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A new approach for cost modelling and performance evaluation within operations planning

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ABSTRACT

The industrial organizations need to seek continuously for excellence in their processes to promote their competitiveness. Therefore effective operations planning, control and evaluation will maximize customer value creation by eliminating several types of waste, common in almost all organizations. The dramatic changes on operations led by continuous process improvements requires also changes in traditional performance evaluating approaches so that they can be adapted to a new production environment. Aligned with the implementation of operational improvements in core processes, we propose a new approach in the implementation of cost modelling and performance evaluation system. This approach is not limited to a single company but can be extended to global value streams observed within collaborative networks.

1. Introduction

Understanding what the customer defines as "value" and how this value can be improved is the main goal of all modern organizations independently of their role and the market segment where they are performing. Maximize customer value by reducing waste in the operations is the objective of continuous improvement processes embedded in lean management principles. Their implementation promises significant improvements in productivity, quality and delivery, which should result in substantial cost savings. In this context, many lean organizations find that traditional accounting systems are not supportive on the focus of waste elimination [1]. In fact, traditional performance evaluation approaches are not able to show the effects of operational improvements on financial results [2]. One of the most effective tools for improving customer value creation is by defining, understanding, monitoring and improving the value stream. By mapping the value stream of a product or product families, it is possible to identify operational improvements that will lead to reduction of lead times, better quality and improved delivery time. In order to show the operations planning improvements is required an effective value stream management and a different approach in cost modelling systems.

The cost modelling system must make visible operation performance, giving to everyone real information in a basic understandable format and focusing on what is actually happening at any given moment in the operations throughout the value stream. This perspective is not obtained with traditional costing methods based on standard costing or weighted average cost and motivates the search for alternative approaches, balancing financial and non-financial measures to evaluate operations planning in a dynamic environment.

In this paper it is suggested a new approach in cost modelling and performance evaluation and the steps required for its successful implementation, aligned with continuous operational improvements. The proposed approach will reduce the effort to collect and analyse data and foster a quicker reaction to problems and implementation of improvements within operations planning activities. Highlighted is the interest to extend the application of this methodology to collaborative networks in global value streams. The industrial case study presented shows an experience in implementing some of the main concepts that support an alternative approach for cost modelling and performance evaluation, describing what was done in each stage of implementation and some of the benefits obtained.

2. Inconsistencies between operational improvements and traditional cost modelling systems

Operational improvements have the goal of maximizing efficiency and effectiveness throughout the production system, reducing non-value added activities. A successful lean management implementation will bring some operational improvements, such as (i) lower production lead times, (ii) higher production

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quality expressed through fewer defects and rework, (iii) higher reliability in the delivery time, (iv) less allocated production space, and (v) lower inventory levels.

However, it is common that operational improvements are not visible in a company's financial results and, in a first phase, financial results will frequently decrease [3]. Most common financial results from a lean management implementation are:

(1) Profit level will be the same or even decrease as customers will decrease their demand by reducing their inventory levels, due to better lead times from their suppliers.
(2) Cost will be kept to the same levels except for some overtime reduction and scrap reduction in consumed materials.
(3) Operational results will decrease due to reduction of production value derived from better use of inventory in production process.

The reason for what is mentioned above is related with traditional cost modelling systems and its inconsistencies towards operational improvements [4–7].

The cost modelling systems have evolved from simple "rules of thumb" to relatively complex models, motivated by the growing complexity of products, processes and services, and the increasing pressure on performance improvement. Cost modelling techniques like rules of thumb, traditional cost accounting techniques, activity-based costing (ABC) and technical cost modelling (TCM) have been applied to different environments and played fairly important role in design and production stages as well as in the company business decision-making [8–11].

Rules of thumb are often based on material cost and cycle time, considered the core cost drivers of any manufacturing activity [12]. In [7] is mentioned that the first answer to the problem of the lack of valid costing methods for new production paradigms of continuous process improvement was activity-based cost. ABC measures the cost and performance of activities, resources and cost objects, in which resources are assigned to activities and activities are assigned to cost objects, based on their use. The disadvantages of this approach are the huge cost and long time required for costing complex services [11] or production systems. Technical cost modelling (TCM) tend to overcame the limited number of inputs (e.g. materials, equipment and labour cost) to estimate final cost, relating process parameters and analysing the effect of changes in input variables on manufacturing cost. It is less adequate for estimating total product cost, including overheads, because it focuses mainly on manufacturing costs.

The aforementioned cost modelling techniques are highly dependent on the level of detail of the selected cost model, the previous experiences and the data accuracy. Also they require a huge amount of data to be collected and for this reason is limited their ability to allow a detailed cost monitoring and understanding the impacts of operational improvements in the manufacturing system [8,13].

Those systems, based on standard costing or weighted average cost, have some common additional constraints when used to support company decision making. Some of these constraints are related with the following aspects:

(1) Decisions based on standard costing

The standard costing concept by itself defines that all products have a standard cost. The product standard cost does not evaluate the value chain, and so, is not possible to understand where to act in order to improve value creation. The cost of a product is usually calculated once or twice a year and it depends on several factors, such as: (i) projection of sales quantities for a certain period, (ii) used production capacity, (iii) production process, (iv) projected direct and indirect costs and (v) cost allocation methods and allocation ratios. Based upon these factors, product cost is calculated and kept for a period of time, regardless of operational improvements made during this period.

The concept of standard costing is also linked to the concept of production value, in which results will increase if production is also increasing. Results tend to be favourable if stocks of finished goods are created, independently of whether they are sold or not. This system leads to a propensity to reward the building of inventory and to punish the drawdown of inventory levels [1].

A company that is capable of reducing its inventory and creating additional production capacity will not see any improvement in the financial results, because production value will decrease together with inventory [4]. This fact is related to the method of absorbing all overhead costs into inventory, known as full absorption costing. Full absorption costing allocates overhead costs, both variable and fixed, to the current year's production. The product costs are capitalized and held in inventory on the balance sheet until the goods are sold. By deferring some of the fixed costs, full absorption costing rewards overproduction.

Therefore, as mentioned by other authors [5], it could be decided to prematurely reject operation plans that are searching for improvements due to standard cost concepts.

(2) Technical and complex communication of cost reporting

Cost reports are a result of a complex analytical costing system whose concepts are not easily understood by shop floor people and where cost allocations could lead to wrong operational decisions. A traditional costing system is based on several allocation criteria, whereas: (i) general costs are allocated to all organization departments; (ii) shared costs centres are then allocated to production cost centres; (iii) production costs are finally allocated to products and business lines. This system causes difficulty in understanding where to act to improve costs, and who should take the action. In some cases, only cost accounting experts can understand the costing web and shop floor people will need to use only non-financial indicators to manage operations. Frequently, financial and non-financial indicators show different conclusions with regards to the same reality. If so, strategy planning and the decision process will be compromised. Thus, the possibility to make visible, easily understandable and coherent, both operational and financial results it is a key issue to support an effective operations planning.

(3) Analysis of company's performance based on budget deviation

In traditional budgeting process there are some common problems such as:

(i) *Deviation analysis*: The concept of deviation analysis will focus the organization on the differences adopted towards budget. This method has some advantages, by enabling a faster reaction to the root cause of the differences. In this context, a deviation is something that did not go as planned. Even a good deviation must be determined and the reasons for it explained. Usually, managers tend to follow budget as planned, not aiming for higher standards, even if they are possible. Normally, operational improvements are delayed until the next year, if they were not considered to have been accomplished in "this year's budget".
(ii) *Availability of financial resources*: In the budget process, spending allowances are determined, based on planned activities. It is common that allowances are used even if they are not needed to avoid explaining deviations and to assure a

similar budget allowance for the next year, generating unnecessary overspending.

(iii) *The "cut" effect*: The complexity of budgeting process approval frequently will lead to adjustments and cuts to initial versions of the budget. Managers very often create budgetary slacks to deal more easily with adjustments requests. If adjustments are not requested the budget will be excessive and overspending will be the consequence.

(iv) *Last year's budget*: Making a *Zero Base Budgeting* exercise is a task that requires a good planning and process knowledge level. Frequently, companies will use historical data to improve budget quality. Very often, highly standardized companies will gradually fall on a "copy/paste" from last year's budget, which will avoid the implementation of improvements in operations, by lack of "out of the box" thinking.

(4) Cost driven instead of cash driven organizations

Although cash return is the ultimate goal of companies' stock holders, performance evaluation is usually measured by results and not by free cash flow creation. Business budgets are generally focused on profits and EBITDA, disregarding cash flow impacts. Operational improvements could lead to significant improvements in cash flow due to decrease of stocks and lead times, but these will not be shown in financial results measured by profit creation. Companies that used profit KPI's to measure their performance, usually focus on obtaining their resources as cheaply as possible, although this could lead to long lead times and poor efficiency in stock management.

In a company and with the aim to have an effective performance management approach to support the operations planning, the existence of a well balanced reporting, with financial and non financial KPIs, is necessary in order to improve the decision making process [14].

In this paper the purposed approach intends to solve those inconsistencies by creating a system that will be able to show the results of the implementation of operational improvement activities, less complex than common costing methodologies, easier to understand by all company members, more focus on value creation than in cost control and budget deviations, and much more flexible to adapt to each one of the steps taken in an operational improvement process.

3. New cost modelling system

The gradual implementation of operational improvements requires a continuous alignment of performance evaluation processes. The implementation of changes in cost modelling and performance evaluation system can be obtained through a sequence of steps in which the use of certain methods and the analysis performed will drive the changes in operations and performance evaluation tasks (Fig. 1).

As the company intends to start a project to improve their operations, costing methodologies should be also identified and improved, at the same time operational improvements are being designed and implemented. Fig. 1 shows us how the several steps of a project to improve the operations performance, should be supported by a continuous alignment of performance evaluation methodologies, that will enable to show the results of the improvement project, in its several phases.

3.1. Understanding the as-is

The first step is to identify the current state and use of the existing performance evaluation system within a company. This will allow to evaluate: (i) if the cost modelling system of a certain company is able to show the results of operational improvements, (ii) if the company is organized by value streams, and (iii) if the operational KPI's are aligned with the improvements the company intends to achieve.

The *as-is* identification should begin with an analysis of data about the strengths and weaknesses of the company by comparing

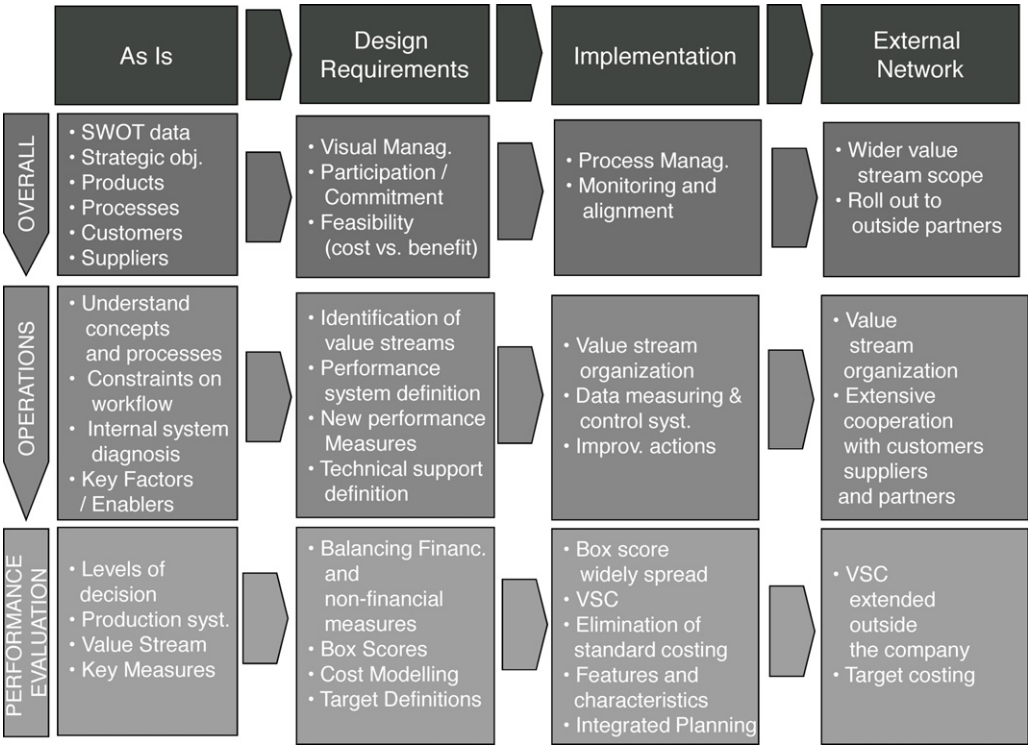

Fig. 1. New cost modelling implementation.

the organization with its competitors. The business opportunities and the existing threats in the overall environment should also be known, as well as the identification of strategic objectives, products, processes, customers and suppliers. The analysis of data has to cover all hierarchical levels of the company.

At operations level, it is important the analysis of company's processes as well as identifying the constraints to the production workflow, the key success factors and their enablers. It is also required to verify the effective use of the current performance evaluation system by observing the shop floor processes, conducting interviews at shop floor and management level, and through' analysis of production reports.

To finalize the *as-is* phase, it is very important to understand the current cost modelling system and how the performance of the company is measured. An interview with the company's manager and the analysis of the management reports are recommended at this stage. Finally, a detailed questionnaire can be applied to assess the current use of the cost modelling and performance evaluation system with regard to the need of the company and the willingness to improve its results.

By identifying the *as-is* and the insufficiencies of current cost modelling and performance evaluation system, it will be possible to start adapting or re-designing the new performance evaluation system.

3.2. Designing the evaluation system

The analysis of the *as-is* allows us to draw the *as-is* value stream maps. A company's value stream identification will be helpful in the definition of the new cost modelling and performance evaluation system. It is necessary to define the new performance measures, balancing financial and non-financial performance measures.

Visual management can be implemented and improved through the use of a box score, as a reporting tool that combines operational results with financial results and capacity usage. The operational KPIs that should be included can vary depending on the organization and the improvements it is seeking. Most common operational indicators are:

- *Dock-to-dock days*: Time spent from reception of raw materials until the delivery of product to end customers.
- *First time through*: Quality tool that measures the percentage of products that are produced without the need of rework or repair.
- *On-time shipment*: Measures the quantity of products that were shipped to end customers on time and in the correct quantity.
- *Floor space*: Space occupied by the value stream.
- *Sales per person*: Productivity and value creation tool, that measures the sales revenue, divided by the number of full time equivalent persons in the value stream.
- *Average cost per unit*: Measures the total of value stream costs, divided by the number of shipped quantities.
- *Accounts receivable days outstanding*: Measures the average time before reception of customer payments.

Operational indicators are focused on control and waste reduction but they need to be completed by financial indicators that should be related with operational and cost aspects of the production system. Some examples of financial indicators are the following ones:

- *Inventory turnover*: Inventory in the value stream in a certain period.
- *Revenue*: Value stream sales in a certain period.
- *Material costs*: Purchasing of raw materials made by a value stream in a certain period.
- *Conversion costs*: Manufacturing and indirect costs needed to manage the value stream in a certain period.
- *Value stream profit*: Measured by the difference of receipts less value stream costs.

The most relevant indicators, however, are the ones related with capacity analysis. Capacity analysis indicators are:

- *Productive capacity*: People and resources occupied in value added tasks to customer.
- *Non-productive capacity*: Time spent in non value added tasks to customers, such as administrative tasks, reworking, inspections, purchasing, management.
- *Free capacity*: People and resources available due to introduction of lean improvements.

When there is an improvement in value stream operations free capacity is created. This free capacity should be seen as an opportunity for value creation and not as a way to implement downsizing.

Another important aspect during the design phase is to define the targets and goals to be achieved. Finally the cost modelling and performance evaluation system should be defined in a way that can facilitate the visualization of operational improvements.

3.3. Implementing the system

Once the organization identifies its value streams it will be possible to setup a value stream costing (VSC) model which will allow a faster feedback and an integrated understanding, as well as definition of improvement activities, in all areas of the value stream. In Fig. 2 is presented a structure that represent how value stream cost model can be composed and implemented, taking into consideration company's organization. Taking this example, all of the departments or main processes, e.g. sales and marketing, production planning, purchasing and warehouse, are part of a value stream and have some direct costs, which include labour overheads and depreciations, and allocation of facilities cost. The allocation of facilities cost is based on square meters used by this value stream. Comparing with standard costing methodology, the use of the value stream costing model has advantages since cost allocations are kept to a minimum and it can be defined as follows:

$$VSC = VSMC + VSLC + VSOC + VSDC + AFC$$

where *VSMC* is the material cost used in the value stream; *VSLC*, labour cost of the staff included in the value stream; *VSOC*, overhead cost of cost centres included in the value stream; *VSCD*, depreciation cost of the equipments and tools used in the value stream cost centres; and *AFC* is the facilities cost, allocated to the value stream based on used m^2.

Value stream results could be calculated on weekly or monthly basis as the difference of value stream revenues and its incurred costs.

$$\mathrm{VSR} = R - \mathrm{VSC}$$

where *R* is the revenues of the value stream and VSC is the total cost of the value stream.

To implement value stream costing it would be needed:

(i) To report results by value stream and not by departments.
(ii) Employees should be allocated to only one value stream.
(iii) Shared services should be kept to a minimum.
(iv) Production processes in a value stream should have high control and standardization, with good management of

VSC		Sales & Mkt	Prod. Plan.	Design	Purch.	Eng.	WH	Assy	Quality	Outg.	Invoic.	Accts Rec.
		VALUE STREAM										
Direct Costs	Labour	x	x	x	x	x	x	x	x	x	x	x
	Overheads	x	x	x	x	x	x	x	x	x	x	x
	Depreciation	x	x	x	x	x	x	x	x	x	x	x
	Materials							x				
Alloc.	Facilities	x	x	x	x	x	x	x	x	x	x	x

Fig. 2. Applicable costs in VSC.

exceptions, such as scraping and reworking. Inventory should be low and stable.

Once VSC is established as part of cost modelling and performance evaluation system, it is needed to identify the measures and targets for the organization improvements. A methodology to collect and represent data should be implemented, promoting a visual management methodology and a quick response to changes, as shown in the data visualization example presented in Fig. 3.

The identification of value stream take time is a key aspect for the value stream performance and improvement because it is related with the most critical bottleneck operation in the value stream. All products within a value stream are contributing to the value stream results and one way to improve them is by making and selling products that are not using additional capacity in the bottleneck operation. The approach of product cost definition must allow identification of what are the product characteristics and how they affect the use of the bottleneck operation. This approach defines the cost of a product as the addition of the material costs of each product to their manufacturing cost, calculated based on the usage of the bottleneck operation. Therefore it is possible to defend the idea that a certain product could be produced in a value stream without additional costs, if the bottleneck operation is not used.

In Fig. 4 it is presented the sequence of steps suggested to implement the new cost modelling system implementation and it is resumed the main inputs and outputs, as well as the tools and control mechanisms to be used.

For an effective use of a cost modelling and performance evaluation system, supporting a successful planning process, it is important to proceed with the integration of relevant activities and functional areas within an organization. Mainly, the annual cost allocation process, besides its complexity and required effort, is not dynamic enough to cope with faster reactions to market conditions or operational improvements. Therefore there is a need to introduce a much more dynamic planning process, which should start by sales information and market feedback, continuing with required changes in operations and finally evidencing the financial requirements to achieve the proposed results. The planning and performance evaluation processes must be fully interlinked and to allow the organization to seek for continuous improvements and value creation. Thus, it is justified the need to establish an integrated planning process as it is proposed in Fig. 5.

The integrated planning must allow a continuous alignment of all organizational processes that foster the decision making and proactive response to market and operational demands.

As - Is		Sales & Mkt	Prod. Plan.	Design	Purch.	Eng.	WH	Assy	Quality	Outg.	Invoic.	Accts. Receiv.	
Direct Costs (K€)	Labour	4	2	10	7	8	30	140	15	2	1	2	
	Overheads	1	0,5	3	1	4	8	14	4	3	0,2	0,2	
	Deprec.	0,5	0,6	32	5	32	43	340	24	21	0,2	0,1	
	Materials							1700					
Alloc.	Facilities	1,7	1,1	15,3	2,4	8,7	152,7	82,9	26,2	56,7	0,7	1,5	350
	m^2	40	25	350	55	200	3500	1900	600	1300	15	35	8020
Total Costs		7,2	4,2	60,3	15,4	52,7	233,7	2276,9	69,2	82,7	2,1	3,8	2808,3
Revenues													3420
												Result	611,7

Target		Sales & Mkt	Prod. Plan.	Design	Purch.	Eng.	WH	Assy	Quality	Outg.	Invoic.	Accts. Receiv.	
Direct Costs (K€)	Labour	4	3	9	6	9	28	124	14	3	1	3	
	Overheads	0,8	0,4	2	3	2	7	18	2	1	1	1	
	Deprec.	0,5	0,6	31	5	32	43	323	24	21	0,2	0,1	
	Materials							1820					
Alloc.	Facilities	1,7	1,1	14,9	2,3	8,5	149,3	81,0	25,6	55,4	0,6	1,5	342
	m^2	40	25	350	55	200	3500	1900	600	1300	15	35	8020
Total Costs		7,0	5,1	56,9	16,3	51,5	227,3	2366,0	65,6	80,4	2,8	5,6	2884,6
Revenues													3410
												Result	525,4

GYR		Sales & Mkt	Prod. Plan.	Design	Purch.	Eng.	WH	Assy	Quality	Outg.	Invoic.	Accts. Receiv.	
Direct Costs (K€)	Labour	0	-1	1	1	-1	2	16	1	-1	0	-1	
	Overheads	0,2	0,1	1	-2	2	1	-4	2	2	-0,8	-0,8	
	Deprec.	0	0	1	0	0	0	17	0	0	0	0	
	Materials							-120					
Alloc.	Facilities	0,0	0,0	0,3	0,1	0,2	3,5	1,9	0,6	1,3	0,0	0,0	8
Total Costs		0,2	-0,9	3,3	-0,9	1,2	6,5	-89,1	3,6	2,3	-0,8	-1,8	-76,3
Revenues													10
												Result	86,3

Fig. 3. Data visualization in VSC.

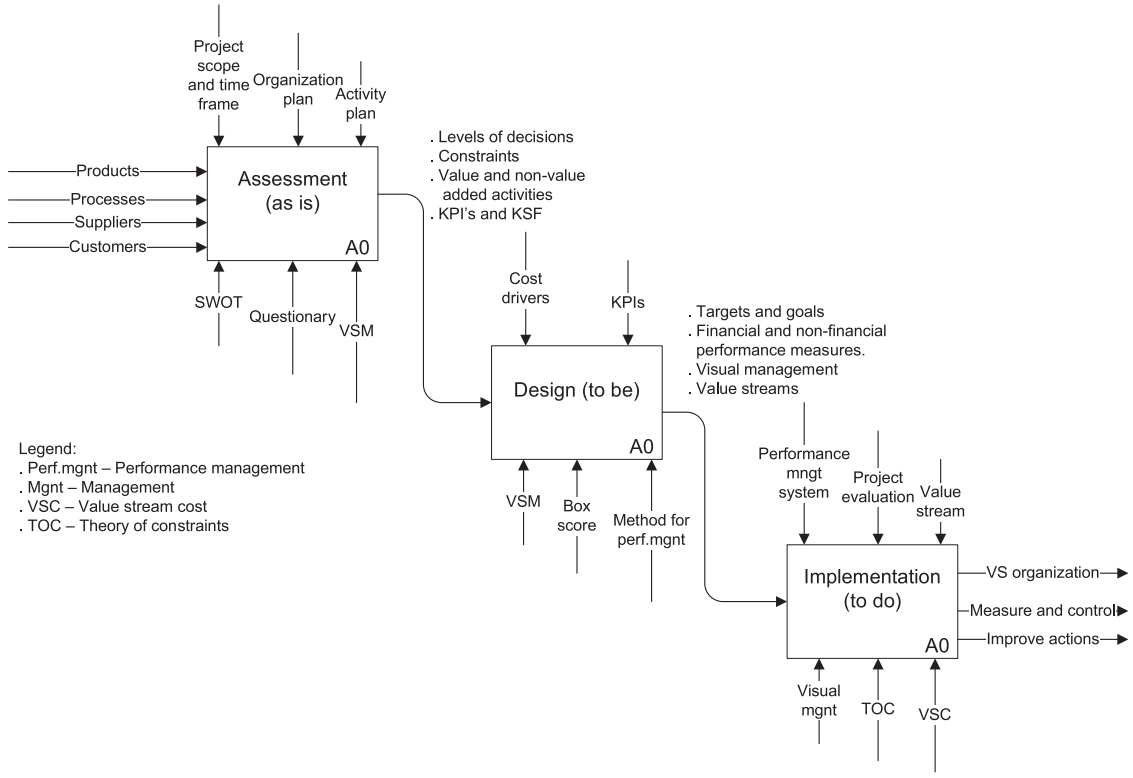

Fig. 4. IDEF0 diagram for new cost modelling system implementation.

3.4. Cost modelling in collaborative networks

The last dimension of using this cost modelling approach is related with the perspective of collaboration with outside partners. As it is presented in Wendell and Lutz [15] the picture of a stand-alone company linked to its customers and suppliers only by delivery and procurement of products is no longer valid. Thus, the implementation of operational improvements in order to eliminate

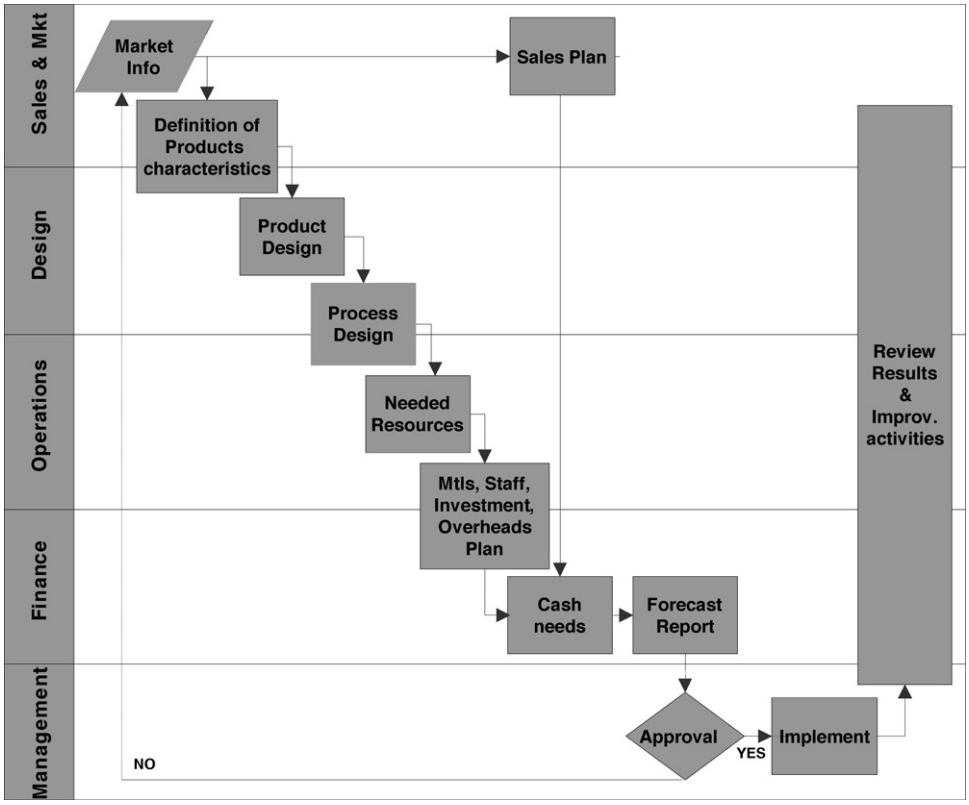

Fig. 5. Integrated planning process.

waste in operations and create value to the customer should not be confined in a single company but expanded to the collaborative networks in which it is operating.

The traditional view of manufacturing companies with clear boundaries, limited relationships with other companies and a focus on internal efficiency and effectiveness only, has evolve for a formation of closer co-ordination in the design, development, costing and the coordination of the respective manufacturing schedules of cooperating independent manufacturing enterprises and related suppliers [16,17]. This new form of organization, here described as collaborative network, is a type of cross-company cooperation with a high degree of versatility, with an intended duration of cooperation and a certain level of integration.

Gunasekaran [18] summarized the characteristics of networked organizations in terms of their strategy formulation, tactical decision, operational controls, purchasing and logistics, knowledge management and information technology. In collaborative network the integration of intra-companies or inter-organizational functions is a key issue, being planning and evaluation tasks the prime candidates for the integration effort [19]. Network partners have their own strategies and their collaboration lays on common or compatible objectives and strategies that are perceived as network objectives and strategies. Therefore each company contributes with its activities into a wider value stream described within the network, where its suppliers and customers also need to improve their operations, following the same value creation concepts [20]. The global value stream map can be also drowned and improved, with the use of collaborative partner networks. The same tools that are used to improve the core operations of a company can also be extended to business partners. This requires a maturity in the use of value stream concepts and the willingness to improve the overall flow.

The drive motive related with the collaborative network cost modelling is to identify critical factors or activities, formulate actions to take advantage of opportunities or overcome weaknesses and improve the overall network performance. Cost modelling and performance measurement is critical to the success of collaborative networks because by measuring or estimating the impact that any decision can have it is possible to create understanding, mould behaviour and improve competitiveness [18] and its main ability is to link strategies with targets and goals. Cost modelling and performance evaluation is considered, within an integrated planning environment, as a way to obtain a global view of all activities and the existing correlation between themes [15], based on financial and non-financial information about activities.

One of the key areas to develop is the information flow. As mentioned by Cunha et al. [19], information exchange plays a key role in the manufacturing strategies and in the cooperation to be promoted in planning and decision-making. By integrating the information systems, from end customer demand up to raw materials' requests, it is possible to eliminate redundancies that normally exist in the global value stream. Therefore, possible improvements are in (i) reducing finished goods and raw materials inventories at suppliers and customers, (ii) allowing automatic accounts receivable and accounts payable process, (iii) introducing improvements in purchasing and sales activities, reducing non value added tasks, (iv) simplifying logistic processes, (v) integrating design teams to improve value creation to end customer, and (vi) improving planning and evaluation processes within the network.

In this sense, the network value stream costing and target costing should be used as tools to manage the continuous improvements processes and to contribute to increase the performance of the collaborative networks.

4. Case study: implementation in an industrial company

To illustrate the benefits of using the proposed approach for cost modelling and performance evaluation within operations planning it is described the experience in implementing these concepts in an industrial company, highlighting what was done in each stage of implementation and some of the benefits obtained.

This company produces electronic components to automotive business in Europe and had 3 different business units (e.g. after market, OEM and 3rd party business). It was organized by processes and by departments and each of them was linked to a single cost center. The main departments were Auto Insertion, Final Assembly, Production Engineering, Warehouse and Quality Assurance. The managing director decided to implement a continuous improvement project, in order to reduce waste in core business activities and create additional value to the customer.

4.1. Understanding the as-is

This project involved the top managers that have conducted a SWOT analysis, and its conclusion was that the main threat was, in that moment in time, the fierce cost competition of Asian companies (especially from Thailand and China). In each department it was chosen a key person (“Sensei”), an expert in implementing continuous improvement methodologies and with ability to train all employees. Those “senseis” were responsible to identify and implement, together with their teams, continuous improvement actions, in all company departments. All managers were individually interviewed by the project team, in order to identify their expectations and in each way they could contribute to increase the added value in the company processes. Some of the questions performed in the interview were the following:

- Management strongly supports organization and continuous improvement culture with a reward and recognition systems?
- Employees know their contribution and take responsibility?
- Everyone knows the well defined process for analyzing root causes of problems?
- Most processes are mapped and VSM is recognized by all employees and management?
- Management and employees use VSM as a valuable tool in the continuous improvement effort?
- Emphasis is on making facility more responsive to customers?
- Value added is a key driver in product and process design?
- Performance management system provides financial and operational data, based on measurements at the value stream and provides support for continuous improvement initiatives?
- Suppliers and customers are utilized or involved for continuous improvement projects?
- Improvement actions are used to improve collaboration relationships between stakeholders (e.g. suppliers and customers)?

As-is VSM for the 3 business units were prepared, and quick wins identified.

In *as-is* value stream, presented in Fig. 6, it was identified that for a value added time of 11.5 min, the total lead time of the value stream was 46.5 days. Main improvement areas were identified: (i) decrease the inventory days in Warehouse (27 days); (ii) decrease inventory days in Auto Insertion (5 days); increase value added activities in Auto Insertion (value added time is 0.08%) and in Final Assembly (value added time was 8.6%). Brainstorming sessions with multidisciplinary teams took place, and as outcome of those meetings, several mini-projects were defined, each of them with a project owner and a project team and scope.

It was understood by the project team that the cost modelling system in place will not be able to identify and make visible the

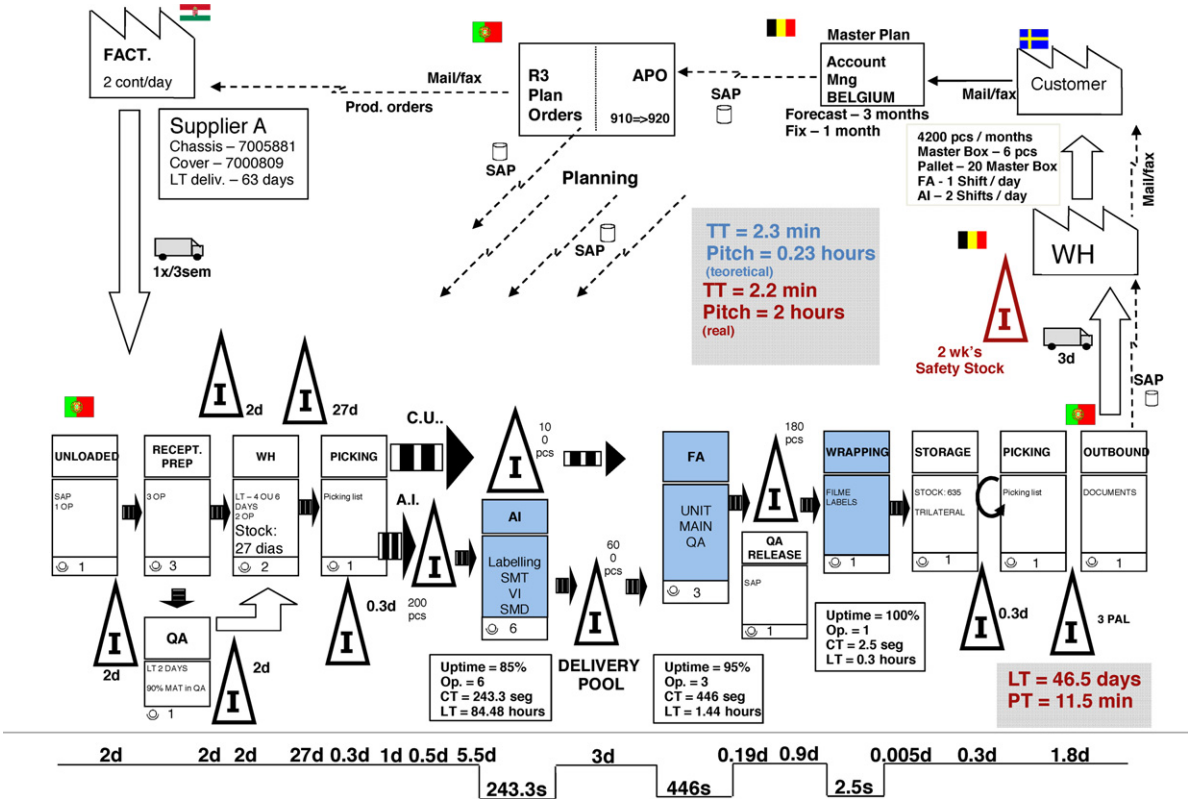

Fig. 6. *As-is* VSM for OEM business.

expected outcomes of those continuous improvement actions. Company was using standard costing methodology, which defines a stable production costing, in spite of the improvements that were aimed to achieve.

It was then necessary to define new tools to evaluate the benefits of operational improvements implementation.

4.2. Designing the evaluation system

In Fig. 7 it is presented a simplified box score, implemented to manage the impacts of "quick wins" implementation. Each mini project had an expected improvement, in time (free capacity creation), cost; inventory reduction (in days), quality (PPMs) or other benefits. Impacts were measured in multidimensional scores and not only focusing in financial outcomes.

The impacts of continuous improvement actions were then visible to all organization, which creates a positive motivation and synergies between the several project teams.

4.3. Implementing the system

After implementation of "quick wins", company identified its future value streams, starting by a pilot cell or a small business unit, which created the need to re-adapt costing methodologies to

Nº	Description	Type of Improvement					Estimated Impact				
		Time	MTL Cost	Stock	PPM	Others	IBT (€)	Stock Turnover (days)	Cash Flow (€)	Value Creation (FTE)	
1	STD time Reduction - AFTM model (low)	Y					3.236		3.236		Implemented
2	STD time Reduction - AFTM model (mid)	Y					2.380		2.380		Implemented
3	Change supliers in value stream		Y	Y			31.025	-0,16	31.025		Implemented
4	STD time Reduction - OEM models	Y					726		726		Implemented
5	Internal Calibration Process					Y	5.500		5.500		Implemented
6	STD time Reduction - AFTM model (mid-high	Y					595		595		Implemented
7	STD time Reduction - AFTM model (high)	Y					137		137		Implemented
8	F,A&C restructuring	Y								1,00	On Going
9	FA internal Quality	Y	Y		Y					0,23	Implemented
10	FA internal Quality	Y	Y		Y					0,42	On Going
11	2,5 PPM's	Y	Y		Y					0,06	Implemented
12	2,5 PPM's	Y	Y		Y					0,03	On Going
13	Material Cost		Y				50.000		50.000		Implemented
14	Material Cost		Y				1.450.000	-1	1.450.000		On Going
15	LT WH stock (slow moving stock, GR processing time, Inbound flow)	Y		Y			6.000	-5	225.000	0,20	On Going
16	Effective Meetings	Y								1,00	On Going
17	Picking of Small parts to FA	Y		Y						1,20	On Going
							1.549.598	**-6,16**	**1.768.598**	**4,14**	

Legend:

MTL:	Material	FTE:	Full time equivalent	OEM:	Original equipment manufacturer	LT:	Lead Time
PPM:	Parts per million	STD:	Standard	F,A&C:	Finance, Accounting & Controlling	WH:	Warehouse
IBT:	Income Before tax	AFTM:	After Market	FA:	Final Assembly	GR:	Goods receipt

Fig. 7. Box score to measure "quick wins" impacts.

a value stream costing (VSC), replacing standard costing methodology. VSC was only putted in place, when VSM was clearly implemented. During VSM implementation phase, standard costing were kept as the main costing methodology, but box scores, as the one showed in Fig. 7, were widely spread to all organizational improvements projects, as the way to measure the outcomes of continuous improvement activities.

5. Summary

Traditional cost modelling techniques are not able to show the result of operational improvements that create additional available capacity in the value streams. The proposed approach in cost modelling and performance evaluation system provides valuable information for facilitating the improvements in operation planning and its execution, at different organization and inter-organizations levels. This new approach was designed to be applied both within a single company and to be expanded through outside partners, organized in collaborative networks. Organization cost modelling and performance evaluation concepts applied to networks will introduce new challenges because it implies dealing with a larger domain, including new processes, new stakeholders and a less clear concept of internal and external network organizations. Further research will be required in defining collaborative processes and tools to promote network value stream costing and management of continuous improvement processes for more sustainable and competitive networks.

With the proposed cost modelling and performance evaluation system, a simplification of performance evaluation processes is expected because it will require less effort than traditional cost modelling processes. Additionally, it will promote the use of faster method to collect data and analyse results, and a quicker reaction to problems that will lead to faster implementation of operation improvement activities.

The industrial case study show that these concepts should be implemented progressively and in simultaneously with a continuous improvement activity plans. The ability to make visible the effects of operational improvements on financial results contributes for a better understanding of operations and to drive changes through the organization, improving the existing value streams. By extending these achievements to collaborative network organizations it will facilitate the way information is specified and shared and will have an important impact in the communication process between partners, promoting trust and a better cooperation in a network environment.

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