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# The translation of will into act: achieving a consensus between managerial decisions and operational abilities

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**Abstract:** In the current industrial context, strategies intended to bring about continuous improvement have to include the multi-criteria performance expression aspects. A MAUT model is proposed in the first part of this paper: it captures the managers' strategy in terms of performances improvement. The search of an efficient improvement is formalized as an optimization problem. Nevertheless, MAUT models address purely managerial decisions but do not include the material constraints related to the action plans that address the required improvement. A qualitative model is thus proposed to support this implementation part. It models the relations between goals and actions to define the most relevant action plan. Finally, a unified framework is proposed to conciliate managerial and implementation aspects in an industrial improvement project. It integrates a preferences' model for the managerial aspects and a CSP model for the operational aspects. Both models are conjointly run into an iterative process to define an efficient improvement.

**Keywords:** Management, Industrial performance, Performance improvement, Efficiency, Multi Attribute Utility Theory (MAUT), Optimization, Constraints Solving Problems (CSP).

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## 1. INTRODUCTION

To deal with the complexity of the current industrial context, new control strategies intended to bring about continuous improvement have to include, on the one hand, the multi-criteria performance expression aspects, and on the other hand, the modelling of their relationships (Bititci, 1995; Berrah *et al.*, 2001). Indeed, control strategies have to define, compare and choose action plans with regard to the relationships between performance expressions (Bititci, 1995). The Performance Measurement Systems (PMSs), which are instruments to support decision-making (Bititci, 1995; Neely, 1999; Kueng *et al.*, 1999), fulfill that purpose. From a global point of view, a PMS is a multi-criteria instrument for informing decision-makers about a variety of different things, e.g. the level of performance, the reasons for poor or good performance, and the criteria for which improvement is required. A PMS is made of a set of performance expressions to be consistently organized with respect to the objectives of the company (Berrah *et al.*, 2001). Then, in order to support the decision, the set of performances has to be processed so as to compare the different situations. PMSs thus require by nature the use of multi-criteria methods (Santos *et al.*, 2002). The main quantitative frameworks used in the PMS literature are aimed at reducing the dimensionality. Thus they are a product of the MAUT (Multi Attribute Utility Theory) aggregation model school (Diakoulaki *et al.*, 1992; Lee *et al.*, 1995; Rangone, 1996; Kim *et al.*, 1997; Suwignjo *et al.*, 2000), even though few studies are based on outranking models (Mareschal *et al.*, 1991; Babic *et al.*, 1998).

Aggregation models allow defining aggregated performances w.r.t. the different elementary objectives of the company (Berrah

*et al.*, 2004). MAUT models enable to provide the synthesis of the elementary performances into an aggregated one: this aggregated performance may be interpreted as the overall performance of the company, a concept of common use in industry. They also enable to highlight the priorities in the decision-maker's strategy (Berrah *et al.*, 2008). Finally, they make it possible to compare any two described situations by means of their elementary performance expressions (their performance profiles). Thus, MAUT models are to be considered as preference models.

As soon as the model for aggregated performance has been established, mathematical formulations can be envisaged to design strategic performances improvements (Berrah *et al.*, 2008 ; Sahraoui *et al.*, 2007a; b; Labreuche, 2006): these works provide solutions for choosing the partial performances to be improved first from a managerial point of view. However they do not enable to choose an action plan for improving the company's performance, except in trivial cases (e.g., when there is a one-to-one relation between actions and partial performances). Hence, it can be objected that MAUT models only capture managers' preferences (ideal world and managerial decisions) but do not take into account material constraints (real world and implementation decisions) that may prevent to achieve the expected improvement.

This paper aims at clarifying this objection against MAUT models for industrial performance improvement. Section 2 provides some recalls and discusses the nature of the aggregated performance. The MAUT model is seen as an explicit representation of the tacit managers' preferences system. The concepts of improvement and efficient improvement are formalized in this managerial framework. Section 3 introduces

constraints of the real world. That is the implementation part of the performance improvement design. A qualitative representation is proposed to model the relations between goals and actions and then define the most relevant action plan satisfying all these constraints. A unified framework is finally proposed in section 4 to conciliate the managerial and the implementation aspects of industrial improvement and gives a better idea of the complexity of decisions concerning industrial improvements. Most of the studies mentioned in this paper concentrate on the managerial part or on the implementation part, but do not consider both aspects at the same time. Thus, our method is not compared to the other methods that are referred in this paper; our aim is only to clearly identify the role of preferences models and constraints models in the design of an industrial improvement project.

## 2. THE MANAGERIAL ASPECT OF IMPROVEMENT

### 2.1 MAUT: a model of preferences

Defining an improvement in the multi-criteria context of performance raises some problems. First of all, one must be able to compare any two described situations by means of their elementary performance expressions.

Decision support can thus consist in reducing the dimensionality to facilitate this analysis. Indeed, human beings generally cannot make rational decisions as soon as more than 3 or 5 criteria are concerned. The MAUT, *i.e.*, Multi-Attribute Utility Theory (Fishburn, 1970 ; 1982 ; Keeney et Raiffa, 1976) provides the necessary tools to tackle this problem.

The representation of preferences is a central topic in decision-making and measurement theory (Modave *et al.*, 1998). Usually, it amounts to find a real-valued utility function  $U$  such that for any pair of alternatives  $x, y$  in some set  $X$  of alternatives of interest,  $x \succeq y$  ( $x$  is preferred to  $y$ ) *iff*  $U(x) \geq U(y)$ . When

alternatives are  $n$ -dimensional, *i.e.*,  $X = \prod_{i=1}^n X_i$ , a widely

studied model is the decomposable model of Krantz *et al.* (Krantz *et al.*, 1971), where  $U$  has the form  $U(x_1, \dots, x_n) = g(u_1(x_1), \dots, u_n(x_n))$  where the  $u_i(\cdot)$  are real-valued functions. Assuming that  $\succeq$  is a weak order on  $X$ , it is known that a representation with  $g$  being strictly increasing can be found *iff*  $\succeq$  satisfies independence and  $X$  is separable (Krantz *et al.*, 1971).

The MAUT is based upon the utility theory which is a systematic approach to quantify individual preferences. Utility theory consists in interpreting any measurement as a satisfaction degree in  $[0, 1]$ . 0 is related to the worst alternative and 1 to the best one. Measurements are thus made commensurable and interpretable. In this way, a utility function  $u_i(m_i)$  is attached to each measurement  $m_i$ ; the MAUT then aims at providing the synthesis utility  $U$  that brings an answer to the comparison problem of two described situations by means of their elementary performance expressions (their performances profiles). Many MAUT studies concern the necessary properties

of decision-maker's preferences to be captured in the analytic form  $g$  and the way  $g$  can be identified.

### 2.2 Industrial performance improvement in the MAUT framework

Let  $\bar{P}^I$  be the initial performances profile of the company and  $\bar{P}^F$  its final one, *i.e.*  $\bar{P}^I = (P_1^I, \dots, P_n^I)$  and  $\bar{P}^F = (P_1^F, \dots, P_n^F)$  in our multi criteria framework. Expressions of performances can be built as elementary utility functions (Berrah *et al.*, 2001). The evolution from  $\bar{P}^I$  to  $\bar{P}^F$  is considered as an improvement *iff*  $\bar{P}^F$  is preferred to  $\bar{P}^I$ . An experienced manager is supposed to be able to assess whether there is or not improvement by simply observing both profiles: an experienced manager thus implicitly uses a weak order relation between any two performances profiles. Furthermore, the manager can mainly express richer pieces of information: beyond the ordinal knowledge he uses to rank any two company's results, he is often able to assess an intensity degree to his preferences which corresponds to a cardinal piece of knowledge. This managerial know-how is related to the manager's tacit model of the company's development strategy.

The minimal formal model of improvement is thus:

Representation of preferences and improvement. Let  $\bar{P}^I$  and  $\bar{P}^F$  be two performances profiles. Both following propositions are equivalent:

- (1)  $\bar{P}^F \succeq_S \bar{P}^I$ , *i.e.*  $\bar{P}^F$  is preferred to  $\bar{P}^I$  w.r.t. the strategy  $S$  of the company;
- (2) A substantial improvement has been achieved between the two observed states of the economy's company.

Now, let us define an improvement in the MAUT framework of quantitative evaluations of performance built as elementary utility functions. In this case the overall performance  $P$  of the company is modeled as:  $P = P_{\text{Aggregated}} = g(P_1, \dots, P_n)$ .

In the following, let us note  $\bar{P} = (P_1, \dots, P_n)$ ,  $P = g(P_1, \dots, P_n)$ .

Aggregative framework for improvement. Let  $\bar{P}^I$  and  $\bar{P}^F$  be two performances profiles. Both following propositions are equivalent:

- (1)  $g(\bar{P}^F) \geq g(\bar{P}^I) \Leftrightarrow \bar{P}^F \succeq_S \bar{P}^I$ , *i.e.*  $\bar{P}^F$  is preferred to  $\bar{P}^I$  w.r.t. the company's policy  $S$ , where  $g$  captures the company's strategy in the aggregative framework;
- (2) A substantial improvement has been achieved between the two observed states of the economy's company.

### 2.3 Efficient improvement

Once an overall performance expression has been obtained ( $g(\cdot)$  has been identified), the problem is to help the decision-makers in their analysis by considering the way performance could be improved. Indeed, decision-makers generally know the actions that have to be carried out in order to increase one elementary performance. Their problem is to design an improvement that leads to the required overall performance with a minimal increase w.r.t. each elementary performance, *i.e.* a minimal additional cost related to each of them. This notion of optimal improvement is directly related to the concept of efficient improvement. Indeed, the notion of efficiency both

implies the objective to be reached and the allocation of resources (costs, efforts, means, risks, etc.) associated to the improvement: an improvement is thus efficient if any restrictive modification of its allocated resources necessarily entails a decrease of the overall performance.

**Improvement characterization:** a controlled improvement of performances from  $\vec{P}^I$  to  $\vec{P}^F$  that induces a cost  $C$  and leads to an evolution such that  $\vec{P}^F \succeq_s \vec{P}^I \Leftrightarrow g(\vec{P}^F) \geq g(\vec{P}^I)$  can be characterized by its overall performance gain  $g(\vec{P}^F) - g(\vec{P}^I)$  relatively to its cost  $C$ . The higher the overall performance gain and the lower the cost, the more efficient the improvement.

Let  $\vec{P}^I = (P_1^I, P_2^I, \dots, P_n^I)$  be the initial performance profile and  $P^I = g(\vec{P}^I)$  the associated aggregated performance. The problem to be solved is to identify the most "efficient" strategy to improve the overall performance, *i.e.* the least costly improvement of the elementary performances to achieve an expected overall performance  $P^* > P^I$ . What is the minimal investment w.r.t. each criterion to reach  $P^*$ ? It consists in computing the improvement vector that requires a minimal investment. Let us note  $\vec{\delta}^* = (\delta_1^*, \delta_2^*, \dots, \delta_n^*)$  the solution to this problem.  $\vec{\delta}^*$  is thus associated to the most efficient strategy w.r.t. a given  $g(\cdot)$  model and a predefined set of cost functions associated to each criterion of the PMS.

Let us note  $c_i(P_i, \delta_i)$  the cost related to partial improvement from  $P_i$  to  $P_i + \delta_i$ . The cost function for an overall improvement from  $g(\vec{P})$  to  $g(\vec{P} + \vec{\delta})$ , with  $\vec{P} = (P_1, \dots, P_n)$  and  $\vec{\delta} = (\delta_1, \dots, \delta_n)$ , is then (costs separability assumption):

$$c(\vec{P}, \vec{\delta}) = \sum_{i=1}^n c_i(P_i, \delta_i)$$

The search of an efficient improvement can then be formalized into the optimization problem  $(\mathbf{P}_1)$ :

Objective function

$$\min c(\vec{P}, \vec{\delta})$$

Constraints

$$g(\vec{P} + \vec{\delta}) = P^* \text{---(Behavioral constraint)}$$

$$\forall i, 0 \leq L_i \leq \delta_i \leq 1 - U_i - P_i \text{---(Bound constraints)}$$

where  $L_i$  and  $U_i$  are threshold parameters issued from the application (e.g. improvement w.r.t. criterion  $i$  cannot exceed 30%).

A second associated optimization problem  $(\mathbf{P}_2)$  can be considered for efficiency characterization: it consists in computing the maximal expectable improvement for a given additional investment  $\delta B$ .  $(\mathbf{P}_2)$  is defined as follows:

Objective function

$$\max_{\vec{\delta}} g(\vec{P} + \vec{\delta})$$

Constraints

$$c(\vec{P}, \vec{\delta}) = \delta B \text{---(Behavioral constraint)}$$

$$\forall i, 0 \leq L_i \leq \delta_i \leq 1 - U_i - P_i \text{---(Bound constraints)}$$

The MAUT model thus enables to capture the manager's preferences into an analytic form that facilitates the introduction

of concepts such as efficiency under the form of optimization problems. It thus provides a powerful artefact to capture the overall performance of the company and reason over it.

### 3. The implementation aspect of improvement

#### 3.1 Goals and actions relationships

The MAUT framework merely captures preferences of the company's manager without further considerations regarding the material constraints behind the improvement implementation. However, these constraints cannot be ignored to design the implementation part of the improvement project. Thus, MAUT models for overall performance have been criticized in (Felix, 1994). Felix explains why there are some troubles to a priori postulate that decision making should be performed by aggregation operators based on a few general axioms (Felix, 1994; 2008). In contrast to that, he claims that human decision makers usually do not describe their goals by formulas and renounce the use of axiomatically specified operators in order to work out their decisions. Instead of this, they concentrate on the estimation of which goals are distracted by which alternatives. Furthermore, they evaluate this information (which in most cases is uncertain) in order to infer how the goals do depend on each other and ask for the actual preferences of the goals. He then determines for each partial performance  $P_i$  the set  $S_i$  of actions  $a_j$  that support an improvement of  $P_i$  with degree  $\mu_j$  and the set  $D_i$  of actions  $\bar{a}_j$  that distract  $P_i$  with degree  $\bar{\mu}_j$ . From these considerations he provides relations between performances expressions, *e.g.*  $P_i$  assists  $P_j$  when  $S_i \subset S_j$  and  $S_i \not\subset D_j$ . For sake of simplicity, the uncertainty degree  $\mu_j$  is not considered in this paper:  $\mu_j \in \{0;1\}$  is a mere Boolean parameter.

He concludes that a conjunctive aggregation model is appropriate for cooperative goals, whereas a disjunctive model should be preferred when goals are independent or competitive. From his viewpoint, the aggregation model should be based upon the analysis of physical constraints afferent to the potential improvement action plans. In this way, the aggregation model is no longer the expression of strategic preferences. It clearly differs from the MAUT philosophy in section 2. This controversial point will be discussed in section 4. For the moment, let us simply consider the notions of actions and relationships between actions and goals as introduced by Felix, *i.e.* the implementation part of industrial improvement. Industrial improvement is now considered in terms of actions to be planned to achieve some goals that have been specified elsewhere. That is a complementary viewpoint to the managerial viewpoint in section 2. In the next subsection a basic implementation is proposed to compute the adequate actions to be carried out in order to achieve the goals  $P_i^*$  related to each  $P_i$ .

#### 3.2 Convenient and permissible action plans

Let us note the partial performances  $P_i, i=1..n$ , their assigned goals  $P_i^*, i=1..n$  and the actions  $a_j, j=1..p$ . An action  $a_j$  may belong to  $S_i$ , to  $D_i$  or may be of no influence on  $P_i$ . Actions and

performance indicators relations can be represented through a digraph such that (see example in Figure 1):

$$\forall \text{ action } a_j, \forall \text{ indicator } P_i,$$

$$\text{arc}_{ij} = +1 \text{ iff } a_j \in S_i$$

$$\text{arc}_{ij} = -1 \text{ iff } a_j \in D_i$$

Let us note the partial performances to be improved  $P^+$  ( $P_i \in P^+ \Leftrightarrow P_i^* > P_i^l$ ) and  $P^0$  ( $P_i \in P^0 \Leftrightarrow P_i^* = P_i^l$ ) when no improvement is required w.r.t.  $P_i$ .

A permissible action plan corresponds to a set of actions that conjointly improve all the partial performances in  $P^+$ . Then let us consider the following arc:  $V_{ij}(k)$ . It takes its value in  $\{0,1\}$  and has the following meaning for action plan  $k$ :

$$\begin{cases} V_{ij}(k) = 1 \Rightarrow a_j \text{ is applied} \\ V_{ij}(k) = 0 \Rightarrow a_j \text{ is not applied} \\ V_{ij}(k) = \omega \Rightarrow V_{ij}(k) = 1 \vee V_{ij}(k) = 0 \end{cases}$$

The  $\omega$  case corresponds to the case when action  $a_j$  has no influence on  $P_i$  ( $\omega$  is a Boolean variable such that  $\omega = 0$  or  $\omega = 1$  is of no influence w.r.t.  $P_i$ ) or action  $a_j$  is not necessary w.r.t.  $P_i$ 's improvement.

Finally let  $V_i(k) = [V_{i1}(k) \dots V_{ip}(k)]$  be a convenient action plan for  $P_i \in P^+$  (i.e., it improves partial performance  $P_i \in P^+$ ). The following assumptions are made:

- the gain between action  $a_j$  and partial performance  $P_i$  is a purely qualitative data: it is simply known that  $a_j \in S_i$  or  $a_j \in D_i$  (represented as a directed signed graph in Figure 1);
- if  $a_j \in D_i$  is applied, then at least two actions in  $S_i$  are to be performed to compensate the effect of action  $a_j$  on  $P_i$ .

The graph in Figure 1 means:

- partial performance improvements are expected w.r.t.  $P_1$  and  $P_n$  in  $P^+$ ;
- partial convenient action plans for  $P_1$  are:

$$V_1(k) = [1, \omega, \omega, \dots, \omega], k = 1.. 2^{(p-1)},$$

$$V_1(k) = [\omega, 1, \omega, \dots, \omega], k = 2^{(p-1)} + 1.. 3.2^{(p-2)}$$

- partial convenient action plans for  $P_n$  are:

$$V_n(k) = [\omega, 0, \omega, \dots, 1_{(j)}, \omega, \dots, \omega], k = 1.. 2^{(p-2)}$$

$$V_n(k) = [\omega, 0, \omega, \dots, \omega, \omega, \dots, 1], k = 2^{(p-2)} + 1.. 3.2^{(p-3)}$$

$$V_n(k) = [\omega, 1, \omega, \dots, 1_{(j)}, \omega, \dots, 1], k = 3.2^{(p-3)} + 1.. 2^{(p-1)}$$

More generally a partial convenient action plan for  $P_i \in P^+$  is of type:

- if no action in  $D_i$  is carried out, then any action plan with at least one action  $a_j$  in  $S_i$  is a partial convenient action plan for  $P_i$ ;
- if  $m$  actions in  $D_i$  are carried out, each of these actions must be compensated with at least 2 actions in  $S_i$ .

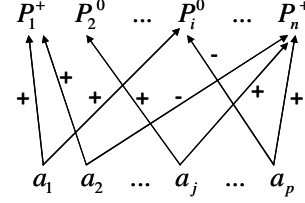


Fig. 1: an influence graph

Let  $V_i, i = 1..n$  be partial convenient improvements for  $P_i, i = 1..n$ . A permissible action plan  $\cap V_i$  can be deduced from the  $V_i$ 's if the partial convenient improvements are compatible, i.e., when the following constraints are satisfied:

$$\forall (i, i') \in \{1; \dots; n\}^2, V_{ij} = V_{i'j} (\mathbf{I}) \text{ or } V_{ij} = \omega (\mathbf{II})$$

Hence, the following rules state:

- if there exist  $i, i'$  such that  $V_{ij} = 1$  and  $V_{i'j} = 0$  then no permissible action plan can be found from the  $V_i$ 's; constraints are incompatible (there are constraints' conflicts);
- if  $\forall i \in J \subset 2^{\{1..n\}}, V_{ij} = 1$  [resp. 0] and  $\forall i \in \bar{J}, V_{ij} = \omega_{(j)}$  then action  $a_j$  is a permissible improvement for the  $V_i$ 's [resp.  $a_j$  is an inadmissible improvement] if and only if  $\forall i \in \bar{J}, \omega_{(i)} := 1$  [resp. 0].

Several solutions may be got for  $\cap V_i$  from the  $V_i$ 's when most of the constraints are of type (II). Furthermore, several families  $V_i$ 's can be generated (see example in Figure 1).

The problem thus consists in (1) generating all the partial convenient improvement  $V_i$  for each  $P_i \in P^+$ , (2) computing all the permissible action plans  $\cap V_i$  from the combination of compatible partial convenient improvements  $V_i$ . The search of an acceptable action plan in this qualitative representation is thus formalized into an elementary constraint solving problem (CSP).

The algorithm complexity is not a problem as long as the number of relations between the  $P_i$  and  $a_j$  is limited (if all the actions  $a_j$  influence all the performance  $P_i$  the problem is  $np$ -complete). In practice, this condition is verified and the matrix  $P_i \times a_j$  is sparse. Furthermore, to solve efficiently the problem, some heuristics can be introduced such as starting to study the  $P_i \in P^+$  connected with the minimal number of  $a_j$ .

Then the  $P_k \in P^+$  in relation with a minimal number of  $a_j$  but having the maximal number of  $a_j$  in common with  $P_i$  are studied... and so on, to incrementally construct the permissible improvement action plan. With such an approach the complexity of the resolution is decreased by removing the incompatible subsets as soon as possible.

At the end of the process, a configuration vector of the  $a_j$  is got where some of them may still have the  $\omega$  value which means that several permissible action plans may be envisaged.

To enhance this problem with quantitative values for the  $P_i \times a_j$  gain matrix and discrete finite set of values for the  $a_j$ 's (e.g. more than 2), a CSP approach can still be used.

### 3.3 Efficient improvement

Let us note  $(\cap V_i)_k$  the permissible action plans related to  $P^+$ . A cost  $c_j$  is then attached to each action  $a_j$ . Hence, the cost  $C(.)$  of  $(\cap V_i)_k$  is:

$$C((\cap V_i)_k) = \sum_{j=1}^p [(\cap V_i)_k]_j \cdot c_j \quad ([(\cap V_i)_k]_j = 1 \text{ when action } a_j \text{ is processed else } 0).$$

An efficient improvement is thus defined as:

$$\text{Arg min}_k C((\cap V_i)_k)$$

The search of an efficient improvement in the implementation viewpoint is first based on a CSP, and then the action plans  $(\cap V_i)_k$  with the lowest cost are enumerated.

In this framework, improvement costs are directly related to actions and the interpretation is obvious. In the MAUT framework (section 2), costs are associated to partial performance improvements  $c_i(P_i, \delta_i)$ : in general, several actions are permissible to improve  $P_i$  to  $P_i + \delta_i$ . It means that  $c_i(P_i, \delta_i)$  can only represent an average cost in the MAUT framework because the action to be planned is not taken into account explicitly in the model. The mean cost of a partial improvement necessarily in the MAUT model relies on managers' know-how: they evaluate the improvement cost on an average based upon observations in recent past years.

## 4. A unified framework

This section is devoted to propose a trade-off between the managerial and the implementation aspects of industrial improvement. The MAUT model in section 2 enables to synthesize the managers' preferences w.r.t. partial performances to be improved first. It provides a relevant formalization for the search of efficient improvements. Felix criticizes the way such a MAUT model is established (Felix, 1994): to his mind, the aggregation model should capture the cooperative or competitive nature of goals and this analysis should be based upon the impact actions have on partial performances.

Nevertheless, Felix's critical analysis of current MAUT models for industrial improvement cannot be taken for granted. Let us take a common example. A father may wish his son to be good at school and to be a great football player; although he knows that learning lessons at home and spending one's time playing football are incompatible hobbies. The father's expectations are not necessary well-matched with the son's abilities. The ideological question behind this could be "Is world governed by preferences or abilities?". Furthermore, the father may be fully satisfied if his son becomes any white collar worker and a respectable football player in his village: it means that the boy does not need to work as a minister or to play football in Manchester United in order to be the pride and joy of his father. There are non-linear behaviors in the father's preferences that prevent any a priori classification of competitive or cooperative goals. As a consequence, the way Felix proposes to classify goals reasoning about the actions that support and discard them may appear as a common sense attitude but it is not so obvious in practice.

An iterative process is thus proposed in order that the managers' expectations and the workers' abilities might converge to a satisfying compromise. The MAUT model of section 2, *i.e.*, the managerial aspect of industrial improvement and the goal-action model of section 3, *i.e.*, the implementation facet of improvement, are conjointly used to support this iterative process.

First, managers express their preferences in terms of strategy and a MAUT model is built to capture their preferences as proposed in section 2. A global objective  $P^*$  is assigned to the company. This objective is then distributed onto partial performances. Next, the set of partial performances  $P_i^+$  to be improved first is computed thanks to the optimization problem  $(P_1)$  in section 2.

The  $P_i^*$ 's are computed. That is the managerial part of the performance improvement design. Secondly, the actions to achieve these improvements are computed thanks to the model in section 3. The efficient permissible action plans that warranty improvements w.r.t. the  $P_i \in P^+$ 's are computed. Because data in the CSP problem are generally qualitatively known, only improvements w.r.t. the  $P_i \in P^+$ 's are guaranteed but not the precise objectives  $P_i^*$ .

An efficient permissible action plan is applied. Several iterations may be necessary to achieve satisfying quantitative results. Indeed, after the permissible action plan is applied, a new performances profile is obtained. Managers then analyze and diagnose these new results. They may consider that the observed performances are close enough to the objectives  $P_i^*$  and accept the result. When the discrepancies between the expected results and the observed performances are too significant, they may also readjust their objectives  $P_i^*$ : they realize that their expected objectives were not compatible with implementation constraints (technical, material, temporal reasons). A new set of  $P_i \in P^+$  is computed from the optimization problem  $(P_1)$ , then the CSP provides the corresponding permissible action plan, and so on.

## 6. CONCLUSIONS

In the current industrial context, strategies intended to bring about continuous improvement have to include the multi-criteria performance expression aspects. A MAUT model captures the managers' strategy in terms of performances improvement. The search of an efficient improvement can be formalized as an optimization problem. Whereas MAUT models appear to conveniently address the purely managerial decisions related to performances improvement, they do not include the material constraints related to the corresponding implementation in counterpart. That is the reason why some authors have severely criticized aggregated performance models issued from the MAUT. A CSP model has been proposed to support the implementation part of an improvement project. It qualitatively captures the relations between goals and actions to design efficient permissible action plans. Finally, a unified framework has been proposed to conciliate the managerial and the implementation aspects of industrial improvements. Each of the models proposed in this paper could be clearly refined but it was not the subject. Our aim is to show that models intended to define an improvement implementation do not discard the managerial MAUT model but complete it on the contrary. This paper does not claim to better meet industrial requirements regarding the design of performance improvement than other approaches mentioned in this paper: it merely contributes to clearly distinguish which knowledge (preferences or physical constraints) is useful at each stage of performance improvement design. The managerial/implementation decomposition that is proposed enables to accurately combine quantitative/qualitative pieces of knowledge, strategic preferences/operational constraints, that constitute the performance improvement decision-making process. This breakdown has also cognitive purposes: it underlines why strategic preferences rarely meet operational constraints by nature, why there are so often conflicts between manager's office and operatives. Modelling performance improvement into a unique optimization problem that would mix both viewpoints would inevitably lead to misleading conclusions. The explanatory purposes of our model rely on this cognitive breakdown: head managers *wish the best* for their companies; operatives *do their best*. The challenge is the consensual translation of will into act.

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