KEY PERFORMANCE MEASURES FOR SUPPLY CHAIN MANAGEMENT FROM THE COLOMBIAN SHIPYARD

WILSON ADARME JAIMES[1]

[1] Industrial Engineering, Production Specialist, MSc Industrial Engineering. cPhD Logistics. Professor, Universidad Nacional de Colombia - Bogotá.Research Group Director. Society, Economy and Productivity- Supply Chain Management.wadarmej@unal.edu.co

MARTÍN DARIO ARANGO SERNA[2]

[2] Industrial Engineering, Finance Specialist, MSc Computer Engineering. PhD *in Industrial Engineering.* Full Professor, Universidad Nacional de Colombia – Medellín. International Consultant: Supply Chain-logistics. Research Group Director: Industrial and organizational logistics. mdarangos@unal.edu.co

NICOLAS CLAVIJO BURITICA[3]

[3] Industrial Engineering. cMSc Industrial Engineering. Professor Universidad Agraria de Colombia Bogotá. Research in supply chain logistics.nicolasclbr@yahoo.es

Please leave this page blank

ABSTRACT

This article compiles the particularities that apply in the measurement of key performance indicators of supply chains (SC), at key points of logistic processes in shipyards dedicated to the design, manufacture, maintenance and repair of sea and river vessels in Colombia. The study provides a comprehensive collection of key performance measures proposed by many authors in the last ten years, which have been classified to determine the performance of the SC; international benchmarks are collected from western and eastern shipyards, along with their trends in structuring, selecting and measuring key performance indicators (KPI's Key Performance Indicators), finally made a verification of the measuring system of Colombia's main shipyard and proposes a model of performance measurement Global SC under the strategic perspectives inspired by the BSC Balanced Scorecard methodology, expanded by a perspective of Information Technology and Communications, as a determinant of enhancing competitive advantage in the market. In the latter stage of the study, the measurement model proposed is materialized by the design of an application coded in SQL (Structured Query Language), allowing its operation by a SC operating under coordinated decentralized and autonomous actors.

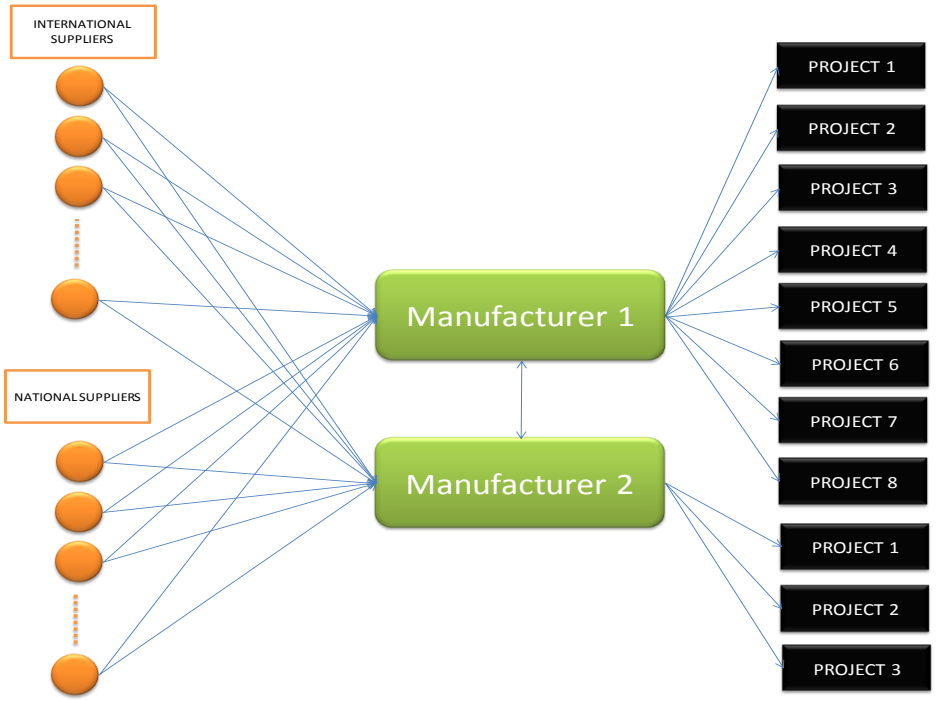
Keywords: performance, supply chain, yard, flag, coordination, SQL.

1. INTRODUCTION

The management of the SC is considered factor in the search strategy and the competitiveness of manufacturing and service organizations. The study provides a SC that operates with autonomous actors in decentralized environments, in the main yard of Colombia, located in Cartagena, Colombia.

This shipyard, has relationships with external stakeholders, which determine a configuration of two-tier SC Figure 1., National and international suppliers, transformation, represented by two major processing locations (Shipbuilding) 2 Plant 1 and Plant 2, care with limited capacity of 8 and 3 projects (Project shop) 3 respectively.

Figure 1. Network Configuration Flow AC on two levels, the main Colombian Shipyard



Source: *Own*

Independent of the approach, product type or size of operations, the performance of the SC determines its ability to generate customer value. Organizational management requires the development of a performance measurement system adapted to the presence of several companies, considered as tools for greater impact in the management of SC (Ballou et al, 2000; Lancioni, 2000).

The performance measurement system in the SC, is important in the joint efforts of the *stakeholders* in the logistics system under the premise that generates added value to customers in the short, medium and long term, better-looking global local optima and not SC. According to Ramdas et al.2003, improving the performance of the SC is a continuous process that requires an analytical system for measuring performance and a mechanism for the implementation of KPI's. At this point connects planning and execution, and then the construction of performance goals in the daily routines of

work.To measure the performance of the SC should be a set of measurable variables in the current work of the chain linking the impact on revenue and costs throughout the system.

The need to develop performance measurement systems at different levels of organizational decision making led to Robert S. Kaplan & David P. Norton (1992) to develop and propose the *Balanced Scorecard, BSC* as a means to evaluate corporate performance from four perspectives: financial, internal processes, customer and learning and growth. However under the new market trends in environmental terms *(Green Supply Chain),* Information and Communication Technologies (ICTs), leanness *(LeanSupplyChain)* Collaborative models *(CSC Collaborative Supply Chain)* and SC agile *(Agile Supply Chain*), among others, bring contemporary perspectives oriented and future of SC, under the overall dynamism and the era of information technology (IT).

The KPI's as input for decision making at every step of the SC, should be available at the right time and readily available means and consultation in this way, each stakeholder in the chain can manage your system a comprehensive picture logistics. The web is a good choice for designing query tools.

2. THEORETICAL BACKGROUND

2.1 Logistic and Supply Chain Management SCM.

Council Of Logistics by Logistic Management (2003), "... that part of the management of the SC, which plans, implements and controls the efficient flow of materials and efficient forward and backward, the storage of goods, services and related information between a point of departure and point of consumption to meet customer requirements. "This definition is closely related to management processes that include shopping, transportation, storage, production, marketing, return products and packaging (reverse

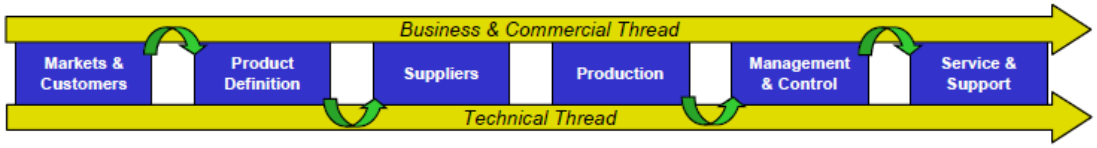
logistics aftermarket) and environmental management of waste (reverse logistics post-consumer) (Sarache et. al 2008).

According to Kumar et al. 2011, SC Management is the art of management that determines the requirements, acquisition, distribution through different channels and activities that create quality products and services for life. Supply Chain Management is the design, planning, execution, control and monitor the activities of the SC, the raw material to finished product. This ensures the right product movement in a smart, efficient and quick, to the right customer in the place, time and right price.

2.2 Shipbuilding.

Within the shipping industry, there are certain peculiarities concerning the supply, processing, distribution and consumption of sea and river ships. You can reference a traditional business chain focused on the satisfaction of stakeholders. Figure 2.

Figure 2. Technical and business chain typical of the maritime industry.



Source: *Derived from T. Brewton & Steller. M, 2005*

Shipbuilding is a type of industry in which design, build, test and repair ships. The process begins with design, in which engineers from the needs of clients develop a ship that suits them. In this industry, develop generic designs for mass production, in which the ship is then customized to the needs of each client. After the completion of the design, carried out the processing. Construction begins on the ground usually, but sometimes takes place once the interior fittings and the ship is launched. Once the ship has been completed, is derived from sea trials to check the quality parameters.

2.3 Supply Chain Performance.

The performance measurement process has evolved since the mid-eighties of last century when its foundations were formalized and integrated into the management of organizations, have developed various models of performance measurement structures to reach metrics intra-organizational or inter-organizational performance (Folan & Browne, 2005). Interorganizational system focuses on measuring the performance of SC.

Hausman et al. (2003), proposed several metrics to measure performance in the SC organized around three main pillars: services, activities and speed, other authors such as Lambert & Pohlen (2001) propose indicators that are established on the basis of financial performance indicators and economic the entire SC. From another perspective, Kleij & Smits (2003), suggest that measuring the performance of a SC should consider the fact that each company is a particular economic system and a different legal entity.

Bhagwat & Sharma, (2007) established a performance measurement approach of CS based on the perspectives provided in the BSC, Table 1.

Table 1. Performance measures from the perspectives of BSC.

BSC PERSPECTIVE	SUPPLY CHAIN PERFORMANCE INDICATORS
FINANCE	Return on investment (ROI) Variation from budget Asociación empresa-level provider Operation cost per hour Cost management information Rejection rate of provider
COSTUMERS	Customer Time Level of value of proceeds received by the client Range of products and services Order Delivery Time Flexibility of service on customer specific Asociacióncliente-level provider Order delivery performance Efficient invoice delivery Reliability of shipments Responsiveness to urgent deliveries Planning program efficiency distribution Cost management information Quality of delivery documentation Quality productosentregados Deliveries with zero defects

INTERNAL PROCESS	Total cycle time supply chain Supplier delivery time versus the industry standard Level of supplier delivery with zero defects Accuracy of forecasting techniques Cycle Time Product Development Cycle time of orders Effectiveness of the master production schedule Using capacidadinstalada Total inventory cost Inventory cost of raw materials and inputs Cost of inventory in transit Cost of finished goods inventory Cost of waste Percentage of purchases back Efficiency of the order cycle time Delivery frequency
LEARNING AND GROWTH	Responsiveness to technical problems Viable initiatives for cost reduction Reserve vendor procedures Order entry methods Accuracy of forecasting techniques Cycle Time Product Development Range of products and services

Source: *Adapted from* Bhagwat & Sharma, (2007)

Studies of Gunasekaran et al. 2001, collected performance measures for SC, in strategic, tactical and operational according to multiple investigations revolve around performance measurement as an input in decision making in logistics management. Table 2.

Table 2. SC performance measures under strategic levels.

LEVEL	PERFORMANCE MEASURE	FINANCIAL	NON-FINANCIAL	REFERENCE
STRATEGIC	Time total cash flow		x	Stewart (1995)
	Rates of return on investment	X		Christopher (1992); Dobler & Burt (1996)
	Ability to meet customer needs		X	Bower & Hout (1988), Christopher (1992)
	Delivery Lead Time		X	Rushton & Oxley (1991), Christopher (1992).
	Total cycle time		X	Christopher (1992), Stewart (1995)
	Level of association between buyer and supplier.	x		Toni et al. (1994)
	Consumer consultation time		X	Mason-Jones & Towill (1997)
TACTICAL	Level of cooperation to improve the quality		X	Graham et al. (1994)
	Total transportation cost		X	Rushton & Oxley (1991)
	Demand Truth		X	Fisher (1997), Harrington (1996).
	Cycle time for product development and implementation of predictability and forecasting		X	Bower & Huot (1988)

	methods			
OPERATIONAL	Manufacturing costs	X		Wild (1995)
	Capacity Utilization		X	Stewart (1995)
	Cost of carrying information	X		Levy (1997), Lee & Billington (1992)
	Cost of carrying inventory	X		Stewart (1995); Dobler & Burt (1996), Slack et al. (1998); Pyke & Cohen (1994)

Source: *Adapted from* Bhagwat & Sharma, (2007)

2.4 Supply Chain Coordination and integration

SC are complex and share the assumption that organizations interact across levels of the same and behave as a unified entity with a common purpose which is sometimes violated (Choi et al. 2001). As a result, there is great interest in the literature of Operations Management in coordination mechanisms related to systems of Information Technology (IT), which facilitate integration and coordination of the SC, especially in the control and connectivity (Mukhopadhaya et al., 1997, Lee et al., 2000, Ye & Farley, 2006).

Cooper et al. (1997) and Lambert & Cooper (2000) identify and describe the key in the SC business that need to be integrated and coordinated in the silos of individual functions within a single company and through various corporate silos within the network supply.

Das. ét. 2006, integration of supply defined as a state of synergy achieved through a variety of practices of integration between suppliers, purchasing and manufacturing of an organization.

3. PRACTICAL BACKGROUND

3,1 Performance Measures worldwide

Taken into account in this paper the performance indicators posed by international benchmarks (Table 3 and 4) and international institutions (Table 5) of the shipbuilding practices.

Table 3. International benchmarks of Shipbuilding

REGARDING INTERNATIONAL
Shipbuilding Alabama (U.S.)
Avondale Industries (U.S.)
Halter Marine (U.S.)
Newport News Shipbuilding (U.S.)
NASSCO (U.S.)
Shipyards Spanish (ES)
Fincantieri (IT)
Odense Steel Shipyard (DN)

Source: *Own*

Table 4. International institutional reference points related to shipbuilding

REGARDING INTERNATIONAL
Ocean Engineering Department, Graduate School of Engineering - COOPE
Federal University of Rio de Janeiro, UFRJ Technology Center
Department of Naval Architecture and Marine Engineering, University of Michigan.

Source: *Own*

The common key performance indicators in the marine industry, from a holistic perspective of shipyards worldwide, are summarized in Table 5.

Table 5. Key Performance Indicators common in the shipbuilding industry.

KPI's
SC Cost Management
Distribution cost
Inventory Cost
ROI
Cost Management Information
Turnover cost
Sales
Customer Satisfaction
Percent of on-time delivery
Fulfillment of order
Rate to costumer Complaints
Rate of stockounts
Procurement Flexibility
Delivery Flexibility
Logistics Flexibility

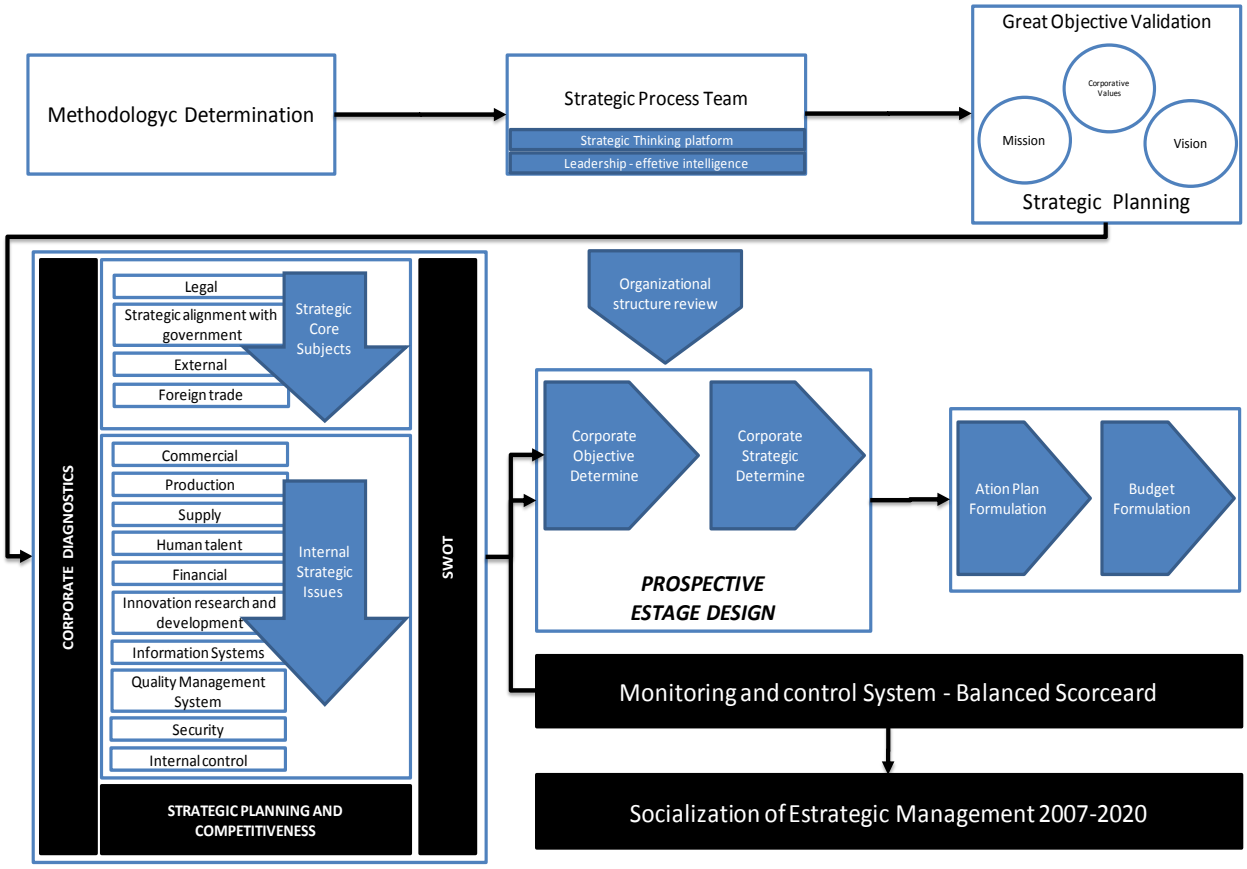
Flexibility NP
Flexibility IS
Rates of NP sales
Supply Chain Stability
Process Improvement

Source: *Own*

3,2 Performance Measures in the main Colombian Shipyard

Conceptual platform of strategic management process of the Home Builder Colombian, corresponds to an integrated approach based on theoretical models of Michael Porter's competitive analysis, Strategic Planning Humberto Serna, Michel Godet Foresight and Kaplan Balanced Scorecard and Norton. Fig. 3

Figure 3. Strategic Management Process in Colombia Shipyard Home



Source: *shipyard* study

The BSC is used as a tool for monitoring and control of the strategic guidelines using indicators designed for the corporate objectives 2007-2011 in each of the perspectives (Financial, Customer, Internal Processes, Learning and Growth). It contains 7 strategic variables (Finance, Commercial, Production, Logistics, Human Resource, Technology and Innovation Management) to guide corporate efforts in achieving the institutional vision. Each of these variables is in line with a strategic perspective (Table 3)

Table 3. SC performance under strategic levels.

PERSPECTIVE	VARIABLE	OBJECTIVE	GOAL WEIGHT	No.	INDICATORS
FINANCIAL	FINANCIAL	Maximize the value of the Corporation	14%	1	Weighted Yield Excess Liquidity
		Strategy: Growth and Control: revenue growth, cost		2	% Operating Margin

		and expense control, efficient use of resources.		3	EVA
CUSTOMER	COMMERCIAL	Ensure continuity of development programs Surface Fleet of the Colombian Navy and increase market share for repairs and construction in a growing and highly competitive market. Strategy: Differentiation and cost competitiveness, market access COTECMAR using a combined approach and cost competitiveness diferenciaicón	14%	4	% Compliance with the sales budget
				5	% Sales to new customers
				6	% Orion Forward Plan
INTERNAL PROCESSES	PRODUCTION	Responding effectively to the requirements of production projects sales of service and products of the Corporation. Strategy: Excelenciaoperativa: cost effectiveness, quality and timeliness.	14%	7	% Contribution Margin
				8	Consumption of providing guarantees for repair and maintenance projects
				9	Consumption of providing guarantees for new construction projects
				10	% Share of effective guarantees for repairs projects
				11	% Customer satisfaction for repairs
				12	% Customer satisfaction for new buildings
	LOGISTICS	Ensure the flow of supplies to ensure compliance with current and future corporate projects.	14%	13	% Order Management
		Strategy: Operational Excellence: effectively articulate her determination, achievement and implementation of information inputs, goods and services required for the development of corporate projects.		14	% Returns in acquisitions
LEARNING AND GROWTH	HUMAN TALENT	Ensure workforce development required for effective management of the Corporation and the basis for the development of future talent management. Strategy: Growth: Create an ample labor pool, which specializes in the shipping industry, maritime and river transport.	15%	15	% Staff Turnover
				16	% Contribution level of employment in the region
				17	% Execution investment in training
	TECHNOLOGY AND INNOVATION	Management to accelerate the achievement of the domain and coverage of existing technologies, appropriate new technologies that contribute to effective implementation of the objectives set for this period and lay the groundwork for the creation of a culture of innovation aimed at the satisfaction of the target market . Strategy: Applied research and innovation: Developing original works based on existing knowledge and transform ideas into marketable products.	15%	18	% Execution investment projects I + D + I
	MANAGEMENT	Dynamic and respond effectively to the challenges and demands of the competitive environment which manages COTECMAR. Strategy: A systems approach: Streamline internal processes and link	14%	19	Compliance with the delivery time of general information (Balance Sheet and

	them external.	with		Income Statement)
			20	% Corporate Compliance Management
			21	% Execution operating expense budget
			22	% Investment Budget Execution
			23	% Advance of Internal Control System
			24	% Execution Technology Watch Project

Source: *Colombian Naval Production*

In general, the review of the status of tie and the modus operandi of the shipbuilding industry are the impact of the Shipyard services offered which may get to take a dominant position in the industry if their organizational capacities and coordinating appropriate; for the Colombian case indicates that the first studies in this field are those that have been developed by research groups and GICO SEPRO [4] of the National University of Colombia in the field of logistics process improvement, in this sense does not exist yet Colombian naval sector tools, techniques and methodologies that allow their agents to work in a coordinated manner to maintain independence and have real time information so they can review, feed and make decisions based on it. Just the paper will present the proposed tool for the integrated management of the performance of SC Naval sector developed in SQL.

4. METHODOLOGY

This research in the Colombian naval sector has since 2008, where they have managed to characterize the sector and especially the main shipyard operation using tools, techniques and tools such as surveys, meetings, structured interviews and participant observation of the system.

This research proposes a tool to facilitate decision making at the strategic level of SC operating in coordination with autonomous agents in real-time decentralized environments.

A review of literature to establish benchmarks, mainly in supply chain management (SCM), shipbuilding, mechanisms of coordination and integration in supply chains and strategic management is carried out a benchmarking study where provides performance measurement from shipyards worldwide institutional referents and in referencing such factors arise most common key performance from a holistic perspective; later reference the performance measurement system in the main Colombian shipyard Then we propose a methodology for measuring supply chain performance using a model inspired by BSC, extended with a strategic perspective based on IT and communications, innovation and contribution of this research. In fourth place, a tool designed DASH BOARD scheduled in SQL language which is then validated with data from a supply chain.

5. RESULTS AND DISCUSSION

As a result of this research was first proposed in the structuring of a methodology for carrying out the key performance measures in the shipbuilding industry in Colombia, followed by the design of the tool set to SQL language, which is validated in a decentralized SC coordinated and autonomous operation.

5,1 Extending the Balanced Score Card Perspectives BSC

Since BSC is also the model in the nineties, the rapid technological development has forced organizations to seek a high flexibility and quick response to market fluctuations, a situation that leads to the concept of Systemic Organization (SO) which, according to Know (2006), refers only to a fixed and unchanging structure, a dynamic system whose characteristics change as the assumptions change, media and parameters within which it operates. The SO is based on information and communication technologies that

support the organizational changes and new forms of work in enterprises. This implies that ICT's are considered as a medium whose use is relevant to the context and aims. To the extent that technology is conceived as a means, the introduction of ICT is subject to business strategies in a given environment that determine the characteristics of the application of the technique and its effects on the organization.

Strategic outlook raised the BSC, such as (i) Financial Perspective, (ii) Customer Perspective, (iii) internal process perspective, and (iv) Learning and growth from this research and simultaneously adopting a posture in which actors are seen as organizations ac systemic (SO), it is proposed to include a fifth strategic perspective (Table 3) which presents the Information and Communications Technologies as a strategic element that makes sense today, post- multiple benefits generated by the OS and the SC.

Table 3. BSC Expansion

BSC	BSC Extended
Financial Perspective	Financial Perspective
Customers Perspective	Perspective customers, markets and competitors
Internal processes perspective	Process Management Overview, mission and support
Learning and Growth Perspective	Perspective Human Resource and Organizational Culture
	Overview of Information and Communications Technologies

Source: *Own elaboration*

.

5,2 Proposed Methodology For Performance Measurement In Shipbuilding

Since the fifth dimension arises strategic KPIs in CA in the shipbuilding industry and from the review of this topic are structured as shown in Table 4.

Table 4. KPI's for CA under 5 strategic perspectives

STRATEGIC PERSPECTIVE	PERFORMANCE INDUCATOR
FINANCIAL	- Return on investment - Operational cost per hour - Economic value added - Total time investment flow - Operating margin

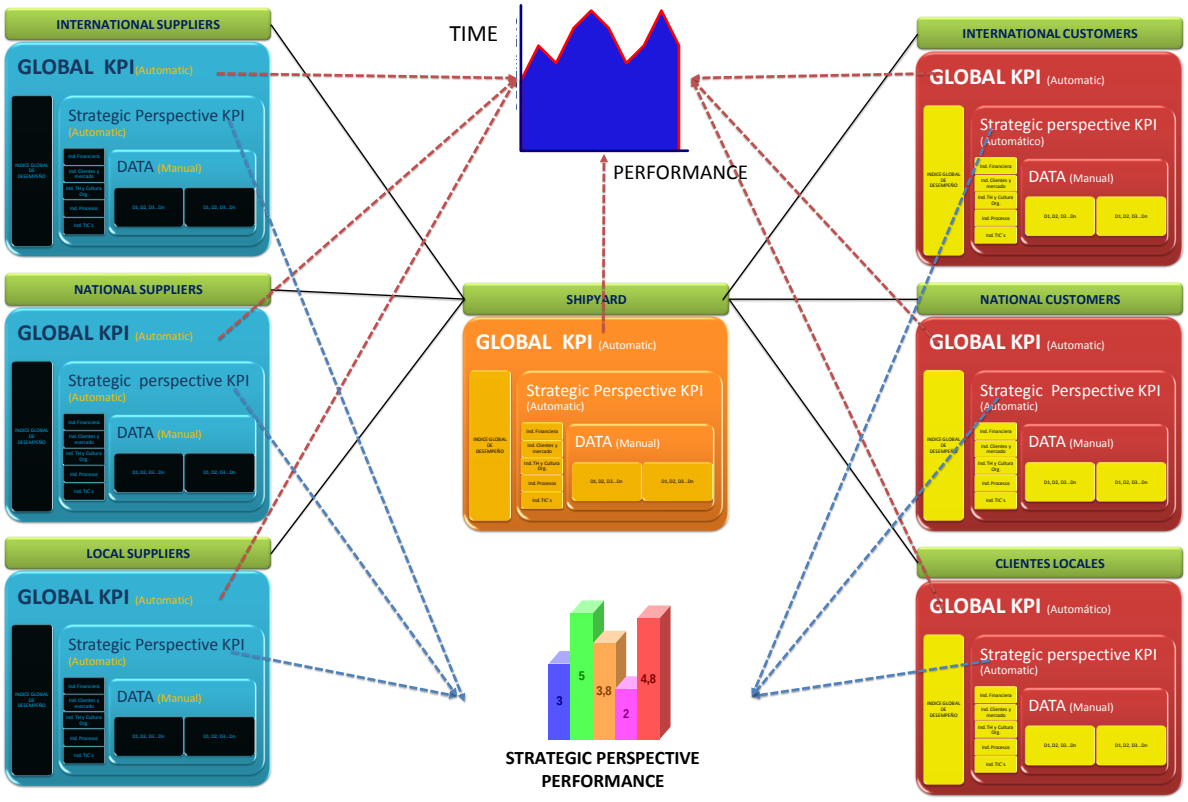
	- Weighted average cost of capital wacc - Level of environmental cost absorption - Percentage of investment budget performance - Operating cost information
CUSTOMERS, MARKET AND COMPETITION	- Customer response time - Ability to recognize the needs of customers - Enterprise-supplier association level - Flexibility of service by special customers - Delivery lead time - Supplier rejection rate - Product delivery performance - New customers - Claims by customers - Efficiency of billing - Responsiveness to urgent deliveries - Effectiveness of distribution planning schedule - Zero defects deliveries - Product returns
MANAGEMENT PROCESS, MISSION PROCESS AND SUPPORT PROCESS	- Total supply chain cycle time - Supplier lead time against industry norms - Level of suppliers defect free deliveries - Holding cost - Accuary of forecasting techniques - Tiempo de ciclo de desarrollo de productos - Effectiveness of master production schedule - Pproductividad de activos fisicos - Installed capacity utilization - Inventory turnover - Inventory total cost - Material inventory cost - Finished goods in transit inventory cost - Finished goods inventory cost - Scrap inventory cost - Space used cost - Frecuency of delivery
HUMAN TALENT AND ORGANIZATIONAL CULTURE	- Supplier assistance in solving technical problems - Sustainable initiatives to reduce cost - Effective improvement proposals - Number of workplaces accidents - Corporative management compilance - Investment in research, innovation and development - Employees promoted - Welfare activities implemented - Employee turnover - Unscheduled absenteeism
INFORMATION AND COMMUNICATIONS TECHNOLOGY	- Internal connectivity coverage - External connectivity coverage - Acces to information needed - Information safety - Information quality - Automation level - Production stop by fall system - Information systems innovation oriented to detect requeriments - Information systems reliability

Source: *Own*

From the very conception of coordination of SC, the SO and performance measurement from the five proposed strategic perspectives in this study, performance measurement

projects the logistics system from meeting the KPIs each agent in the chain, which then allowed through a tool based on IT, assess the performance of: each actor in the chain, a group of actors (stakeholders), links and key processes. The structuring of the steps follow a logical and hierarchical, beginning with data collection floor in each SO then automatically and through a presentation board (Dash Board) Web via which each SO can access, enabling consultation and streamlines decision-making in the SC, from a stage on which show the overall performance (of the logistics system and each link) and individuals (of each actor and stakeholders of the SC). Figure 4.

Figure 4. Structure Assessment Tool KPI's in CA



Source: *Own*

5,3 Design Tool for Performance Measurement CA

Based on the fact that each SO can enter your information to an application via the Internet in real time to measure performance in the five proposed strategic perspectives in this study, is constructed through language SQL (Structure Query Language) an

application that allowed under the database design, data entry floor on a website, which then stores the information and makes it available for consultation with stakeholders in the form of global performance indicators or private. You select the information on the web, since the SO information, communication and knowledge are crucial. The consolidation and management of a system are related to the speed of communication, information quality and the sense given to it in terms of knowledge, experience and shared culture in the SC.

5,4 VALIDATION, ANALYSIS AND CONCLUSIONS.

To validate the measurement tool DASH BOARD, SC selecting a Colombian naval industry, which presents the data obtained from studies conducted by SEPRO since 2008.

The KPI's evidenced in the shipbuilding industry in Colombia, are presented in various scenarios (multiple queries of the application) where plasma SC performance of the Stakeholders and every perspective, not without leaving the application capability of consultations of each and every link in the chain perspective.

Table 4. KPI´s evaluated in a Supply Chain

STRATEGIC PERSPECTIVE	PERFORMANCE INDICATOR	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3	MANUFACTURER 1	MANUFACTURER 2	CUSTOMER 1	CUSTOMER 2
FINANCIAL	RETURNO ON INVESTMENT	3,5	3,6	5	4,8	4,3	3,9	4,1
	OPERATIONAL COST PER HOUR	0,67	0,7	0,45	0,99	0,3	0,9	0,5
	ECONOMIC VALUE ADDED	0,75	0,25	0,21	0,65	0,87	0,76	0,99
	TOTAL TIME INVESTMENT FLOW	21	32	28	27	33	22	34
	OPERATING MARGIN	0,35	0,67	0,78	0,45	0,55	0,73	0,46
	WEIGHTED AVERAGE COST OF CAPITAL WACC	0,33	0,87	0,87	0,99	0,76	0,45	0,39
	LEVEL OF ENVIRONMENTAL COST ABSORPTION	0,48	0,65	0,45	0,33	0,54	0,42	0,32
	PERCENTAGE OF INVESTMENT BUDGET PERFORMANCE	0,75	0,88	0,21	0,65	0,87	0,69	0,99
	OPERATING COST INFORMATION	0,67	1,56	2,37	2,89	0,99	2,29	2,44
		28,5	**41,18**	**38,34**	**38,75**	**42,18**	**32,14**	**44,19**
CUSTOMERS, MARKET AND COMPETITION	CUSTOMER RESPONSE TIME	0,5	2,99	1,98	1,87	2,56	2,9	1,99
	ABILITY TO RECOGNIZE THE NEEDS OF CUSTOMERS	0,88	0,7	0,45	0,99	0,76	0,66	0,5
	ENTERPRISE-SUPPLIER ASSOCIATION LEVEL	0,77	0,44	0,67	0,88	0,76	0,55	0,99
	FLEXIBILITY OF SERVICE BY SPECIAL CUSTOMERS	0,49	0,75	0,40	0,60	0,36	0,67	0,60
	DELIVERY LEAD TIME	155	170	159	47	149	64	150
	SUPPLIER REJECTION RATE	0,86	0,37	0,09	0,25	0,58	0,70	0,03
	PRODUCT DELIVERY PERFORMANCE	0,16	0,91	0,04	0,90	0,43	0,92	0,58
	NEW CUSTOMERS	1	3	4	5	6	8	7
	CLAIMS BY CUSTOMERS	5	7	17	11	16	13	12
	EFFICIENCY OF BILLING	0,23	0,41	0,33	0,95	0,10	0,53	0,33
	RESPONSIVENESS TO URGENT DELIVERIES	0,34	0,35	0,74	0,54	0,57	0,88	0,99
	EFFECTIVENESS OF DISTRIBUTION PLANNING SCHEDULE	0,34	0,68	0,09	0,57	0,69	0,73	0,60
	ZERO DEFECTS DELIVERIES	0,40	0,36	0,04	0,82	0,22	0,22	0,45
	PRODUCT RETURNS	0,5	17	16	5	7	2	19
		166,47	**204,96**	**200,84**	**76,36**	**185,02**	**95,77**	**195,06**
MANAGEMENT PROCESS, MISSION PROCESS AND SUPPORT PROCESS	TOTAL SUPPLY CHAIN CYCLE TIME	120	245	178	190	230	136	222
	SUPPLIER LEAD TIME AGAINST INDUSTRY NORMS	0,96	0,44	0,61	0,52	0,75	0,20	0,01
	LEVEL OF SUPPLIERS DEFECT FREE DELIVERIES	0,05	0,90	0,34	0,45	0,88	0,26	0,90
	HOLDING COST	0,66	0,74	0,41	0,23	0,60	0,32	0,28
	ACCUARY OF FORECASTING TECHNIQUES	0,99	0,55	0,25	0,79	0,77	0,22	0,91
	TIEMPO DE CICLO DE DESARROLLO DE PRODUCTOS	101	190	178	199	110	150	144
	EFFECTIVENESS OF MASTER PRODUCTION SCHEDULE	0,88	0,42	0,65	0,07	0,02	0,97	0,09
	PRODUCTIVIDAD DE ACTIVOS FISICOS	0,78	0,66	0,29	0,66	0,96	0,02	0,80
	INSTALLED CAPACITY UTILIZATION	0,12	0,75	0,11	0,43	0,47	0,93	0,13
	INVENTORY TURNOVER	0,30	0,65	0,96	0,68	0,81	0,40	0,73
	INVENTORY TOTAL COST	0,24	0,74	0,49	0,36	0,46	0,91	0,36
	MATERIAL INVENTORY COST	0,70	0,96	0,76	0,02	0,17	0,12	0,46
	FINISHED GOODS IN TRANSIT INVENTORY COST	0,21	0,23	0,01	0,94	0,20	0,52	0,39
	FINISHED GOODS INVENTORY COST	0,24	0,66	0,17	0,23	0,27	0,10	0,68
	SCRAP INVENTORY COST	0,61	0,37	0,54	0,78	0,06	0,17	0,74
	SPACE USED COST	0,69	0,20	0,23	0,76	0,65	0,14	0,17
	FRECUENCY OF DELIVERY	50	84	82	57	59	83	81
		278,4344776	**527,2568752**	**443,8457739**	**452,9281526**	**406,0615842**	**374,2768958**	**453,6441043**
HUMAN TALENT ABD ORGANIZATIONAL CULTURE	SUPPLIER ASSISTANCE IN SOLVING TECHNICAL PROBLEMS	4,00	7,00	8,00	4,50	10,67	11,00	11,99
	SUSTAINABLE INITIATIVES TO REDUCE COSTS	3,00	23,00	28,00	15,00	22,00	19,00	29,00
	EFFECTIVE IMPROVEMENT PROPOSALS	5,00	7,89	11,99	18,89	20,78	17,00	27,00
	NUMBER OF WORKPLACES ACCIDENTS	0,29	0,79	22,00	25,80	29,00	24,00	13,00
	CORPORATIVE MANAGEMENT COMPLIANCE	0,66	0,94	0,67	0,55	0,69	0,92	0,61
	INVESTMENT IN RESEARCH, INNOVATION AND DEVELOPMENT	0,01	0,08	0,09	0,05	0,03	0,09	0,08
	EMPLOYEES PROMOTED	0,50	0,99	4,00	2,00	4,09	3,33	4,79
	WELFARE ACTIVITIES IMPLEMENTED	0,99	5,89	3,90	2,00	0,89	0,09	1,00
	EMPLOYEE TURNOVER	-	0,07	0,19	0,10	0,07	0,02	0,01
	UNSCHEDULED ABSENTEEISM	0,10	0,46	0,81	0,14	0,35	0,74	0,81
		14,55	**47,11**	**79,65**	**69,03**	**88,57**	**76,19**	**88,29**
INFORMATION AND COMMUNICATIONS TECHNOLOGY	INTERNAL CONNECTIVITY COVERAGE	0,3	0,99	0,79	0,87	0,45	0,23	0,88
	EXTERNAL CONNECTIVITY COVERAGE	0,56	0,76	0,90	0,65	0,33	0,44	0,98
	ACCES TO INFORMATION NEEDED	0,68	0,25	0,11	0,22	0,23	0,42	0,77
	INFORMATION SAFETY	0,32	0,34	0,72	0,18	0,83	0,86	0,83
	INFORMATION QUALITY	0,04	0,66	0,45	0,66	0,81	0,97	0,08
	AUTOMATION LEVEL	0,43	0,27	0,67	0,84	0,75	0,41	0,10
	PRODUCTION STOP BY FALL SYSTEM	0,99	5	2	3	7	5,9	6
	INFORMATION SYSTEMS INNOVATION ORIENTED TO DETECT REQ	0,45	0,81	2,00	0,98	1,00	4,00	0,99
	INFORMATION SYSTEMS RELIABILITY	0,88	0,01	0,62	0,81	0,67	0,96	0,19
		4,647356318	**9,101322137**	**8,260944646**	**8,229347369**	**12,07064642**	**14,18506158**	**10,81727036**
		492,60	**829,61**	**770,93**	**645,30**	**733,90**	**592,56**	**792,01**

Source: *Own*

6. BIBLIOGRAPHY

BALLOU, R., GILBERT, S. & MUKHERJEE, A. (2000). New Managerial Challenges from Supply Chain Opportunities. *Industrial Marketing Management* 29, pp. 7–18.

LANCIONI, R. (2000). New Developments in Supply Chain Management for the Millennium. *Industrial Marketing Management* 29, pp. 1–6.

KAPLAN, R.S. & NORTON, D.P. (1992). The balanced scorecard – measures that drive performance. *Harvard Business Review* 70 (1), pp. 71-79.

BHAGWAT, R. & SHARMA, M. (2007). Performance measurement of supply chain management: a balanced scorecard approach. *Computers & Industrial Engineering* 53, pp. 43–62.

KUMAR. B PAWAR (2011), Supply Chain Management : An exploring areas of management research. *JSPM'S Jayawant Institute of Management Studies Tathawade, Pune, India* 2

FOLAN, P. & BROWNE, J. (2005). A review of performance measurement: Towards performance management. *Computers in Industry* 56, pp. 663–680.

HAUSMAN, W.H. (2005). Supply chain performance metrics. In: HARRISON, T.P., LEE, H.L. and NEALE, J.J., *The practice of supply chain management: where theory and application converge*, Chap. 4. NewYork: Springer, 356 P.

SARACHE & IBARRA, W. &. (2008). *Dirección de la Producción, Una Aproximación Conceptual.* Bogotá: Unibiblios.

WEIS, A. (2010). *Cambio Empresarial y Tecnologías de Información en Colombia – Nuevas Formas de Organización y Trabajo.* Bogotá: Centro de Estudios Sociales, Universidad Nacional de Colombia, Unibiblios.

BREWTON T. & STELLER M. (2005) Integrating the Shipbuilding Business Model, *Maritime Management Consulting.* M, pp 1-13.

K. RAMDAS, R.E. SPEKMAN, Chain or shackles: understanding what drives supply-chain performance, Interfaces 30 (4) (2000) 3–21.

CHOI, T.Y. DOOLEY, K.J., RUNGTUSANATHAM. M 2001. Supply Networks and complex adaptive systems: control vs. emergence. *Juornal of operations management* (19) 3, 351-366.

MUKHOPADHYAY, T., RAJIV, S. SRINIVASAN, K. 1997, Information technology impact on process output and quality. *Management Science* 43 (12), 1645-1659.

Lee, H.L., 2000 creating value through supply chain integration. *Supply Chain Management Review* 4 (4), 30-36

YE. N., Farley, T., 2006. Information sharing and control in homogenous and heterogeneous supply networks under different market conditions. *International Journal of Modeling and simulation* 26 (2), 160-168.

HAUSMAN W., BILLINGTON C, HARRISON T., LEE H., NEALE J. (2003), Supply Chain Performance Metrics, in the practice of the Supplky Chain Management. Kluwer Boston.

LAMBERT D., POHLEN T., 2001 International Journal of Logístics Management, 12 (1), 1.

KLEIJNEN J., SMITS M. 2003, Journal of the Operational research Society, 54 (5), 507

COOPER, M C., LAMBERT D M., PAGH J.D., 1997. Supply Chain Management: more than a new name for logistics. *The international journal of Logistics Management.* 8 (1), 1-13.

LAMBERT D.M., COOPER M C., 2000. Issues in Supply Chain Management. *Industrial Marketing Management* 29. 64-83

DAS, A., RAM, N., TALLURY S. 2005 Supplier Integration – Finding an optimal configuration. *Journal of operations management.* (1) 563-586

SAUER, D. (2006). Von der Systemischen Rationalisierung zur permanenten Reorganisation. En Baukrowitz, Berker, Boes, y Pfeiffer. *Informatisierung del Arbeit-Gesellschaft im Umbruch (pp.84-97).*