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Function Value Map

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Abstract

The paper proposes a new approach to analyze processes in the field of Business Process Engineering. The approach is called a Function Value Map and combines insights from VAVE (Value Analysis Value Engineering) and TRIZ (Theory of Inventive Problem Solving), linguistics and strategic and operational information to find the preferable direction for improvements and/or innovations. The methodology consists of defining all present technologies that occur in a certain (production) process, without making a distinction per process step. The share that every technology holds in the complete production process - expressed in money - will set priorities for further improvement initiatives.

"Keywords: Function Value Map; system modelling; TRIZ; law of evolution; micro meso and macro processes"

1. Function Value Map

The Function Value Map is a method, developed by P41, to get a thorough insight in how a process or company works. The method identifies which technologies or functions innovation initiatives are the most designated. We have applied the Function Value Map in several real business cases, with results up to 30% improvement in terms of productivity, efficiency, quality or cost.

The Function Value Map combines insights of BPR, VAVE and TRIZ. The goal of both BPR and the Function Value Map is the same, namely redesigning the way work is done to better support the organization's mission and reduce costs and reach its ideality. Nevertheless, the path to achieve these goals is completely different.

Value Analysis and Value Engineering originated from General Electric mainly associated with Lawrence Miles. [1] VAVE is the process in which value is defined as the ratio of function to cost. Value can thus be increased by either improving the function or by decreasing the cost. VAVE will not spend too much time on the definitions of the functions, in contrast with the Function Value map, although, the wa y of analyzing a process is rather similar.

The Function Value Map can also be seen as a reference graph before an innovation project is started, to measure the financial impact of the solutions by recalculation.

1.1. Research objectives

The main objective of this paper is to find out to what extent the Function Value Map can attribute to Business Process Reengineering. Therefore, the next research questions are asked:

- What is the method and where are the directions for improvement
- What is the added value of looking at a technical system as a set of functions?
- What are the directions for more research?

2. Steps towards a Function Value Map

2.1. Function Value Map algorithm

The Function Value Map is performed following the next steps, which are explained in detail later on:

(a) Based on the competitor's cube, determine the critical indicators following the strategy of the company to be different than your competitors.

(b) For each indicator, define the carriers of technology through functions, on micro, meso and macro level.

(c) Analyze the process based on the critical indicator(s), using the carrier chosen in step (b).

(d) Express everything in money using the appropriate calculator

(e) Group, cluster or combine the quantified carriers based on same technological impact, i.e. all technologies that have the same function (for micro, meso and macro verbs).

(f) Make a Pareto analysis of all quantified carriers

(g) Deeper investigation of most expensive Technical Systems that have an impact on the critical indicators (on micro, meso and macro level).

2.2. Defining the elements of a Function Value Map

Some of the terms used in the algorithm need more clarification.

(a) Carrier: Nominated as measurable quantity is always the primary function of a technology.

(b) Calculator: Helps to quantify the carrier. The objective is to express every carrier in money. For instance, if scrap is your carrier then the cost of production loss can be the calculator together with the cost needed to repair the product. The latter are based on all resources needed, like rework time, material costs and so on.

(c) Micro verb (highest level of function detail): very detailed action necessary in a process to make the process function as it should be. E.g. in an assembly environment, you would find: get and place, screw, walks, transport. It's important to understand that same micro verbs can be found in different process steps.

(d) Meso verb (moderate level of function detail): what is in most cases the process steps in a company. Here, different technologies are combined to carry out a whole process step. E.g. pelletizing, packaging, shipping process step . For every phase, there will be a new Meso verb [5].
(e) Macro verb (highest level of abstraction): function that describes in a very abstract way what the technology does. E.g. change form, change structure. Here again, same macro verbs can be found in different process steps. .The overview of abstracted verbs is found in [5].

2.3. Technology codified as a function

Every process can be expressed by a combination of Technical Systems used to perform a process. The law of completeness defines a technical system as shown below (Figure 1). Do note that "information" is added here for means of control.

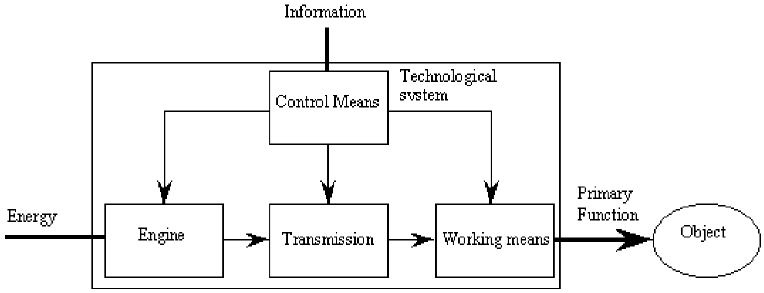

Figure 1: Law of System Completeness

The Technical System performs a function towards an object. We assume that the object undergoing the function is the product the client wants or any step from raw material to end-product. The basic goal of the function is to change the attributes of the object.

A company can thus be seen as a set of different processes transforming the products (or information) towards a desired end result defined towards the client. So finally all processes can be defined as set of functions.

It's important to understand, when reasoning in the opposite direction, that one function can have numerous Technical Systems to carry out that function. E.g. a rag, a hand, pressed air and a cleaning machine are all different Technical Systems to carry out the same primary function, namely cleaning. The primary function is defined as the affordance for which the product was originally intended. An affordance is a quality of an object, or an environment, which allows an individual to perform an action. The primary function is equal to the perceptible affordance as defined by William Gaver [4]. This differs from all possible affordances a technology could have (false, hidden or perceptible) or also differs from lower level functions of which the law of completeness speaks (convert energy, give power, control information, transmit to perform function) .

The primary function is associated with a technology. The primary function can be delivered in different specific contexts can make use of other resources and can be leveraged through different physical effects. For instance, a primary function “to transport” can be technologically delivered through different physical effects such as mechanical (pushing (wheel), gravity (rolling down hill), air (hovercraft)..) , electrical (battery on bike), thermal (combustion engine),..etc. . It also used different resources of the environment but always the primary function will act on the subject.

E.g. the function of a fastener power tool is screwing.[5].

2.4. Steps towards a Function Value Map

(a) Competitors cube: defining the critical indicator.

While composing the Function Value Map, the authors strongly advise to focus on the competitor's performance in comparison to the company, instead of only the end client's wishes.

The reason for this is that whatever the product or even service it is, the client will only buy the product if he can find one on the market that suits his needs. If there is a monopoly of the company concerning the product and there is a need, the client will buy it. But on the other hand, if your product is only marginally better than your competitor's product and thus many versions exist, the product will have a good chance that clients buys it. Since it's acceptable that producing a product that is slightly better than your competitor's is more economical than producing the company’s product that is far away from the current market, it's advisable to chose the first option. After all, the amount of buyers will be the same, production costs will differ enormously.

The competitors cube helps to set your position in respect to your clients. In the figure below, three possible critical indicators are presented, namely cost, quality and logistics.

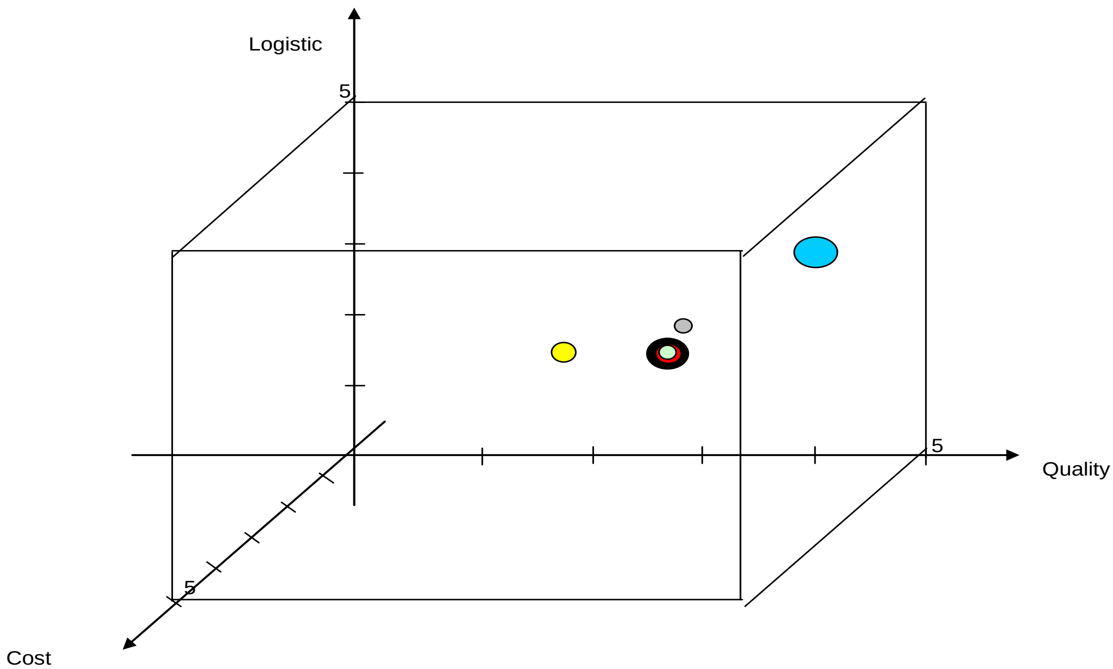

Figure 2: Competitor Cube

These critical indicators can be expressed in wishes of the client, e.g. the client prefers the supplier who delivers the fastest products. The same rule counts here as for the clients. The company will choose in most cases that product which is performing just better than its competitors. In that case, you have to translate the clients wishes into company parameters, e.g. rapid delivery can be established e.g. by creating more flow or by increasing inventory levels. When a client asks for a high quality, you'll translate product features into process features. Of course, it's also possible to define company parameters that are not relevant to the client, but relevant to you, e.g. the production cost of your competitor is lower than yours. In that case, you need to reach that same production cost, or your competitor will price you out of the market.

No matter what the reason for improvement is, the result of this step is a critical indicator that can objectively be measured within the company and will be linked to the technology the company uses to deliver the product. This can for instance be productivity measured through time or quality measured by means of material cost of scrap.

Thus, in principle any aspect can be analysed for the company, but in all cases it is assumed that the technologies for processing, are the aspects that will be addressed or improved. Since every product is produced through a process, and a process consists of actions, time is always a factor and technology in some form always will be used.

(b) Defining the carrier: carrier analysis: micro, meso and macro.

Depending on what critical parameter you have chosen, you'll end up with a limited amount of possible carriers. When you've chosen the critical parameter to be quality, several carriers are possible. The carrier can be types of product defects, but it will need to be converted in to functions, see more examples in table 1, namely which function(s) is (are) needed to repair a broken part. The most appropriate calculus will take in account the occurrence of the defect, rework time and the full scale of associated costs. These costs can be categorized into material, production and facility costs. The more costs you can indentify, the larger the budget involved in the FVM will be, yet it is perfectly possible to work with a simplified calculus, for example only looking at operator costs.

Subject	Carrier
Productivity	Functions associated with producing
Quality	Functions associated with repairing, inspecting, controlling, eg visions systems, measuring devices, technology that ensures correct product
Safety	Functions associated with keeping people safe, eg safety curtains
Maintenance	Functions associated with repairing a machine, tool, .
Environment	Functions associated with protecting the environment
Logistics	Functions associated with transportation,

Table 1: Non limitative list of examples of carriers

For every function, three levels of detail/abstraction can be defined.

At the highest level of detail you find the micro verbs. A micro verb is the smallest action that can be performed in a production process as used for MTM1 analysis [6]. At this level we are talking in time study terms. The MTM1 verbs are reach, grasp, move, release, position, engage, turn, apply pressure, disengage, eye motions, body motions (such as walk, sit,..). Verbs, like “to transport”, “to take and to place”,” to screw”, are all verbs at are a combination of the MTM1 verbs but have more meaning to what is happening.

For instance, “to screw” means “grasping a screw, moving it to its position, releasing it, grasping a screwdriver, moving it to the screw, positioning it, engaging it, applying pressure and moving the screwdriver to its end position, releasing the screwdriver.” Take into account that for micro verbs you don’t need so much in detail but just look at the actions of the operator and timing it according to the standards (MTM1, sampling or clock study). Please remark that some of these verbs will return in a next process step. As a result, micro verbs are process independent. Also note that time study is oriented towards people actions, so non-operator actions and processes are not yet included in this verb list. When evaluating machine operation and looking into the different technologies present, we use verbs related to physical processes. For example in a glueing machine, one can find micro verbs like to heat, to flow, to bond as micro verbs.

At the meso level you find the typical process steps. Process phases that are clearly marked out are meso verbs, e.g. pelletizing, packaging, shipping, .. but should always be associated with a technology. For instance if packaging consists of a carton box machine and typing in data in a mainframe, then these two should be split up anyway. In this sense there can be more process verbs than one normally would define in a process [7].

At the highest level of abstraction we find the macro verbs. There is a limited amount of macro verbs and all of them together can describe any kind of production process.

Abstract verb	Highest level parameter	Example
Change/keep or control	Form	Bend
Change/keep or control	Structure	Blend
Change/keep or control	Mass	Join, break
Change/keep or control	phase/ temperature	Melt, cool
Change/keep or control	Surface	Polish
Change/keep or control	Position	Transport
Change/keep or control	electromagnetic properties	

Table 2. Overview of macro verbs.

The macro verbs are described in table 2. When 'change' would be replaced by 'keep' we're talking about controlling verbs (or functions). The more abstract a description is, the more room there is to think of possible innovation initiatives. Mental inertia is lowered in these environments. It is applied when solving problems with ARIZ [6], and it's the same reason why these macro verbs are included in the Function Value Map. Please remark that here again, macro verbs can return in different process steps of the same process.

Some remarks on the carrier can be useful:

(a) For the Function Value Map, all levels of carrier should be defined.

(b) At the micro level it's very likely that two different verbs will be used that actually mean the same thing. It's inevitable that synonyms will occur, since for example client and company use a different jargon. However, at the end of the verb analysis, only verbs with a different meaning can be used. To obtain this, every micro verb should be clearly and extensively defined so that it is easy to denote when a verb is or is not a synonym of another verb. A means of knowing this is to ask the question: is the same technology used but 2 different words, what is the lowest goal the two verbs have, if it is the same you can use only one verb.

(c) Analyze the process based on the critical indicator(s), using the carrier chosen in step (b). A time study should be used in any case to link the action to the technology. A range of stop watch study, predetermined times, sampling can be used.

(d) Express the carrier in money, using the right calculator: time, quality expressed in money. Depending on the aspects the company wants to improve a calculator for the carrier should be chosen. This can be the cost of time, quality, etc see table for more examples. For example: looking at a repair of products, the cost of the product can be taken into account, and the time it takes to repair the defect It's important that the carrier of the analysis is quantified in terms of cost (money) directly associated with the calculator. As the contradiction matrix doesn't contain cost because every other parameter can be linked to cost, it is clear that many possible costs are to be considered or calculated.

The time study indicates the time needed to perform a certain function (verb). When the function is carried out by an operator, the cost of that verb is simply the product of time and labour cost. When the function is carried out by a machine, the cost of that verb can for instance be the product of time and electricity cost.

When product defects are the carrier, the cost per product defect is the material cost of that defect type. If the defect can be repaired, then repair time and related labour/machine cost will be the calculator.

Subject	Calculator (in money)
Productivity	Time, material tooling (cost), set-up cost, planning cost
Quality	Product cost, hours of repair, failure demand cost of loosing entire client
Safety	Cost of losing a person for one year
Maintenance	hours of repair, material cost used
Environment	Facility cost
Engineering	Drawing cost, engineering cost,
Procurement	Delivery cost, material cost

Table 3: Non limitative list of examples of calculators

As stated before, selecting the most appropriate calculus is identifying the relevant costs involved. For a supplier of extruded polymers, defective products are grinded and re-extruded. It suffices to take in account the product selling value to determine the turnover that is missed by the defect. In an electronics company some hardware has such a high purchasing price that it is crucial to repair, while common components are better just discarded than reworked. To have a better insight in the full FVM, we must take in account the component purchasing costs Please note that the cost of the carrier should be expressed per year.

(e) Group, cluster or combine the carriers based on same technological impact.As denoted previously, we make the assumption that every Technical System can be replaced by its primary function or primary verb. Also, it's important that there are no synonyms in the analysis. If this is still the case, then you combine them together in one word. It doesn't matter what word you chose, as long as no misinterpretation is possible. Thus, it's necessary that every word used in the analysis is clearly defined.

Once these conditions are met, the grouping can begin. All lines that contain the same carrier are grouped together. As a result, the amount of lines is the same as the amount of carriers. For instance, when you have carried out a time study, all lines with the same verb are added together. When defect type is the carrier, you'll get as many lines as there are defect types.

After this grouping, the overall cost per line can easily be calculated by summing up all money that that carrier represents.

When your analysis is expressed in verbs, then it's at this stage that the link between micro and macro verbs is made. Since the verb analysis is the one with the highest level of detail available, this analysis consists of the micro verbs. Based on table 2 you can answer this question for every micro verb in the analysis. E.g. the verb 'screw' merely means 'change mass', because the total mass of the product is enlarged by adding another part to it. [7]. In reference [7] a taxonomy list of links between verbs has been made. The result of this exercise will be an analysis that consists of maximum 6x3 macro verbs based on table 2.The advantage of using macro and thus very abstract verbs is that it gives you the opportunity to easily step away from your own reality. The macro verbs that you have found are used in all industries over the whole world. This gives you a lot of new possible directions towards improvement (Cfr. (g) Deeper investigation of most expensive Technical Systems).

(f) Pareto analysis

After the grouping process, a Function Value Map can be drawn. An example of all types of Function Value Maps is shown on the next page. Such Function Value Maps just visualizes your analysis and orders the carriers from most expensive to least expensive.

From a Functional Value Map, several conclusions can be drawn:

(a) The Function Value Map gives an overview of all different function-technologies (in the case that these are used in multiple process phases, it is not a mere summation of process steps);

(b) By grouping the same verbs of all different process steps in one graphical bar, you immediately get insight into what's the most expensive primary function or technology in the whole process;

(c) The Function Value Map gives an indication of the priorities for improvement initiatives;

(d) Because all similar technologies are grouped, regardless of the process step they belonged to, the results of a single improvement usually has a similar impact on all other process steps;

(e) The Function Value Map gives an indication of how high the cost of a new investment can be, related to the percentage of improvement that can be established. In other words, the payback time can easily be calculated;

(f) Deeper investigation of most expensive Technical Systems that have an impact on the critical indicators;

(g) By composing the FVM, one is forced to check all technologies present in the project scope. This brings a deeper insight in the organisation;

(h) A note of caution is needed because sometimes the jump to conclusions is made here because the verbs/technologies are defined and seem easily changed. A deeper TRIZ analysis per verb will be needed!

Once the Function Value Map is established, further steps can be taken. The directions towards innovation are set by the Pareto analysis and the budget can be determined based on your preferred pay-back time of the investment.

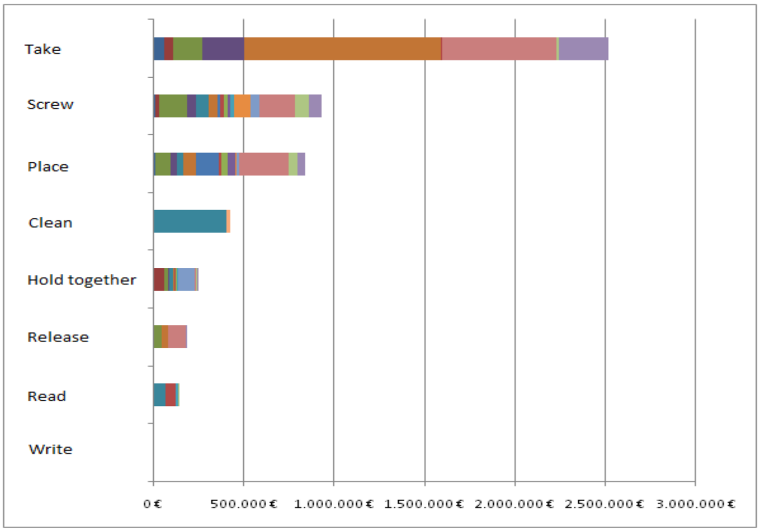

Figure 3. Micro Function Value Map (assemble factory) (the different colors form the objects needed)

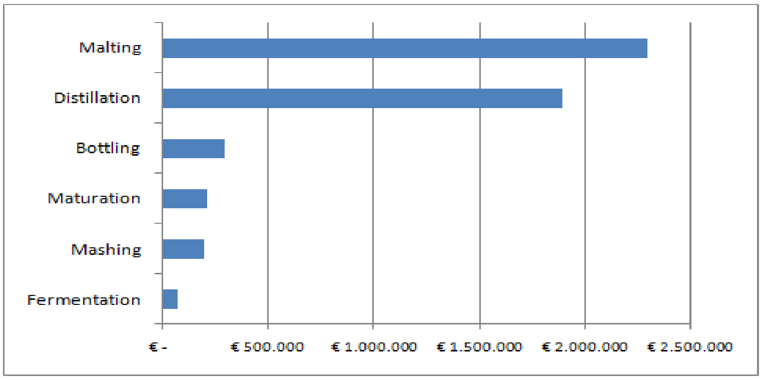

Figure 4. Meso Function Value Map (whisky factory)

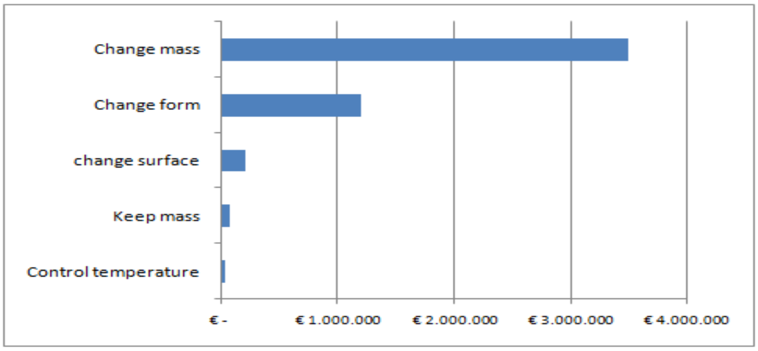

Figure 5. Macro Function Value Map (assemble factory)

When looking for possible innovations, the three levels of abstraction can be helpful. The more abstract (vague) a technology is described; the more neutral one can approach the problem. Moreover, by using the macro descriptions (such as change form) one can easily move away from its own industry and look for similar technologies in other sectors. When you find a solution that is applied in one sector and could also be applied in your own, this is called a borderling [3]. A borderling is thus a technology that works in one sector, but seems to be applicable in another sector as well, cfr. 3 level of invention. Obviously, the more industries you will research, the more possible solutions (borderling) you will find.

3. Identifying further research in link to scientific literature & research objectives

(a) The verbs and their abstractions would be an interesting field of study. Not only to have a complete list of abstracted verbs, but also to define precisely which verbs to use when.

(b) The link with the Defect Value Map is to be developed. The DVM is a methodology that focuses only on repair costs. The weight of importance of a process is linked to the needed processing time.

(c) When analyzing a process, it often seems that the same technologies return in different process steps. The Process Value Analysis [2] splits the process into process phases which act as separate blocks and thus treats the same technologies in separate process steps as two different things. The Function Value Map will group all similar technologies, indifferent of the process step to which they belong. A next step would be a controlled experiment to compare and evaluate the two methods .

4. Conclusion

Function Value Mapping focuses on the financial importance of technologies. The fact that it is calculated per year and represented in a graph means that the payback time can be deduced visually.

Function Value Mapping allows approaches that influence several process phases at the same time. The FVM acts as a filter to techno supposing that the process is completely delivered by the technology. Yet, this is not necessarily so: also organizational aspects, like how many and when, need to be addressed.

Even quality issues can be addressed with the FVM, when selecting the correct calculus.

The Function Value Map can be focused on increasing the company's competitiveness.

There is always a strict relationship between the FVM and the time needed to perform the process.

5. Acknowledgements.

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