Extent to which the customers are satisfied with products, despite the modifications to meet green requirements	Medium

Table 3: Adapted Metric Set for Plant Engineering and Commissioning (WP6)

5.2 Multi-Dimensional Metric Set – Customer-oriented Production (WP7)

Table 4 presents the relevant key performance indicators (KPIs) for Customer-oriented Production (WP7).

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description	Reflection Level
Cost	Supplier	Ordering cost	The cost associated with orders placed on raw materials over a specific period of time	Low
	Inbound Logistics	Inventory cost	The cost associated with inventory storage within a company over a specific period of time	Medium
	Operation	Production cost	The cost associated with production over a specific period of time	Medium
	Operation	Transportation cost	Aggregated cost of transportation over a specific period of time	Low
	Outbound Logistics	Delivery cost	The cost of delivering finished goods over a specific period of time	Low
Efficiency	Supplier	Purchase order cycle time	Time elapsed between the ordering of raw materials and their arrival	Medium
	Supplier	No. of suppliers	Number of suppliers managed by the company	High

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description	Reflection Level
	Operation	Production cycle time	Time elapsed during production activities, i.e. total time required to produce a product	Medium
	Outbound Logistics	Delivery cycle time	Time elapsed between customer order and the arrival of the product to customer	Medium
	Marketing and Sales	Customer query time	Time elapsed between customer query and response	Medium
Quality	Supplier	Supplier quality	The number of claims (due to quality failures or late deliveries) made by the company against the supplier over a specific period of time	Medium
	Inbound Logistics	Inventory accuracy rate	The rate of inventory accuracy over a specific period of time, i.e., the gaps between inventory in the information system and actual inventory in the warehouse	Medium
	Inbound Logistics	Out of stock occurrence	The frequency of out-of-stock situations over a specific period of time	Medium
	Operation	Production quality	Percentage of products in need of rework	Low
	Operation	Order quality	Percentage of products erroneously manufactured per order	Low
	Outbound Logistics	Percentage of on-time deliveries	Percentage of orders delivered on time over a specific period of time	Low
	Outbound Logistics	Percentage of erroneous deliveries	Percentage of erroneous deliveries over a specific period of time	Medium
	Marketing and Sales	Customer complaints	The number of complaints (due to quality failures or late deliveries) made by customers over a specific period of time	High
	Marketing and Sales	Customer satisfaction	Customer satisfaction as indicated by satisfaction surveys	Medium
Flexibility	Supplier	Supplier flexibility	Supplier response time to a new demand	Medium
	Operation	Production flexibility	Time required to add new products to existing production operations	High
	Operation	Flexibility of service system	Percentage of special customer requests met	High

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description	Reflection Level
	Outbound Logistics	Product delivery lead-time flexibility	Percentage of orders delivered promptly	Medium
Innovation	Operation	Number of new designs	Number of new designs over a specific period of time	Medium
	Operation	Process pipeline flow	Number of new product concepts in each stage of development (e.g. new design process, new design option, new design/ production option)	High
	Marketing and Sales	Success rate of new products	Percentage of launched products survived over a specific period of time	High
Sustainability	Operation	Level of waste generated during production	Quantity of waste generated through manufacturing operations	Medium
	Operation	Customer satisfaction from greening	Level of customer satisfaction with green products	Medium
	Marketing and Sales	Customer satisfaction with green products	Extent to which the customers are satisfied with products, despite the modifications to meet green requirements	Medium

Table 4: Adapted Metric Set for Customer-oriented Production (WP7)

5.3 Multi-Dimensional Metric Set – Mobile Maintenance (WP8)

Table 5 presents the relevant key performance indicators (KPIs) for Mobile Maintenance (WP8).

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description	Reflection Level
Cost	Operation	Transportation cost	Aggregated cost of transportation over a specific period of time	High
	Operation	Total resource cost	The aggregated cost of all resources over a specific period of time	High
	Operation	Service cost	The cost associated with service operations over a specific period of time	High
Efficiency	Operation	Order processing cycle time	Time elapsed between the placement of customer order and the delivery at the customer's location	Medium
	Operation	Availability Efficiency (*)	The ratio of time in which machines are available out of the total production time	High

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description	Reflection Level
	Operation	Maintenance Response time (*)	Time elapsed between a service request and its corresponding response	High
	Operation	Mean time to repair (*)	Average time required to repair a failed component or device	High
	Marketing and Sales	Customer query time	Time elapsed between customer query and response	High
Quality	Operation	Service order path	The number of activities that need to be completed by the customer to get a service (e.g. fill an online form, send an Email, make a call to contact centre, call an account manager)	High
	Operation	Percentage of erroneous services	Percentage of erroneous services provided over a specific period of time	High
	Marketing and Sales	Customer complaints	The number of customer complaints registered over a specific period of time	High
	Marketing and Sales	Customer satisfaction	Customer satisfaction as indicated by satisfaction surveys	High
Flexibility	Operation	Operative flexibility	Time required to add new services to existing service operations	High
	Outbound Logistics	Service delivery lead-time flexibility	Percentage of service calls delivered promptly	Medium
Innovation	Operation	Range of services	Range of services offered to customers	Medium
	Operation	Process pipeline flow	Number of new service concepts in each stage of development	High
	Marketing and Sales	Success rate of new services	Percentage of launched services survived over a specific period of time	Medium
Sustainability	Operation	Utility use	Quantity of utilities (e.g., electricity) used over a given period of time	Medium
	Marketing and Sales	Customer satisfaction with green activities	Extent to which the customers are satisfied with products, despite the modifications to meet green requirements	Medium

Table 5: Adapted Metric Set for Mobile Maintenance (WP8)

5.4 Consolidated Multi-Dimensional Metric Set

Table 6 presents the consolidated list of KPIs over all three application areas (Table 3, Table 4, Table 5). This list serves as a generic metric-set to measure the performance change due to *ComVantage* platform, which should be adapted to the specific characteristics of the implementing organization.

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description
Cost	Supplier	Ordering cost	The cost associated with orders placed on raw materials over a specific period of time
	Inbound Logistics	Inventory cost	The cost associated with inventory storage within a company over a specific period of time
	Operation	Cost of product design modifications	Cost of modifications that are performed to overcome errors over a specific period of time
	Operation	Production cost	The cost associated with production over a specific period of time
	Operation	Service cost	The cost associated with service operations over a specific period of time (e.g. receiving a customer request, examining its feasibility, performing the necessary action to fulfil the request).
	Operation	Total resource cost	The aggregated cost of all resources over a specific period of time
	Operation	Transportation cost	Aggregated cost of transportation over a specific period of time
	Outbound Logistics	Delivery cost	The cost of delivering finished goods over a specific period of time
Efficiency	Supplier	No. of suppliers	Number of suppliers managed by the company
	Supplier	Purchase order cycle time	Time elapsed between the ordering of raw materials and their arrival
	Operation	Availability	The ratio of the time a unit is capable of being used to the total time
	Operation	Mean time to repair	Average time required to repair a failed component or device
	Operation	Mean time to restore	Average time to repair a failed component
	Operation	Order processing cycle time	Time elapsed between customer order placement and delivery at the customer's location
	Operation	Production cycle time	Time elapsed during production activities, i.e. total time required to produce a product
	Operation	Response time	Time elapsed between a request and the first corresponding response
	Outbound Logistics	Delivery cycle time	Time elapsed between customer order and the arrival of the product to customer
	Marketing and Sales	Customer query time	Time elapsed between customer query and response
Quality	Supplier	Supplier quality	The number of claims (due to quality failures or late deliveries) made by the company against the supplier over a specific period of time

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description
	Inbound Logistics	Inventory accuracy rate	The rate of inventory accuracy over a specific period of time, i.e., the gaps between inventory in the information system and actual inventory in the warehouse
	Inbound Logistics	Out of stock occurrence	The frequency of out-of-stock situations over a specific period of time
	Operation	Order quality	Percentage of products erroneously manufactured per order
	Operation	Percentage of erroneous services	Percentage of erroneous services provided over a specific period of time
	Operation	Percentage of rework	Percentage of rework performed to overcome errors
	Operation	Production quality	Percentage of products in need of rework
	Operation	Service order path	The number of activities that need to be completed by the customer to get a service (e.g. fill an online form, send an Email, make a call to contact centre, call an account manager)
	Outbound Logistics	Percentage of erroneous deliveries	Percentage of erroneous deliveries over a specific period of time
	Outbound Logistics	Percentage of on-time deliveries	Percentage of orders delivered on time over a specific period of time
	Marketing and Sales	Customer complaints	The number of complaints (due to quality failures or late deliveries) made by customers over a specific period of time
	Marketing and Sales	Customer satisfaction	Customer satisfaction as indicated by satisfaction surveys
Flexibility	Supplier	Supplier flexibility	Supplier response time to a new demand
	Operation	Flexibility of service system	Percentage of special customer requests met
	Operation	Operative flexibility	Time required to add new services to existing service operations
	Operation	Production flexibility	Time required to add new products to existing production operations
	Outbound Logistics	Product delivery lead-time flexibility	Percentage of orders delivered promptly
	Outbound Logistics	Service delivery lead-time flexibility	Percentage of service calls delivered promptly
	Marketing and Sales	Flexibility of service system	Percentage of special customer requests met

Operational Effect Dimension	Business Process Dimension	KPI	KPI Description
Innovation	Operation	Number of new designs	Number of new designs over a specific period of time
	Operation	Process pipeline flow	Number of new service concepts in each stage of development
	Operation	Range of services	Range of services offered to customers
	Marketing and Sales	Success rate of new products	Percentage of launched products survived over a specific period of time
	Marketing and Sales	Success rate of new services	Percentage of launched services survived over a specific period of time
Sustainability	Operation	Customer satisfaction from greening	Level of customer satisfaction with green products
	Operation	Level of waste generated during production	Quantity of waste generated through manufacturing operations
	Operation	Utility use	Quantity of utilities (e.g., water, electricity) used over a given period of time
	Marketing and Sales	Customer satisfaction with green activities	Extent to which the customers are satisfied with products, despite the modifications to meet green requirements
	Marketing and Sales	Customer satisfaction with green products	Extent to which the customers are satisfied with products, despite the modifications to meet green requirements

Table 6: Consolidated Metric Set

6 CONCLUSION AND OUTLOOK

The development of the multi-dimensional metric set started with a proposition of key performance indicators to assess organizational performance following the implementation of *ComVantage*. Based on the revised evaluation framework, presented in D.9.2.1, six performance aspects with 67 metrics were generated and adapted to the context of each of the project's application areas. This metric set was assessed using questionnaires administrated to stakeholders from all three application areas, followed by corresponding interviews.

The results obtained show that the multi-dimensional metric set reflects the expected improvement in organizational performance as a consequence of implementing the *ComVantage* applications. The results also reveal that there are differences in the extent to which the different metrics reflect the effects of *ComVantage* across different application areas. These differences are attributed to the different logistic focus and priorities, nature of goods/services provided, industry's characteristics, organizational size, etc. The KPIs should therefore be adapted to the specific organizational and supply chain context. This conclusion is consistent with research (Cuthbertson, 2011) that recommended viewing performance measurement as a context-dependent process, tailored to specific characteristics of the organization.

To conclude, the output of this deliverable provides a generic metric set, based on a balanced and process based approach, to introduce key performance indicators (KPIs) in a structured manner, with room for customization with respect to individual organizational needs.

In the next stages of the project, this metric set will be used to define both objective performance indicators and subjective performance instrument. The objective performance indicators will be used to set objectives of a simulation study, while the subjective performance instrument will be used to assess performance, based on the subjective interpretations of individual actors, in a survey-based study.

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8 APPENDIX I: Initial Metric Set

Performance Aspect	Logistic Process	Metric	Description	Reference
Cost	Supplier	Ordering cost	Cost associated with orders placed on raw materials over a period of time	(Beamon, 1999b, Chan and Qi, 2003, El - Baz, 2011, Chan et al., 2003)
	Supplier	Supplier pricing against market	Supplier pricing against rivals in the same category	(Kumar, 2004)
	Inbound Logistics	Inventory cost	The cost associated with inventory storage over a period of time	(Chan and Qi, 2003)
	Operation	Cost of product design modifications	Cost of modification which are performed to overcome errors over a period of time	(Chan and Qi, 2003, Beamon, 1999b, El - Baz, 2011, Chan et al., 2003)
	Operation	Production cost	Costs associated with production over a period of time	(Chan and Qi, 2003, Beamon, 1999b, El - Baz, 2011)
	Operation	Service cost	Costs associated with service operating over a period of time	(Chan and Qi, 2003, Beamon, 1999b, El - Baz, 2011)
	Operation	Total resources cost	Aggregated cost of all resources in a period of time	(Beamon, 1999b)
	Operation	Transportation cost	Aggregated cost of transportation over a period of time	(Chan and Qi, 2003, Shepherd and Günter, 2006)
	Operation	Warranty / Returns processing cost	Cost associated with processing returns of a unit	(Lockamy and McCormack, 2004)
	Operation	Total logistics cost	Aggregated cost of all logistics activities over a period of time	(Garcia et al., 2012)
Efficiency	Outbound Logistics	Delivery cost	Cost of delivering finished goods over a period of time	(Chan and Qi, 2003, Beamon, 1999b)
	Outbound Logistics	Warehouse costs	Aggregated cost of all activities associated with warehousing	(Chan and Qi, 2003, Chan et al., 2003)
	Supplier	No. of suppliers	Number of suppliers managed	(Gunasekaran, 2004)



Performance Aspect	Logistic Process	Metric	Description	Reference
	Supplier	Purchase order cycle time	Time between the ordering of raw materials and their arrival	(Gunasekaran et al., 2001)
	Operation	Order Processing Cycle Time	Time between the customer order placement and the delivery in the customer's location	(Stewart, 1995, Gunasekaran et al., 2001),
	Operation	Response time	Time between a request and the corresponding first response	(Gunasekaran et al., 2001)
	Operation	Production cycle time	Time elapsed between the production procedure started and the moment the product is ready for shipping	(Beamon, 1999b)
	Operation	Immediately fill rate (of orders)	The percentage of orders that can be filled immediately	(El - Baz, 2011)
	Operation	Accuracy of forecasting techniques	The rate of accurate forecasts (variance<10%)	(Gunasekaran, 2004)
	Operation	Planned process cycle time	Estimated time between the customer order placement and the delivery at the customer's location	(Gunasekaran et al., 2001)
	Operation	Mean time to restore	Average time to repair a failed component	(Mathur et al., 2011)
	Operation	Overall Efficiency (OEE)	Parameters that measure how well a manufacturing unit performs relative to its designed capacity, during the periods when it is scheduled to run	(Mathur et al., 2011)
	Operation	Availability efficiency	The ratio of time in which machines are available out of the total production time	(Mathur et al., 2011)
	Outbound Logistics	Orders delivered before due date	Number of orders arrived before due date	(Beamon, 1999b, El - Baz, 2011, Chan et al., 2003)
	Marketing and Sales	Customer query time	Time between customer query and response	(Gunasekaran et al., 2001)
Quality	Supplier	Supplier's quality	The number of claims made by the company to the supplier over a period of time	(Gunasekaran et al., 2001)
	Supplier	Supplier rejection rate	Average rejection rate of supplier's deliveries	(Gunasekaran et al., 2001)



Performance Aspect	Logistic Process	Metric	Description	Reference
	Supplier	Supplier's defect-free deliveries	Average defect-free supplier's deliveries	(Gunasekaran et al., 2001)
	Inbound Logistics	Inventory accuracy	Inventory accuracy rate over a period of time	Chan and Qi, 2003
	Inbound Logistics	Out of stock occurrence	Out of stock occurrence over a period of time	(Chan and Qi, 2003)
	Operation	Order quality	Percentage of wrong products manufactured per order	(Behrouzi, 2011)
	Operation	Rework	Percentage of rework performed to overcome errors	(Behrouzi, 2011)
	Operation	Wrong services	Percentage of wrong services provided over a period of time	(Behrouzi, 2011)
	Operation	Service order path	The number of activities that are need to be done by the customer in order to receive service	(Gunasekaran et al., 2001)
	Outbound Logistics	Late or wrong deliveries	Percentage of late or wrong deliveries over a period of time	(Shepherd and Günter, 2006)
	Outbound Logistics	On-time deliveries	Percentage of orders delivered on time over a period of time	(Beamon, 1999b, Chan et al., 2003)
	Marketing and Sales	Customer complaints	Rate of complaint over a period of time	(Beamon, 1999b)
	Marketing and Sales	Customer satisfaction	Customer satisfaction as indicated by satisfaction survey	(Beamon, 1999b, Chan et al., 2003)
	Marketing and Sales	Customer-to-customer dissemination of information	Level to which customers are applying the word-of-mouth concept to encourage their peers and friends	(Dyckhoff et al., 2004, Yew Wong and Karia, 2010)
Flexibility	Supplier	Supplier's flexibility	Supplier's response time to new demand	(Garcia et al., 2012)
	Supplier	Supplier quality flexibility	supplier ability to respond to quality problems	(Gunasekaran et al., 2001)
	Inbound Logistics	Transportation flexibility	Ability to adjust to changes in the normal transportation processes	(Chan and Qi, 2003)
	Inbound Logistics	Inventory range	Average number of Stock Keeping Units (SKU) per period	(Shepherd and Günter, 2006)



Performance Aspect	Logistic Process	Metric	Description	Reference
	Operation	Flexibility of service system	Percentage of special customer's requests met	(Gunasekaran et al., 2001, El - Baz, 2011)
	Operation	Operative flexibility	Time required to add new services to the existing service operations	(Gunasekaran et al., 2001, El - Baz, 2011)
	Operation	Production flexibility	Time required to add new products to the existing production operation	(Lockamy and McCormack, 2004)
	Outbound Logistics	Product delivery lead-time flexibility	Percentage of prompt orders delivered	(Beamon, 1999b, Chan and Qi, 2003)
	Outbound Logistics	Responsiveness to urgent deliveries	Response time to urgent orders	(Chan and Qi, 2003, Gunasekaran et al., 2001)
	Marketing and Sales	Flexibility to meet particular customer needs	Percentage of special customer's needs met	(Gunasekaran et al., 2001)
Innovation	Operation	New designs	Number of new designs per period of time	(Kuczmarski, 2006)
	Operation	Process pipeline flow	Number of new services concepts in each stage of development	(Kuczmarski, 2006)
	Operation	R&D expenses	Total expenses on R&D	(Kuczmarski, 2006)
	Operation	Patent pending	Number of patent pending requests	(Kuczmarski, 2006)
	Marketing and Sales	New product survival rate	Percentage of launched products survived over a period of time	(Kuczmarski, 2006)
	Marketing and Sales	Success rate of new services	Percentage of launched services survived over a period of time	(Kuczmarski, 2006)
Sustainability	Supplier	Supplier initiatives on environmental management	Number of initiatives suppliers have put in place to enhance their green status	(Yew Wong and Karia, 2010)
	Supplier	Supplier environmental certification	Number of environmental certifications acquired over the years	(Yew Wong and Karia, 2010)
	Supplier	Supplier initiatives in recycling process	Number of initiatives put in place by the suppliers to encourage and promote effective recycling	(Yew Wong and Karia, 2010)



Performance Aspect	Logistic Process	Metric	Description	Reference
	Operation	Customer satisfaction from greening	Level of customer satisfaction with green products	(Yew Wong and Karia, 2010)
	Operation	Waste generated during production	Quantity of waste generated through manufacturing operations	(Olugu et al., 2011)
	Operation	Utility use	Quantity of utility used over a period of time (e.g. water, electricity)	(Yew Wong and Karia, 2010)
	Operation	Management effort to enlighten costumers on sustainability	Level to which the management is enlightening the customer with information about sustainability effect	(Yew Wong and Karia, 2010)
	Marketing and Sales	Customer satisfaction with green products	Extent to which the customers are satisfied with products, despite the modifications to meet green requirements	(Yew Wong and Karia, 2010)
	Marketing and Sales	Availability of eco-labelling	Availability of obvious sight of green conscious	(Yew Wong and Karia, 2010)

9 APPENDIX II: Questionnaire for Interviewee, WP6

Metric set assessment For WP6 – Plant Engineering and Commissioning

Name: _____

Date: _____

In order to evaluate the business value that is expected to be gained by organizations adopting *ComVantage* platform, we have defined a preliminary multi-dimensional metric-set.

The purpose of this questionnaire is:

1. To assess to what extent you expect each metric to reflect the expected change in the business performance as a result of implementing *ComVantage*.
2. To verify that all key performance metrics for value-adding areas in your organization, are included.

The following table presents the preliminary metrics-set.

Please assess to what extent you expect each metric to reflect the expected change in the business performance as a result of implementing *ComVantage*.

Indicate your opinion on the scale presented, where 1 = not at all and 7= to a large extent.

Please add comments if needed. Also, suggestions for additional metrics are most welcome.

Many thanks for your cooperation,
 BGU team

	Metric	Description	Reflection level of the metric							Comments
			not at all	to a large extent						
1	Transportation cost	Aggregated cost of all transportation over a specific period of time	1	2	3	4	5	6	7	
2	Service cost	The costs associated with service operating over a specific period of time	1	2	3	4	5	6	7	
3	Cost of product design modifications	Cost of modification which are performed to overcome errors over a specific period of time	1	2	3	4	5	6	7	
4	Order processing total cycle time	Time elapsed between customer order placement and the delivery in customer's location	1	2	3	4	5	6	7	
5	Customer query time	Time elapsed between customer query and response	1	2	3	4	5	6	7	
6	Percentage of rework	Percentage of rework performed to overcome errors	1	2	3	4	5	6	7	
7	Percentage of wrong services	Percentage of wrong services provided over a specific period of	1	2	3	4	5	6	7	

	Metric	Description	Reflection level of the metric							Comments
			not at all						to a large extent	
		time								
8	Percentage of on-time deliveries	Percentage of orders delivered on time over a specific period of time	1	2	3	4	5	6	7	
9	Customer complaints	Rate of complaint	1	2	3	4	5	6	7	
10	Customer satisfaction	Customer satisfaction as indicated by satisfaction survey	1	2	3	4	5	6	7	
11	Flexibility s to meet particular customer needs	Percentage of special customer's needs met	1	2	3	4	5	6	7	
12	Operative flexibility	Time required to add new services to the existing service operations	1	2	3	4	5	6	7	
13	Service delivery lead- time flexibility	Percentage of prompt service calls delivered	1	2	3	4	5	6	7	
14	Process pipeline flow	Number of new services concepts in each stage of development	1	2	3	4	5	6	7	
15	Success rate of new services	Percentage of launched services survived over a specific period of time	1	2	3	4	5	6	7	
16	Level of waste generated during production	Quantity of waste generated through manufacturing operations	1	2	3	4	5	6	7	
17	Level of customer satisfaction with green products	Extent to which the customers are satisfied with products, despite the modifications to meet green requirements	1	2	3	4	5	6	7	
18	Total resources cost	The aggregated cost of all resources in a specific period of time	1	2	3	4	5	6	7	

Additional metrics

If you have ideas for additional metrics please write them here.

	Metric	Description
A		
B		
C		
D		

10 APPENDIX III: Questionnaire for Interviewee, WP7

Metric set assessment For WP7 – Customer-oriented Production

Name: _____

Date: _____

In order to evaluate the business value that is expected to be gained by organizations adopting *ComVantage* platform, we have defined a preliminary multi-dimensional metric-set.

The purpose of this questionnaire is:

3. To assess to what extent you expect each metric to reflect the expected change in the business performance as a result of implementing *ComVantage*.
4. To verify that all key performance metrics for value-adding areas in your organization, are included.

The following table presents the preliminary metrics-set.

Please assess to what extent you expect each metric to reflect the expected change in the business performance as a result of implementing *ComVantage*.

Indicate your opinion on the scale presented, where 1 = not at all and 7= to a large extent.

Please add comments if needed. Also, suggestions for additional metrics are most welcome.

Many thanks for your cooperation,
 BGU team

	Metric	Description	Reflection level of the metric							Comments
			not at all		to a large extent					
1	Ordering cost	The cost associated with orders placed on raw materials over a specific period of time	1	2	3	4	5	6	7	
2	Inventory cost	The cost associated with inventory storage within a company over a period of time	1	2	3	4	5	6	7	
3	Production cost	The costs associated with production over a specific period of time	1	2	3	4	5	6	7	
4	Delivery cost	The cost of delivering finished goods over a specific period of time	1	2	3	4	5	6	7	
5	Transportation cost	Aggregated cost of transportation over a specific period of time	1	2	3	4	5	6	7	
6	Supplier's quality	The number of claims (due to quality fails or due to out of time deliveries)made by the company to the supplier in a specific period of time	1	2	3	4	5	6	7	

	Metric	Description	Reflection level of the metric							Comments
			not at all			to a large extent				
7	Inventory accuracy rate	Inventory accuracy rate in a specific period of time	1	2	3	4	5	6	7	
8	Out of stock occurrence	Out of stock occurrence in a specific period of time	1	2	3	4	5	6	7	
9	Production quality	Percentage of products need rework	1	2	3	4	5	6	7	
10	Order quality	Percentage of wrong products manufactured per order	1	2	3	4	5	6	7	
11	Percentage of on-time deliveries	Percentage of orders delivered on time over a specific period of time	1	2	3	4	5	6	7	
12	Percentage of late or wrong deliveries	Percentage of late or wrong deliveries over a specific period of time	1	2	3	4	5	6	7	
13	Customer complaints	The number of complaints (due to quality fails or due to out of time deliveries) made by customers in a specific period of time	1	2	3	4	5	6	7	
14	Customer satisfaction	Customer satisfaction as indicated by satisfaction survey	1	2	3	4	5	6	7	
15	Purchas order cycle time	Time elapsed between the ordering of raw materials and their arrival	1	2	3	4	5	6	7	
16	No. of suppliers	Number of suppliers managed	1	2	3	4	5	6	7	
17	Production cycle time	Production cycle time	1	2	3	4	5	6	7	
18	Delivery cycle time	Time elapsed between customer order and the arrival of the product to customer	1	2	3	4	5	6	7	
19	Customer query time	Time elapsed between customer query and response	1	2	3	4	5	6	7	
20	Supplier's flexibility	Supplier's response time to new demand	1	2	3	4	5	6	7	
21	Production flexibility	Time required to add new products to the existing production operation	1	2	3	4	5	6	7	
22	Product delivery lead-time flexibility	Percentage of prompt orders delivered	1	2	3	4	5	6	7	
23	Flexibility of service system	Percentage of special customer's needs met	1	2	3	4	5	6	7	
24	Number of new designs	Number of new designs per period of time	1	2	3	4	5	6	7	

	Metric	Description	Reflection level of the metric							Comments
			not at all			to a large extent				
25	Process Pipeline Flow	Number of new product concepts in each stage of development	1	2	3	4	5	6	7	
26	Success rate of new services	Percentage of launched products survived over a specific period of time	1	2	3	4	5	6	7	
27	Level of waste generated during production	Quantity of waste generated through manufacturing operations within an organization over a given period of time	1	2	3	4	5	6	7	
28	Customer satisfaction from greening	Level of customer satisfaction with green products	1	2	3	4	5	6	7	
29	Level of customer satisfaction with green products	Extent to which the customers are satisfied with products, despite the modifications to meet green requirements	1	2	3	4	5	6	7	

Additional metrics

If you have ideas for additional metrics please write them here.

	Metric	Description
A		
B		
C		
D		

11 APPENDIX IV: Questionnaire for Interviewee, WP8

Metric set assessment For WP8 – Mobile Maintenance

Name: _____

Date: _____

In order to evaluate the business value that is expected to be gained by organizations adopting *ComVantage* platform, we have defined a preliminary multi-dimensional metric-set.

The purpose of this questionnaire is:

5. To assess to what extent you expect each metric to reflect the expected change in the business performance as a result of implementing *ComVantage*.
6. To verify that all key performance metrics for value-adding areas in your organization, are included.

The following table presents the preliminary metrics-set.

Please assess to what extent you expect each metric to reflect the expected change in the business performance as a result of implementing *ComVantage*.

Indicate your opinion on the scale presented, where 1 = not at all and 7= to a large extent.

Please add comments if needed. Also, suggestions for additional metrics are most welcome.

Many thanks for your cooperation,
 BGU team

	Metric	Description	Reflection level of the metric							Comments
			not at all						to a large extent	
1	Total resources cost	The aggregated cost of all resources over a specific period of time	1	2	3	4	5	6	7	
2	Transportation cost	Aggregated cost of transportation over a specific period of time	1	2	3	4	5	6	7	
3	Service cost	The costs associated with service operating over a specific period of time	1	2	3	4	5	6	7	
4	Service order path	The number of activities that are need to be done by the customer in order to get a service	1	2	3	4	5	6	7	
5	Percentage of wrong service	Percentage of wrong service provided over a specific period of time	1	2	3	4	5	6	7	
6	Customer complaints	The number of customer complaints registered over a given period of time	1	2	3	4	5	6	7	
7	Customer satisfaction	Customer satisfaction as indicated by satisfaction survey	1	2	3	4	5	6	7	

	Metric	Description	Reflection level of the metric							Comments
			not at all	1	2	3	4	5	6	
8	Order Processing Cycle Time	Time elapsed between the customer order placement and the delivery in the customer's location	1	2	3	4	5	6	7	
9	Customer query time	Time elapsed between customer query and response	1	2	3	4	5	6	7	
10	Operative flexibility	Time required to add new services to the existing service operations	1	2	3	4	5	6	7	
11	Service delivery lead-time flexibility	Percentage of prompt service calls delivered	1	2	3	4	5	6	7	
12	Range of services	Range of services	1	2	3	4	5	6	7	
13	Process Pipeline Flow	Number of new service concepts in each stage of development	1	2	3	4	5	6	7	
14	Success rate of new services	Percentage of launched services survived over a specific period of time	1	2	3	4	5	6	7	
15	Utility use	Quantity of utility used over a given period of time (e.g. water, electricity)	1	2	3	4	5	6	7	
16	Level of customer satisfaction with green products	Extent to which the customers are satisfied with products, despite the modifications to meet green requirements	1	2	3	4	5	6	7	

Additional metrics

If you have ideas for additional metrics please write them here.

	Metric	Description
A		
B		
C		
D		

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