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# A Possibilistic Approach to Set Achievable and Feasible Goals while Designing Complex Systems

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**Abstract:** How to make, early in the development cycle of complex products, the most promising design choices as regards the customer's requirements and being at the limit of what is technically feasible by the manufacturer? To contribute to solve such a difficult problematic, we propose an original approach based on possibility theory that aims finding the best alternative according to the preferences of the stakeholders and being feasible by the designer team. Customer's and manufacturer's preferences are captured in a multi attribute utility theory (MAUT) framework that is extended to uncertain and imprecise evaluation of the alternatives' characteristics since available knowledge about the future system is mostly qualitative in preliminary design stages.

*Keywords:* design of complex system, imprecise assessment, multiple-criteria decision analysis, possibility theory.

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## 1. INTRODUCTION

The survival of a company is heavily dependent on its capacity to identify new customer needs and develop new products Shen *et al.* (2000). Industries must always search for sustainable advantages, improving their performance. However, designing new products or improving existing ones in today's highly competitive market presents significant risks. Many system requirements must be taken into account when designing or improving a product Baykasoglu *et al.* (2002); Ng (2006). Decisional strategies are required to define, compare and select potential design alternatives with respect to the relationships existing between performance expressions Bititci *et al.* (1995). These relationships may be of a different nature, *e.g.* operational, physical or preferential. Operational relationships between two variables refer to the existence of improvement actions that allow or prevent the conjoint improvement of a subset of criteria (*e.g.*, there does not exist improvement actions that both allow working better and more quickly). Physical relationships express influences, constraints or balances between variables related to performance expressions (*e.g.*, it is difficult to reduce the friction force while increasing the speed of a vehicle because the friction force varies as the speed or the square of speed). Finally, preferential relationships refer to subjective interactions among performance expressions (*e.g.*, "I would like my new car to be both roomy and fuel-friendly" refers to a conjunctive interaction whereas "I would like my new car to be either comfortable or sportive" is a disjunctive interaction). Whereas the customers' preferences regarding the system to be designed are considered to be expressed in their needs, the manufacturers' preferences are rather related to the effort the system achievement will necessitate: the more complex the system, the more uncertain the

achievement and the more time the project risks to consume and finally the less worthwhile the cost/benefit ratio for the manufacturer.

So, design decisions require large analysis and forecasting capacities especially during the preliminary design stage when system requirements, product models and performances' interactions are merely based on unprecise information. Therefore, identifying new solutions to satisfy customers in such a context appears as a complicated task Moulianitis (2004), Couturier *et al.* (2014). The industrial manufacturers must design new products/systems from past experience according to customers' needs at the limit of what is technically feasible as they are aware of their available enterprise-level skills. Defining achievable targets is a matter of situation awareness to relevantly manage the balance between strategic ambition and manufacturing realism Sow *et al.* (2016), Montmain *et al.* (2015). Thus, design alternatives to be retained as a priority are those which allow both significant positive impacts on product/system performance but also correspond to actions that are derived from the expertise of the manufacturer. This will help the designer to avoid focusing on the implementation of alternatives that would be too far from the genuine ability and know-how of the manufacturer.

Despite their interest in design decision making, few works address the modeling of technical feasibility. In Bause *et al.* (2014), the authors clarify the concept of «technical feasibility study» often used in the context of product development process and explain how such concept concerns usually the activities: "idea detection", "modeling of principle and embodiment", "detection of alternative solutions" and "analysis of consequences". However the

authors do not deepen methods and tools required to evaluate. Clivillé *et al.* (2015) are interested with this duality between expected and feasible performances. They do not limit the decision making process to the satisfaction of alternatives but introduce a feasibility function such as “a configuration  $a$  is more feasible than a configuration  $b$ ” if one can pass from  $a$  to  $b$ . For each configuration, they then seek to maximize the satisfaction that can be expected starting from this configuration under feasibility constraints. However the work does not consider relationships existing between performance expressions and all information about feasibility is supposed to be given by experts. In Chinkatham *et al.* (2015) is proposed the ‘Inventive Design Method’ to prevent the surrender of good solution concepts and to reject unfeasible ones as early as possible when designing a product. The approach is based on finding first doubts or uncertain conditions of any solution after reaction of designers or experts. The estimated feasibility is then found by considering one or more behavior model(s), but also design objectives and constraints. However no preference model is discussed.

Also, this paper proposes selecting the most relevant design alternative for the product/system to meet the customer’s requirements subject to the enterprise-level skills in taking into account the uncertain environment and the operational, physical or preferential relationships between performance expressions. At this aim, a fuzzy model of the expected performances and of the ability to achieve is defined. The paper will be organized as follows. Section 2 introduces the problematic and the necessary notations to the problem formalization in the context of design/improvement of complex system. Section 3 presents the possibilistic model of preference required to select a design alternative. Section 4 considers an experimented application. Further prospects for this work are considered in the conclusion.

## 2. PROBLEMATIC AND CHARACTERIZATION

### 2.1 Problematic: Evaluation in System Engineering

Designing a system generally imposes to solve an ill-posed problem admitting multiple solutions and whose definition becomes more and more accurate as the choices for developing a satisfying solution are made. The most critical stage in the design process is the preliminary stage where most of the system development costs are committed Phillips *et al.* (1993). Therefore it is crucial to evaluate concepts and design alternatives against technical and economic criteria very early in the preliminary design stage (i.e. the conceptual and embodiment stages) even if, at this design stages, the available knowledge and descriptions of the system are incomplete, imprecise and subject to change. To respond to this problematic, we assume that some experts can provide advices, as regards design choice performances and feasibility, which can be formulated in form of possibility distributions and we propose an approach that aims at identifying among the possible design solution alternatives, the ones that better satisfy the customer’s criteria and that are achievable by the designer team. This is done by estimating an overall satisfaction of design alternatives on several criteria

with respect to the preference of the stakeholders’ respectively to its feasibility on these criteria. Some definitions and results will be recalled about multi attribute utility theory that manages multiple criteria context and possibility theory before formalizing the proposed approach.

### 2.2 Characterization and Notations

In order to design a complex system, we characterize it by a set of parameters  $(\gamma_1, \gamma_2, \dots, \gamma_n)$  whose values have to be fixed by the designers. Let  $\Gamma$  be the set of all possible values of the vector  $(\gamma_1, \gamma_2, \dots, \gamma_n)$ . A system is then defined by a design solution or configuration  $\gamma \in \Gamma$ . Improving a system is to make it evolve from a configuration  $\gamma \in \Gamma$  to a configuration  $\gamma' \in \Gamma$  which gives better satisfaction regarding the objectives that have been fixed for the system by the customer’s and taking into account cost constraints of the manufacturer (effort, money, risk, time etc.). The satisfaction of the objectives will be evaluated in a multi-criteria decision analysis (MCDA) framework using multi attribute utility theory.

### 2.3 Multi Attribute Utility Theory (MAUT)

Let us denote by  $N = \{1, 2, \dots, n\}$  a set of attributes where the  $i^{\text{th}}$  attribute takes its values in a set denoted  $X_i$ . The MAUT allows establishing an analytical model of the decision maker’s preference relationships over  $X = \prod_i X_i$ . Let  $\preceq$  be a preferential relation over  $X$ . The MAUT proposes to model it through a utility function  $U : X \rightarrow [0, 1]$  such that:

$$\forall (x, x') \in X^2, x \preceq x' \Leftrightarrow U(x) \leq U(x') \quad (1)$$

The function  $U$  of the equation (1) can take several forms; the most often used is the additive model:

$$\forall x \in X, U(x) = \sum_{i=1}^N w_i u_i(x_i) \quad \text{where} \quad \sum_{i=1}^N w_i = 1, \quad \forall i \in N, w_i > 0,$$

and each  $u_i : X_i \rightarrow \mathbb{R}$  is an elementary utility function that synthesizes the preference of the decision maker regarding the  $i^{\text{th}}$  attribute (it translates the value  $x_i$  into a utility value  $u_i(x_i)$ , here a performance with regard to  $i^{\text{th}}$  criterion).

The additive aggregation intrinsically tolerates compensation between criteria and required independence between them Keeney & Raiffa (1976). This additive form is the most widespread because of its simplicity and its intuitive interpretation. It is generally, a very simplifying assumption because in reality attributes interact between them. To solve this problem, a more general model of the overall utility  $U$  in equation (1) has been proposed in Krantz *et al.* (1971) where  $U$  is written under certain conditions of separability and independence:

$$\forall x \in X, U(x) = F(u_1(x_1), u_2(x_2), \dots, u_n(x_n)) \quad (2)$$

where  $F: \mathbb{R}^n \rightarrow \mathbb{R}$  is an aggregation operator. To represent  $F$  in the quantitative case, the Choquet integral is an interesting candidate. Indeed, it is an aggregation operator that generalizes several classical operators, the weighted sum of the additive model, the ordered weighted sum (OWA), the min, the max etc. Grabisch & Perny (1999). Moreover, the Choquet integral allows modeling the interaction between attributes through a fuzzy measure Marichal (1999). In the following, we propose a brief reminder about the concepts of fuzzy measure and the Choquet integral.

#### 2.4 The Choquet Integral

Definition 1: A fuzzy measure  $\mu$  on  $N$  is a set function:  $\mu: 2^N \rightarrow [0,1]$  that satisfies the following conditions:

$$\mu(\emptyset) = 0; \mu(N) = 1;$$

$$\mu \text{ is monotonic non decreasing for inclusion, i.e., for any } A, B \subseteq N, A \subseteq B \Rightarrow \mu(A) \leq \mu(B) \quad (3)$$

In the context of multi-criteria decision analysis,  $\mu(I)$  represents the importance coefficient of the combination of criteria  $I \subseteq N$ .

Definition 2: In the context of multi-criteria decision analysis, the evaluation of the Choquet integral of an alternative  $x = (x_1, x_2, \dots, x_n)$  with respect to  $\mu$  denoted by  $C_\mu(x)$  is defined by:

$$C_\mu(x) = \sum_{i=1}^n (x_{\sigma(i)} - x_{\sigma(i-1)}) \mu(A_{\sigma(i)}) \quad (4)$$

where

$$x_0 = 0 \leq x_{\sigma(1)} \leq x_{\sigma(2)} \leq \dots \leq x_{\sigma(n)}; A_{\sigma(i)} = \{\sigma(i), \sigma(i+1), \dots, \sigma(n)\}$$

with  $\sigma$  a permutation on  $N$  (to simplify the notations,  $x_{\sigma(i)}$  denotes here a utility value, it should be formally noted  $u_{\sigma(i)}(x_{\sigma(i)})$ ).

Furthermore, it is important to note that our approach aims first to select design solutions in a context of imprecision and uncertainty where values of attributes cannot be precisely known in the design stage. Uncertain scores are then modeled as possibility distributions in our framework.

#### 2.5 Possibility Theory

Possibility Theory is an appropriate framework to represent imprecise information Dubois *et al.* (1988).

Definition 3: A possibility distribution  $\pi$  on the set of interpretation  $\Omega$  is a mapping from  $\Omega$  to  $[0,1]$  which satisfies the normalization condition:  $\exists \omega \in \Omega: \pi(\omega) = 1$ .

By analogy with the mathematical expectation of a random variable, the expectation associated to a possibility distribution is also defined in Dubois *et al.* (1987).

Definition 4: Given a possibility distribution two distribution functions are associated to  $\pi$  and are named respectively upper distribution  $F^*$  and lower distribution  $F_*$ :

$$F^*(x) = \sup\{\pi(r), r \leq x\}; F_*(x) = \inf\{1 - \pi(r), r > x\}.$$

The mathematical expectation associated to  $\pi$  is imprecise and is then defined in Dubois *et al.* (1987) by the interval:

$$E(\pi) = [E_*(\pi), E^*(\pi)], \text{ where}$$

$$E_*(\pi) = \int_{-\infty}^{+\infty} x dF_*(x) \text{ and } E^*(\pi) = \int_{-\infty}^{+\infty} x dF^*(x).$$

Roughly speaking and to make the analogy with probabilities, the ‘‘average’’ value of  $\pi$  would be the interval  $[E_*(\pi), E^*(\pi)]$  and a ‘‘measure of dispersion’’ could be  $E^*(\pi) - E_*(\pi)$ . However, for sake of simplicity, it may be useful to define a position indicator which allows reducing the possibility distribution into a unique precise representative value. Indeed, it clearly facilitates comparing possibility distributions.

Definition 6: The position indicator of a possibility distribution  $\pi$  denoted by  $MD(\pi)$  is defined by:

$$MD(\pi) = (E^*(\pi) + E_*(\pi))/2.$$

#### 2.6 Aggregating Possibility Distributions with a Choquet Integral

Given elementary possibility distributions  $\pi_1, \pi_2, \dots, \pi_n$ , the aggregated possibility distribution  $\pi_F$  using an operator  $F$  can be computed using the extension principle of Zadeh (1965) which states that:

$$\pi_F(x) = \sup_{x_1, x_2, \dots, x_n / F(x_1, x_2, \dots, x_n) = x} \min(\pi_1(x_1), \pi_2(x_2), \dots, \pi_n(x_n))$$

To facilitate notations, we denote  $\pi_F = F(\pi_1, \pi_2, \dots, \pi_n)$ . The direct computation of the aggregated possibility distribution by this formula may be extremely time consuming, but in case of Choquet intergral Grabisch *et al.* (2000) proposes a much more practical way to compute the aggregated distribution  $\pi_{C_\mu}$  based on the hyperplan-linearity of the Choquet integral (the Choquet integral in (4) behaves as a weighted mean in each hyperplan  $H_\sigma / x_{\sigma(1)} \leq x_{\sigma(2)} \leq \dots \leq x_{\sigma(n)}$ ). The computation only needs to be processed on a finite set of particular points.

### 3. IDENTIFYING THE BEST AND MOST FEASIBLE CONFIGURATION

#### 3.1. The Precise Assessment Problem

On one hand, there are the customer’s needs and the manufacturer’s aspirations on the other hand. A set of criteria is associated to the customer’s needs and a capacity  $\mu$

captures his priorities over the coalitions of criteria. In other words, any configuration  $\gamma \in \Gamma$  can be assessed through its results on attributes, e.g.,  $x^\gamma = (x_1^\gamma, x_2^\gamma, \dots, x_n^\gamma)$ , as  $U_{customer}(x^\gamma) = C_\mu(u_1(x_1^\gamma), u_2(x_2^\gamma), \dots, u_n(x_n^\gamma))$  where the  $u_i(\cdot)$ 's are utility functions related to the criteria. The higher  $U_{customer}(x^\gamma)$ , the better  $\gamma$  matches the customer's needs.

Otherwise the preference model of the manufacturer is related to the effort the configuration requires. The more difficult is the achievement of the configuration, the less attractive the cost/benefit ratio for the manufacturer. The difficulty of achievement related to the configuration  $\gamma$  is computed from a capacity  $\mu'$  that captures the conjoint impediments over the coalitions of criteria. Hence,  $C_{\mu'}(d_1(x_1^\gamma), d_2(x_2^\gamma), \dots, d_n(x_n^\gamma))$  assesses the perceived difficulty related to the configuration  $\gamma$  by the manufacturer, where the  $d_i(\cdot)$ 's are functions that measure impediments to the achievement of the requirements related to criteria. The preference model of the manufacturer is then given by  $U_{manufacturer}(x^\gamma) = 1 - C_{\mu'}(d_1(x_1^\gamma), d_2(x_2^\gamma), \dots, d_n(x_n^\gamma))$ . Finally, the overall score, the configuration receives is:

$$U(\gamma) = (U_{customer}(x^\gamma), U_{manufacturer}(x^\gamma)) \quad (5)$$

### 3.2. The uncertain assessment problem extension

Now that we have introduced the basic assessment of a configuration when it is described by precise characteristics  $(x_1, x_2, \dots, x_n)$ , let us introduce the configuration selection problem in real design conditions. In product design, the selection of a satisfactory solution is iterative, i.e., designers first determine a class of solutions then refine the solution into this class.

Ex: designers infer from the requirements expressed by some customer that this latter searches for a robot in a class of autonomous robot equipped with a rolling base with tracks, a fork and a set of exteroceptive sensors. Indeed, we assume that at this preliminary design stage a configuration is composed of one type of rolling base, one type of sensor equipment and one type of gripper device and represents a class of robot. The designers have numerous potential candidates (the different possible instances of such a robot) to the customer's requirements. To each of the robot requirement a specific attribute is associated. From their set of potential offers, the designers only know the attributes' ranges of values he can offer to the customer with such a class of robot. They have to get more precise information to refine their proposal. Mathematically speaking, at this early design stage, the values (resp. impediments to performance reaching) of any attribute are known in imprecise and uncertain way and are assumed to be represented as a possibility distribution.

Let consider that  $\Gamma$  is a finite set of configurations. To each configuration  $\gamma \in \Gamma$  is associated its performance vector  $x^\gamma$ , and the possible range of values related to attribute  $i$  is provided by the expert designers as a possibility distribution

$\pi_i^\gamma$  Imoussaten *et all* (2014).. As it has been seen previously, a utility scale  $u_i(x_i^\gamma)$  and a difficulty  $d_i^\gamma(x_i^\gamma)$  scale are then related to the  $i^{th}$  attribute by the expert designers for each configuration (whereas the  $u_i(\cdot)$ 's only depend on the customer's needs, the  $d_i^\gamma(\cdot)$ 's depend on the configuration  $\gamma$ ). In this way, two further possibility distributions are constructed for the configuration  $\gamma$  on attribute  $i$  such that  $\bar{\pi}_i^\gamma = \pi_i^\gamma \circ u_i$  and  $\underline{\pi}_i^\gamma = \pi_i^\gamma \circ d_i^\gamma$  which  $\pi_i^\gamma \circ g_i(x) = \max_{y/g_i(y)=x}(\pi_i^\gamma(y))$  where  $g_i(\cdot) = u_i(\cdot)$  or  $g_i(\cdot) = d_i^\gamma(\cdot)$ . Note that this step could also be the result of a statistical analysis from a database of past settings.

Then the assessment of a configuration in uncertain environment can then be extended as:

$$\begin{aligned} \tilde{U}_{customer}^\gamma &= F_1(\bar{\pi}_1^\gamma, \bar{\pi}_2^\gamma, \dots, \bar{\pi}_n^\gamma) \\ \tilde{D}_{manufacturer}^\gamma &= F_2(\underline{\pi}_1^\gamma, \underline{\pi}_2^\gamma, \dots, \underline{\pi}_n^\gamma) \end{aligned} \quad (6)$$

Where  $\tilde{U}_{customer}^\gamma$  (resp.  $\tilde{D}_{manufacturer}^\gamma$ ) is the possibility distribution representing the degree of possibility of the global satisfaction (resp. difficulty) of the customer (resp. manufacturer), with  $F_1 = C_\mu$  and  $F_2 = C_{\mu'}$ . A position indicator can be used to meet the formula (5) of the precise context:

$$U(\gamma) = \left( MD(\tilde{U}_{customer}^\gamma), 1 - MD(\tilde{D}_{manufacturer}^\gamma) \right) \quad (7)$$

### 3.3. Basic Principles of the Preference Elicitation Step

Without getting into the specifics of computation, this section provides the key points for indirect identification of the parameters of the aggregation operator that provides the overall utility  $U$ . This method called MACBETH has initially been proposed for identifying the weights of a weighted average mean Bana e Costa (1994) and then extended to the case of the Choquet integral Labreuche *et al.* (2003). We simply give the principles of indirect identification method.

Let us consider a finite set  $X$ . When the elements of  $X$  can be ranked w.r.t. to their attractiveness, they define an ordinal information. It means that a number  $U(x)$  can be associated to any element  $x$  of  $X$  such that:

$$\begin{aligned} \forall x, y \in X : [xPy \Leftrightarrow U(x) > U(y)] \\ \forall x, y \in X : [xIy \Leftrightarrow U(x) = U(y)] \end{aligned} \quad (8)$$

where relation  $P$  « is more attractive than » is asymmetric and non-transitive and relation  $I$  « is as attractive as » is an equivalence relation. The  $U(x)$  values define an ordinal scale.

Based upon this first level of information  $P$  and  $I$ , an interval scale can then be built. The second step consists in evaluating the difference of intensity of preference between elements of  $X$  i.e.  $U(x) - U(y)$ . A system of inequalities is deduced from these two steps. The resolution of this system provides an interval scale.

## 4. APPLICATION

### 4.1. Presentation of the Application

The robotic challenge Robafis is organized annually by the French association of Systems Engineering AFIS to promote Systems Engineering practice in engineers' schools. The scope of the Robafis\_2013 challenge was to build an autonomous mobile robot able to compete with other robots and using some imposed materials. Each robot was limited to a  $0.3m^3$  cube and had to achieve the following mission as quickly as possible: to grasp and transport some various coloured spheres between several stock devices spread over a plan playground. Dark lines were drawn on the playground to guide the robot between stock devices. The autonomous robot was built from five sub-systems: a gripper device, sensors equipment, a rolling base, a control device and a battery. The programmable control device and the battery were imposed to the competitors. The robot configurations depend upon the design options and on the skills of each competitor. The design alternate choices are resumed in Table 1. There are three principles for designing the gripper device, three for the rolling base and two for the sensors equipment. Thus, there are 18 configurations to be compared, corresponding to the  $3 \times 3 \times 2$  admissible configurations. For the sake of computation illustration, let us compare for instance the five configurations:  $(G_2, R_1, S_1)$ ,  $(G_3, R_3, S_2)$ ,  $(G_1, R_2, S_2)$ ,  $(G_1, R_1, S_1)$ ,  $(G_2, R_2, S_1)$ .

**Table 1. Design options**

Gripper device	Rolling base	Sensors equipment
$G_1$ : fork taking sphere from below	$R_1$ : with 4 wheels	$S_1$ : 2 color sensors (marks on ground detection), one light sensor (sphere detection)
$G_2$ : gripper taking sphere laterally	$R_2$ : 2 wheels drive + 1 free wheel	$S_2$ : 1 color sensor (marks detection), 1 color sensor (sphere detection)
$G_3$ : grapnel taking sphere over	$R_3$ : with tracks	

### 4.2. Data of the Application

Four criteria are considered to decide between configurations: the robot cost (1), the robot average speed capacity (2), the reliability of the robot (3), and the maintainability of the robot (4) (see Table 1). Taking into account the competition rules, Tables 2 gives examples of customer preferences (the competitors) and feasibility difficulty estimation modeled by two capacities based on the extension of the MACBETH method to the Choquet integral as presented in section 3.3.

Fig.1, shows the kinds of inputs needed for each attribute and configuration. For instance: the possibility of the maintainability attribute values (time in minute to repair the robot) taking into account past experiences and state of the

art; the difficulty to achieve such maintainability values (taking into account the current resource availability of the manufacturer).

**Table 2. Competitors preferences and difficulty of achievement**

$I$	$\mu(I)$	$\mu'(I)$	$I$	$\mu(I)$	$\mu'(I)$
$\emptyset$	0	0	$\{4\}$	0	0,25
$\{1\}$	0	0	$\{1,4\}$	0,14	0,25
$\{2\}$	0	0,25	$\{2,4\}$	0,57	0,42
$\{1,2\}$	0,55	0,33	$\{1,2,4\}$	0,71	0,5
$\{3\}$	0	0,5	$\{3,4\}$	0	0,58
$\{1,3\}$	0,28	0,67	$\{1,3,4\}$	0,43	0,75
$\{2,3\}$	0,71	0,75	$\{2,3,4\}$	0,86	0,75
$\{1,2,3\}$	0,71	1	$\{1,2,3,4\}$	1	1

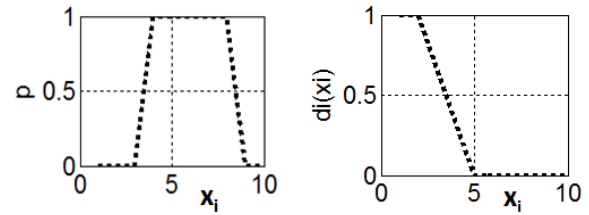


Fig. 1.  $\pi_i^\gamma$  and  $d_i^\gamma$  for the maintainability attribute ( $x_i$ : time to repair the robot in minute) and configuration  $(G_2, R_2, S_1)$ .

### 4.3. Results and Comments

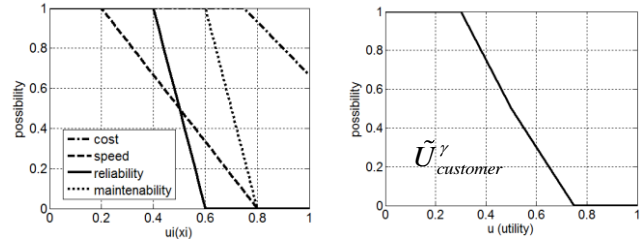


Fig. 2. Possibility distributions  $\tilde{\pi}_i^\gamma$  and  $\tilde{U}_{customer}^\gamma$  for configuration  $(G_2, R_2, S_1)$ .

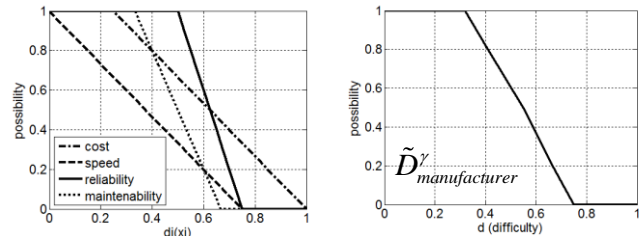


Fig. 3. Possibility distributions  $\tilde{\pi}_i^\gamma$  and  $\tilde{D}_{manufacturer}^\gamma$  for configuration  $(G_2, R_2, S_1)$ .

Fig. 2 (resp. Fig. 3) gives example of possibility distributions  $\tilde{\pi}_i^\gamma$  (resp.  $\tilde{\pi}_i^\gamma$ ) and the aggregated distributions  $\tilde{U}_{customer}^\gamma$  (resp.  $\tilde{D}_{manufacturer}^\gamma$ ) for the configuration  $(G_2, R_2, S_1)$ . From

data of Fig. 1 are computed  $\tilde{\pi}_i^\gamma = \pi_i^\gamma \circ d_i^\gamma$  for the maintainability criterion as shown in Fig. 3.

**Table 3. Configurations global indicator**  
( $MD(\tilde{U}_{cust.}^\gamma)$ ,  $1 - MD(\tilde{D}_{man.}^\gamma)$ )

Configurations	$MD(\tilde{U}_{cust.}^\gamma)$	$1 - MD(\tilde{D}_{man.}^\gamma)$
G <sub>2</sub> ,R <sub>2</sub> ,S <sub>1</sub>	0,52	0,53
G <sub>2</sub> ,R <sub>1</sub> ,S <sub>1</sub>	0,23	0,83
G <sub>3</sub> ,R <sub>3</sub> ,S <sub>2</sub>	0,21	0,62
G <sub>1</sub> ,R <sub>1</sub> ,S <sub>1</sub>	0,21	0,4
G <sub>1</sub> ,R <sub>2</sub> ,S <sub>2</sub>	0,19	0,66

Table 3 gives the  $MD$  position indicators of the aggregated distributions for the five considered configurations. According to the results of Table 3, the configuration (G<sub>1</sub>, R<sub>1</sub>, S<sub>1</sub>) is among the least satisfying and the most difficult one and should be rejected. The most satisfying configuration (G<sub>2</sub>, R<sub>2</sub>, S<sub>1</sub>) is among the most difficult ones. If the manufacturer knows that, according to his/her workload the acceptable feasibility expectation must be upper than 0.53 to do the job, the (G<sub>2</sub>,R<sub>1</sub>,S<sub>1</sub>) configuration should be chosen but the customer satisfaction expectation could be only 0.23 and so the risk not to satisfy the customer is high. Otherwise (G<sub>2</sub>, R<sub>2</sub>, S<sub>1</sub>) can be chosen.

## 5. CONCLUSIONS

This paper has proposed a possibilistic approach to better manage the balance between strategic ambition and manufacturing realism in the case of the design or the improvement of complex systems. The approach takes into account the operational, physical or preferential relationships between performance expressions and the uncertainty of preliminary design context. The aim was to guide the designer to find and implement the most satisfying solutions without being exposed to the risks of choosing infeasible solutions. At this aim, fuzzy models of the expected performance and of the ability to achieve have been defined. The proposed method has been illustrated in the case of the design of an autonomous robot. In future research work we expect to widen our method (using Imoussaten *et al.* (2016) results established in a probabilistic context) to define on which set of criteria an existing product has to be improved in priority given the preference and feasibility models.

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