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Ethics and decision

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Abstract

Real World situations can be faced by qualitative and by quantitative approaches, by perceptions and by measurements, by feelings and by models. In this paper we first compare the management of Natural Real World situations and the management of Human Real World situations. Although there are strong similarities, there are also major differences. "GOD" is keeping the laws of Nature unchanged and therefore it is not to be included in the models of Physics, while the "MIND" of the Decision-maker has to be taken into account in Operational Research (OR). Decision-making for Human processes requires also to take into account three poles of influence: the Rational, the Subjective and the Ethical one. Most of the basic models of OR are only considering the Rational Pole. No freedom is left to the Decision-maker, no Ethical aspects are considered. It is shown that, if well adapted, the Multicriteria Decision Aid (MCDA) PROMETHEE–GAIA procedure can provide well-balanced solutions between Rationality, Subjectivity and Ethics. Both the Mind of the Decision-maker and the "Ethical Conscience" of Mankind can be represented and included in the model. © 2002 Published by Elsevier Science B.V.

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1. Introduction

Since the beginning of their existence on Earth, all living beings have to face Real World situations. Their first approach is qualitative and based on perceptions, appreciations, and feelings.

For all of them, especially for Human Beings, important questions are: Is it dangerous? Is it warm? Is it edible? Is it possible? Do I need it? What should I do?

The last question requires a decision. Making decisions has always been one of the most crucial activities of living beings.

1.1. Natural Real World situations: The "Unchanging" world of Physics

When Human Beings are facing Natural Real World situations (Fig. 1), the purpose is:

- to describe,
- to understand,
- to face, to govern, and to manage (decisions are involved),

the Real World phenomena.

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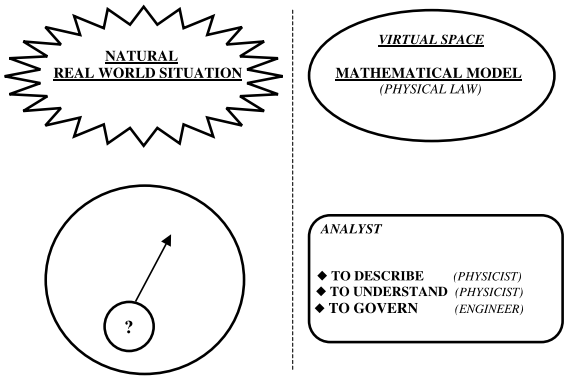

Fig. 1. Modelling of Natural Real World situations.

The first approach can of course always be qualitative and based on perceptions and appreciations. Gravitation, for instance can be particularly well appreciated. When the apple is mature it is falling, when we abandon a beautiful crystal vase in the gravitational field it will fall on the ground and get broken (what a pity!), when the goal keeper is kicking the ball into the air, he knows it will return to other players (preferably to some of his own team). The ancient Greeks already had a marvellous explanation of gravitation, they were considering that the most enjoyable position for any object was to lie and consequently to be as close as possible to the ground. Marvellous and relaxing isn't it?

However, since the most ancient times, especially since the Egyptian and the Greek civilisations, and more recently since N. Copernicus (1473–1536), J. Kepler (1571–1630), I. Newton (1642–1724) and G. Leibniz (1646–1716), another approach to Natural Real World situations has been proposed. It is a very special approach, developed by Human Beings only, not by animals or other living beings. It is the quantitative approach based on measurement and modelling.

The task is not easy. It consists for the analyst in creating a virtual space, not existing in the Nature but only in his mind, consisting of a mathematical model (image of a Physical Law) thanks to which it is possible to describe, to understand and finally to manage the Real World phenomena. The analyst in charge to describe and to understand is usually a Physicist, whereas the one exploiting the Natural phenomena for societal purposes is an Engineer.

Newton's gravitation formula is a marvellous example of the modelling of a Real World phenomenon (Fig. 2).

The border between the activities of Physicists and Engineers is not clearly defined. Overlappings often occur, but it is sure the modelling procedure is certainly performant. Fantastic results have now been obtained, for instance in the fields of Buildings and Bridges, Roads and Railways, Aircrafts and Satellites, Telecommunication Networks and Internet, etc.

Nevertheless, the mathematical models are always abstractions (reductions or approximations) of the related Real World situations. The Real World is complex and even Hypercomplex. Complex means that infinitely many independent equations are required to describe completely the Real World, and hypercomplex means that an infinitesimal neighbourhood is already complex, so that it is consequently impossible to develop models fitting completely the Real World. This is perfectly clear with regard to gravitation. If we abandon an item in the gravitational field of the Earth it will fall on the ground. But its movement is not only influenced by the Mass of the Earth, it is also by the attractive forces of the moon, the sun, the stars, the quasars, and even by the butterfly flying from flower to flower in my garden! For sure, it is impossible to take into account the influences of all the masses of the Universe and therefore any model describing a movement will be reductive. As gravitation acts all over the universe, any model associated to natural phenomena will be an approximation. Physics and Engineering have a strong Predictive power but they remain Experimental Sciences, although the approximations do not impede high performances.

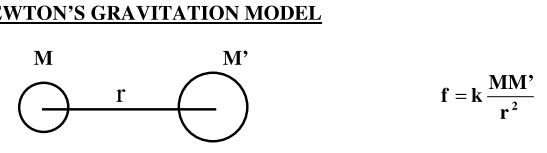

Fig. 2. Newton's attraction formula between two masses.

The main feature of the modelling of Natural Real World situations is that the Physical Law remains unchanged and is universally disseminated. The Models evolve in function of knowledge and experimentations, but the law remains fixed. As soon as discovered it is known forever! It is a huge advantage. Accumulation of knowledge is possible, as soon as a result is obtained, it can be published and diffused all over the world to all the researchers in the field. The Libraries will guarantee that any new result will never get lost. This means that the Responsible item of the Physical Laws (God, the Great Architect of the Universe, or any other mysterious power) keeps its decision stick constant. It is not using any freedom to change the laws. As Einstein said: "God doesn't cheat". This is the most important source of progresses in Physics and Engineering. Suppose it would not be the case and suppose God today selects a field in $1/r^2$ for gravitation, tomorrow a field in $1/r$, the day after a field in $1/r^6$. Some days the planes would fly quite more easily, other days they would crash! Amazing isn't it? In this case, the high performances of Physics and Engineering would never have been possible. The Modelling of "God" itself would then have been compulsory.

1.2. Human Real World situations: The subjective universe of the Decision-maker

Mankind is organised in Social and Economical structures: Countries, Cities, Villages, Governments, Institutions, Companies, Families, etc. Nobody on Earth can avoid them. This means that a Real World situation can be a Human System.

When Human Beings are facing Human Systems, again their purposes are:

- to describe,
- to understand,
- to face, to govern, and to manage it (again decisions are involved).

Of course it is possible to face the situation by means of qualitative approaches based on perceptions, appreciations and feelings. Many Sciences such as Psychology, Sociology, Economics are providing strong supports for such purposes.

But Human Real World Situations are also complex and hypercomplex, even more than the Natural ones because of the additional Human component (Fig. 3). Moreover, due to the further dynamic development of additional structures, the complexity of Human Systems is increasing day after day. In order to help the Decision-makers quantitative approaches based on measurement and modelling, similar to what has been done in Physics and Engineering, are now also developed.

Again a virtual space consisting of a mathematical model can be considered by Analysts in order to describe, to understand and finally to prepare decisions for the Real World. The purpose is to provide Decision Aid. It is the field of OR.

There are strong Analogies between Modelling in Physics and Engineering and Modelling in OR, but there are also major differences.

The main point in OR is the responsibility of the Decision-maker. The Analyst provides assistance to him, but he has his personal preferences, his own freedom. When the Decision-maker changes, the Analyst is facing another problem! This means that the model should include what the Decision-maker has in mind, his preferences, his freedom, his hesitations. Another Decision-maker implies another way to make decisions. There is no optimal solution related to the Real World only. It is therefore essential to include the Decision-maker into the model and to provide him with freedom. However in most cases it is not possible to quan-

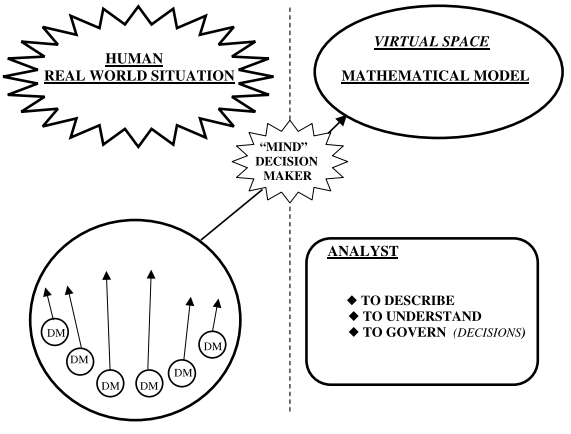

Fig. 3. Modelling of Human Real World situations.

tify all his feelings and for this reason OR must remain a harmonious combination of qualitative and quantitative approaches, of perceptions and measurements.

The modelling of Human Systems is therefore quite more intricate than modelling in Physics and Engineering. This is the reason why OR, as a structured science, is quite recent: it is only 60 years old, while some models in Physics were developed more than 2000 years ago.

1.3. Ethics: Respect of social and ecological environment

Let us consider again a Human System. When Decisions are made, not only the Decision-makers are involved, but also all the *concerned*, *the planned-for people*, all those having to undergo or to enjoy the consequences of the Decision. It is often a huge amount of people, all of them are deserving respect and regards.

On the other hand, it is often the case that Decisions have important consequences on our Natural Environment, but also Nature deserves Respect. The Earth does not belong to Man, Man belongs to the Earth. Also our children and the future generations have rights to a proper environment. Each time a Decision is made, pollution and waste management should be considered.

Taking into account our social and our natural environment is an Ethical problem. How to deal with other people? How to preserve environment? How to ensure sustainable development? How to manage the limited raw materials? How to guarantee a harmonious future to the next generations? How to provide Peace, Security, Happiness and Welfare to everybody?

All these crucial ethical questions should be considered each time a Decision is made.

It is all the more important that due to the Globalisation of the Economy still more multinational companies arise. Such companies are often no longer controlled by governments or by any other public or legal authority. Because of Market competition it is tempting to them to optimise only their profits without considering any other evaluation. It is an evidence that all social and environmental aspects will be neglected by such a behaviour.

Personally I am not against the role the Market can play because it is an important source of progresses, see for instance the recent developments in the fields of Telecommunications, Internet, Electronic commerce, Groupware, etc.

However, I strongly believe that if the Market is no longer controlled, the companies should impose to themselves a strict and fair Ethical behaviour. If not they might bring Mankind and Environment into danger.

It seems therefore essential for all economical and political institutions to take Ethical concerns into account. In case of an appropriate management an Ethical label could possibly be delivered to Institutions.

2. Decision: Three poles of influence

A Decision in a Socio-Economic or Human framework should be submitted to three poles of influence: A Rational, a Subjective, and an Ethical one.

2.1. The rationality pole

Whenever a Human Real World is faced and a model for decision is being built, three components must be considered:

(i) A set A of feasible decisions.

(ii) A criterion $f(x)\ \forall x \in A$, for differentiating the possible decisions.

(iii) A Mathematical procedure for providing Decision Aid.

All the basic OR approaches aggregate these three components into the following model:

$$\text{opt}\{f(x)|x \in A\}. \tag{2.1}$$

An optimal solution $\tilde{x}$ can then be defined such that

$$f\left(\tilde{x}\right) \geqslant f(x) \quad \forall x \in A \tag{2.2}$$

in case the optimisation problem is a maximisation problem.

The purpose of the mathematical procedure is to provide such optimal solutions. Such solutions are then submitted to the Decision-maker to be applied in the corresponding Human Real World situation. If the Decision-maker agrees with the model, ideally he should accept the proposed solution or at least know the consequences if he does not! It is the *Rationality of the Optimal Solution*. In this case, no room is left to the personal Subjectivity of the Decision-maker neither to Ethics. The Decision process coincides completely with the Rationality node (Fig. 4).

An impressive OR toolkit, based on this Rationality has been developed during the last 50 years.

In the 1940s the basic contribution has been obtained in the field of Linear Programming with the Simplex Method. In the 1950s several OR tools were developed such as: Nonlinear Programming, Dynamic Programming, Networks and Graphs, Queuing theory, Inventory problems, Game Theory, etc.

The 1960s was the period where the significance of discrete models was recognised. The theoretical challenges and the abundance of applications led to the development of such powerful tools as Branch and Bound applied to Scheduling, Sequencing, Transportation, and Location. Likewise, algorithms were assessed within the framework of computational complexity.

From the 1970s additional improvements were still obtained, new models were considered, powerful softwares were developed as well in the continuous as in the discrete field. The variety of problems is very large and most of them are not easy according to the nature of A, the kind of the differentiating criteria and the associated mathematical procedure. OR is one of the fields of science on which people published the most and presently thousands of researchers are still developing new models and improving *the Rationality of the Optimal Solution*.

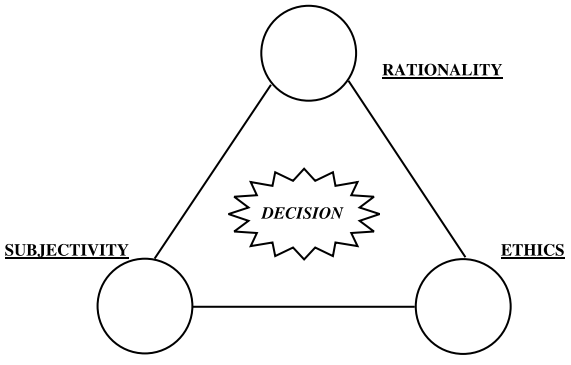

Fig. 4. Decision: three poles of influences.

2.2. The subjective pole

In the 1970s an important crisis took place in OR. On the one hand it was progressively noticed that the single-criterion models were not fitting properly most of the Human Real World situations, and on the other hand more freedom was required to take into account the Subjectivity and the Emotionality of the Decision-maker.

In other words the *Rationality of the Optimal Solution* was no longer appropriate enough to solving Socio-Economic Decision problems. The only freedom of the Decision-maker was largely to accept or to reject the model. This attitude was too drastic; more flexibility, more freedom, more dialogue between Analyst and Decision-maker were required.

It has then been proposed to investigate *other Rationalities* and to consider multicriteria models of the following type:

$$\operatorname{opt}\{f_1(x), f_2(x), \ldots, f_j(x), \ldots, f_k(x) | x \in A\}, \quad (2.3)$$

where $f_1(.), f_2(.), \ldots, f_j(.), \ldots, f_k(.)$ are the k evaluation criteria. In this case the step (ii) of the modelling process is enriched up to k criteria to differentiate the possible decisions. Such an evolution is quite natural. It takes into account the wish of the Decision-maker to "optimise" at the same time several components. In a Human Socio-Economic framework it seems evident to maximise not only the profit (as often is the case in the single-criterion models) but also the social welfare, the technological production, the waste management, and to minimise the pollution, the obnoxious effects, etc. In any Socio-Economic decision problem at least four large classes of evaluation

criteria should always be considered: Economical, Technological, Social and Environmental criteria.

MCDA emphasises the role of the Subjective pole in the Decision process. In this case the Decision-maker is no longer subjected to the drastic Rationality of the Optimal solution, he now has the freedom to consider several optimality points of views, it is then quite natural to require solutions optimising all of them.

The problem is that such solutions usually do not exist or would take it to utopian points, which are beyond the feasible limits. In most of the cases there is no solution optimising all the criteria simultaneously and the Rationality of the Optimal Solution fails! Other Rationalities should be developed.

Of course, it is possible, and many people are doing so, to aggregate all the criteria of (2.3) in a Utility function such that

$$U(x) = U\{f_1(x), f_2(x), \ldots, f_j(x), \ldots, f_k(x)\} \quad (2.4)$$

and to optimise this Utility by considering

$$\text{opt}\{U(x) | x \in A\} \quad (2.5)$$

so that the Rationality of the optimal solution is safe. Of course such a procedure offers advantages, but is also highly questionable at least for the two following reasons:

- Compensation effects occur between strong and weak criteria within the Utility function.
- Again an optimal solution is imposed to the Decision-maker without leaving him any freedom. There is no room for taking into account the Subjectivity, the Emotionality, the Real-life experience of the Decision-maker.

Several authors, among whom Roy is the most renowned one, proposed to develop other Rationalities to face Multicriteria Decision processes (Roy, 1985; Roy and Bouyssou, 1993; Brans, 1996; Brans and Mareschal, 1994; Saaty, 1980; Vansnick and Bana e Costa, 1999).

To illustrate the problem let us suppose the set "A" of feasible solutions is finite and include n items $\{a_i, i = 1, 2, \ldots, n\}$. In this case the data of the multicriteria problem (2.3) consist of a Multicriteria evaluation table (Fig. 5).

	$f_1(.)$	$f_2(.)$	…	$f_j(.)$	…	$f_k(.)$
a_1	$f_1(a_1)$	$f_2(a_1)$	…	$f_j(a_1)$	…	$f_k(a_1)$
a_2	$f_1(a_2)$	$f_2(a_2)$	…	$f_j(a_2)$	…	$f_k(a_2)$
	…	…	…	…	…	…
a_i	$f_1(a_i)$	$f_2(a_i)$	…	$f_j(a_i)$	…	$f_k(a_i)$
	…	…	…	…	…	…
a_n	$f_1(a_n)$	$f_2(a_n)$	…	$f_j(a_n)$	…	$f_k(a_n)$

Fig. 5. Multicriteria evaluation table.

In general such a table does not include a solution optimising all the criteria simultaneously and therefore only compromise solutions can be considered! The problem is then to identify the most appropriate compromises.

Let us first notice that there is no universal absolute best compromise depending on the Real World Situation only (like the Utility approach (2.4) and (2.5) is suggesting it). The best compromise also depends on the Decision-maker and therefore the "Mind" of the Decision-maker (his personal perception of the problem) must necessarily be included in the model (Fig. 2).

This is particularly clear in the following example. Suppose the problem is to select a car. The set $\{a_i, i = 1, 2, \ldots, n\}$ represents all possible choices, and the set $\{f_j(.), j = 1, 2, \ldots, k\}$ all possible evaluation criteria. It is clear that there is no universal absolute best compromise valid for all individuals (since everybody would drive the same car!).

A poor student needing a car to reach the university will emphasise the role of the criterion "cost" so that his best compromise could be a small cheap second-hand car. While the rich manager will emphasise the role of the criteria "comfort" and "prestige" in favour of a luxurious large new car. Clearly the best compromise is strongly depending on the personal views of the Decision-maker. Similar problems arise when selecting a house or a flat, a location for a plant, a strategy for an enterprise. In fact all decisions problems are concerned!

This example shows that a multicriteria problem defined by an evaluation table (Fig. 5) cannot be solved without additional information: information about the relative importance of the criteria (weights, hierarchy, etc.), information about the degree of preference of one solution with regard to another within each criterion (pairwise comparisons). Of course this additional information depends on the Decision-maker (his Mind). It models its personal preferences.

Several authors have proposed different approaches. Each of them requires different additional information, but the spirit is the same. Each of them defines a new *Multicriteria Decision Aid Rationality*. Each of them consists of a considerable enrichment of the poor Rationality of the optimal solution. Each of them offers more room for the Mind of the Decision-maker. Each of them provides better solutions than those obtained by single-criterion models. An "MCDA solution" is "better" than an "optimal solution"!

Many methods have been proposed. Their main differences consist in the kind of additional information they request, the methodology they use, their user-friendliness, the sensitivity tools they offer, and the mathematical properties they verify.

However these new Multicriteria Rationalities also *impose* solutions, so that again no freedom is left to the Decision-maker. We strongly believe that such a freedom should be offered to him because of his hesitations, his Emotionality, his real-life experience. In paragraph Section 3 we will show how such a freedom can be included in a Multicriteria Model.

MCDA methodologies propose Decisions on the Edge "Rationality–Subjectivity" in the Decision triangle (Fig. 4). However on this edge "Ethics" is not yet taken into account.

2.3. The ethical pole

Ethics should also influence any decision because of the necessity to respect the environment: the social and the natural environment. All kinds of Decision-makers are involved: individuals, institutions, organisations, companies, governments, etc. Moreover a decision never involves Decision-makers only. All those belonging to the Socio-Economic system are also involved, all the concerned, the planned-for people.

It is not excluded that the Rationality of the optimal solution, based on single-criterion models (usually the optimisation of the profit) allowed to confirm wrong decisions: wrong decisions in the Social sector (unemployment, social conflicts, etc.), wrong decisions with regard to environment (waste, pollution, etc.). In many cases more Ethics should have been considered!

Moreover, it is also an ethical necessity to consider the next generations. Sustainable development is a crucial problem for the future, nobody can guarantee that an industrial civilisation like the one presently developed on Earth can be maintained more than 300 years!

In the coming years, mankind will have to face plenty of serious major problems, such as:

- *The renewal of raw material*: the danger to be short of major raw materials (petrol, copper, phosphates, etc.) is not negligible. Up to now we have been able to find substitutes. Will it always be the case? The lack of only one major raw material (energy for instance) could completely paralyse our industrial civilisation!
- *The control of the temperature of the atmosphere*: it is not excluded that the average temperature on Earth would increase and make human life impossible. How can we develop appropriate strategies to keep this temperature within reasonable limits?
- *The control of the CO_2 emissions*: this is becoming a crucial problem for all countries in the coming years. How to meet the Rio-Kyoto-Buenos-Aires agreements in this field. The system of quotas is probably not the most Ethical one!
- *The production of energy*: the needs in Energy of mankind are colossal. How to produce this energy without endangering the planet? Nuclear production does not pollute the atmosphere but the radioactive waste is a burdensome problem! The use of natural Gas has no radioactive implications but is giving rise to CO_2 emissions into the atmosphere. Other production means (sun, wind, etc.) seem attractive but up to now they are largely marginal and cannot cover the needs.

- *The pollution, the waste management, etc.*
- *The Social Equilibrium:* a harmonious development should be reached within and between all countries, between North and South, in order to avoid future conflicts and revolutions, etc.

These are major challenges for mankind. The list is not exhaustive. Everybody should be involved, any individual, any organisation. Only a drastic Ethical behaviour, respected by everybody, will save the situation. Any particular egoism should be rejected.

Decision-making is therefore extremely intricate. All human components are involved. Philosophy and Research are required. The task is considerable! All should cooperate to propose appropriate Strategies: Physicists, Engineers, Sociologists, Psychologists, Physicians, Biologists, Politicians, Managers, Economists, etc. The future of mankind is depending on their joint contributions.

3. How to reach well-balanced decisions

A well-balanced decision should take into account the Rationality, the Subjectivity and the Ethical poles (Fig. 4).

If the decision is purely *Rational* (Rationality of the Optimal Solution) it is rather poor because only one evaluation criterion is taken into account. If the decision is purely *Subjective* it can be dangerous because it is only depending on the personal views of the Decision-maker, some hidden consequences, not directly perceptible by feeling, can be particularly damaging. If the Decision is purely *Ethical* it is often not Realistic!

The problem is how to reach well-balanced decisions. It is not an easy problem. Each scientist should include the three poles in his own investigations and propose appropriate methodologies. In each chapter of OR many procedures could be reconsidered.

3.1. Elimination

Suppose that the set A of all possible decisions is enumerated: $A : \{a_i, i = 1, 2, \ldots, n\}$. If n is such a modest-sized number that all the alternatives can be carefully analysed one by one, those which are not enough "Subjective" and not enough "Ethical" could be eliminated. A decision procedure, preferably an MCDA one, could then be developed on the remaining alternatives. It is a classical approach. Everybody according to his personal Education could apply it.

3.2. Additional constraints

Let us consider an example and suppose the decision problem is modelled by a single-criterion Linear Program.

$$\mathrm{Min}\{cx | Ax \geqslant b, x \geqslant 0\}, \tag{3.1}$$

where $x : (x_1, x_2, \ldots, x_j, \ldots, x_n)$ is a vector of $\mathbb{R}^n$, each x_j representing the level of a particular activity j.

In addition if, for Ethical reasons, it is required to limit the total pollution of the n activities to a total amount K, then the following constraint can then be added to the set of constraints:

$$a_1x_1 + a_2x_2 + \cdots a_jx_j + \cdots a_nx_n \leqslant K, \tag{3.2}$$

where a_j is the pollution caused per unit of activity j. Such additional constraints could be added for each kind of pollution. A solution can then be proposed by solving the enlarged problem.

In this case, the decision process is located on the edge of Rationality–Ethics and is obtained thanks to a single-criterion problem (Rationality of the optimal solution).

Let us observe that the Decision-maker has no freedom, except the freedom to reject the model. A better solution could be obtained by considering the left-hand side of (3.2) as a criterion, possibly together with other evaluation criteria, and by solving the associated problem by an appropriate MCDA procedure.

The paradox is that a better solution than the optimal one can then be obtained. Of course "better solution" means here: a solution more appropriate to the Real World situation and taking into account both the feelings of the Decision-maker and Ethical requests.

3.3. A particular MCDA Rationality. The PROMETHEE–GAIA procedure

Suppose the Decision-maker is submitting his Decision problem to a multicriteria evaluation including k criteria $f_j(.),\ j=1,2,\ldots,k$, and suppose the set of possible alternatives is finite and enumerated $A:\{a_i,\ i=1,2,\ldots,n\}$. An evaluation table $\{f_j(a_j),\ i=1,2,\ldots,n,\ j=1,2\ldots,k\}$ is then considered (Fig. 5). As mentioned previously it is impossible to solve a multicriteria problem without additional information.

The additional information required by the PROMETHEE–GAIA procedure consists of:

- *Information between the criteria*: weights of relative importance of each criterion

$$(w_j,\ j=1,2,\ldots,k),\qquad \left(w_j\geqslant 0\,\forall_j;\sum_{j=1}^{k}w_j=1\right).$$

- *Information within the criteria*: for each criterion a preference function $P_j(a,b)$ giving the preference of decision a with regard to decision b, as a function of the difference between the evaluations of a and b on this criterion. There is no objection to suppose $P_j(a,b)$ is an increasing function such as:

$$\begin{aligned}&d_j(a,b)=f_j(a)-f_j(b),\\&P_j(a,b)=P_j\big[d_j(a,b)\big],\\&0\leqslant P_j(a,b)\leqslant 1,\\&P_j(a,b)=0\\&\quad\text{(in case of no preference of } a \text{ over } b),\\&P_j(a,b)=1\\&\quad\text{(in case of strict preference of } a \text{ over } b).\end{aligned}\tag{3.3}$$

This additional information can easily be obtained by considering special shapes for the preference functions (Brans and Vincke, 1985).

The PROMETHEE–GAIA procedure is then based on pairwise comparisons. It is then easy to compute, for each $a\in A$, the following values:

$$\begin{aligned}\phi^+(a)&=\frac{1}{n-1}\sum_{j=1}^{k}\sum_{i=1}^{n}P_j(a,a_i)w_j,\\\phi^-(a)&=\frac{1}{n-1}\sum_{j=1}^{k}\sum_{i=1}^{n}P_j(a_i,a)w_j,\end{aligned}\tag{3.4}$$

$$\phi(a)=\phi^+(a)-\phi^-(a),$$

and if

$$\phi_j(a)=\frac{1}{n-1}\sum_{i=1}^{n}\big\{P_j(a,a_i)-P_j(a_i,a)\big\},\tag{3.5}$$

we have

$$\phi(a)=\sum_{j=1}^{k_1}\phi_j(a)w_j,\tag{3.6}$$

where $\phi^+(a)$ is the *power* of alternative a. It expresses how a outranks all the other alternatives on all criteria, the weight of each criterion being taken into account. $\phi^-(a)$ is the *weakness* of a, it expresses how a is outranked by all the other alternatives. $\phi(a)$ is the global net flow, the balance between the power and the weakness of a. The $\phi_j(a),\ j=1,2,\ldots,k$, are the single-criterion net flows calculated for each criterion separately.

The following graphical displays can then be obtained by an associated appropriate software (Mareschal and Brans, 1993).

PROMETHEE I (Fig. 6) is a partial outranking graph based on the intersection of the preorders induced by $\phi^+(.)$ and $\phi^-(.)$ on A. Two alternatives are incomparable when there is no clear consensus to declare that the one is better than the other. The proposal is fair, not forced!

PROMETHEE II (Fig. 7) provides a *new MCDA Rationality*. It gives a full ranking of all the alternatives from the best to the worst one as a function of their net flow.

The profile of alternatives is obtained by their single-criterion net flow $\phi_j(.)$ (Fig. 8). It shows on each criterion their outranking and outranked

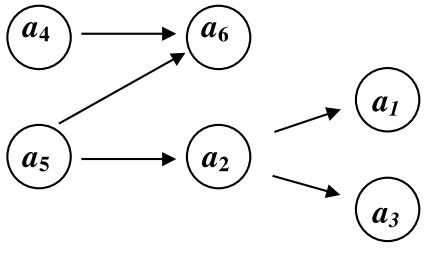

Fig. 6. PROMETHEE I: partial outranking graph.

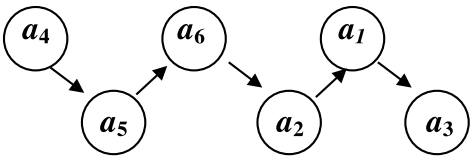

Fig. 7. PROMETHEE II ranking.

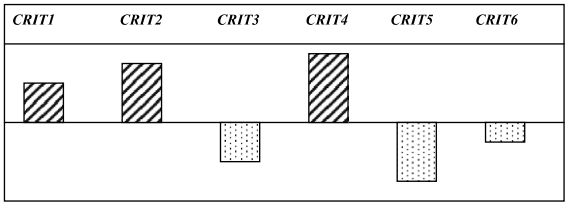

Fig. 8. Profile of an alternative.

character with regard to all other alternatives. It is a particular interesting tool when the performances of different alternatives have to be compared.

The GAIA plane displays how the alternatives are globally performing on the different criteria (Fig. 9). The criteria are represented by axes. When the criteria are oriented in the same direction they express similar preferences, when they are oriented in opposite directions they are conflicting. The GAIA plane is obtained by projection of the information included in the $(n \times k)$ matrix $\{\phi_j(a_i)\, i = 1, 2, \ldots, n,\, j = 1, 2, \ldots, k\}$ on the plane preserving the highest percentage of global information. It is obtained by Principal Components Analysis techniques. The GAIA plane also includes the projection π of the vector of the weights $\{w_j,\, j = 1, 2, \ldots, k\}$ It is easy to show that the direction π is the direction in which the Decision-maker is invited to decide. This direction is called the PROMETHEE decision axis. If the weights are modified, the positions of the alternatives and the criteria in the plane remain unchanged, but the Decision-maker is invited to decide in another direction (Fig. 10).

It is clear that the freedom of the Decision-maker is modelled by the weights. He will select the weights as a function of his personal feelings. The vector of the weights is a *Decision stick* that the Decision-maker can move according to his preferences. The GAIA plane and the decision stick are powerful visual sensitivity tools.

When the weights are fixed, the PROMETHEE II ranking is defined, and according to this MCDA rationality a "best compromise" is proposed to the Decision-maker. However it is extremely difficult to fix the value of the weights. The weights are unstable in his mind because of several hesitations, because the model is only a reduction of the Real World, because the weights could evolve over time, and because of numerous other imprecisions and uncertainties, etc. Nevertheless we have observed that the Decision-makers are usually able to provide intervals including for sure the right values of their weights.

$$w_j^- \leqslant w_j \leqslant w_j^+, \quad j = 1, 2, \ldots, k. \tag{3.7}$$

These intervals define in the space a Subjective cone including all the positions of the decision stick corresponding to the freedom and the hesi-

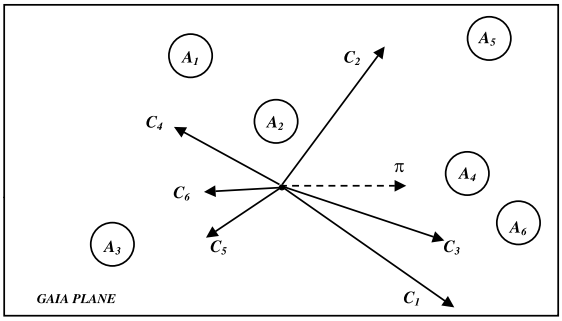

Fig. 9. The GAIA plane.

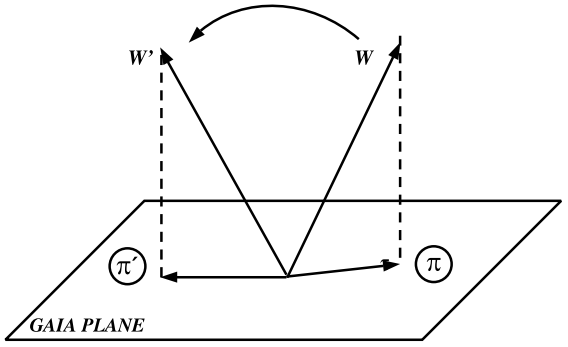

Fig. 10. Sensitivity analysis with the weights.

tations of the Decision-maker. The projection of all weight-vectors included in this cone provides the set giving all acceptable PROMETHEE decision axes in the GAIA plane. This set may be considered as a view of the *Mind of the decision-maker* with regard to his decision problem (Fig. 11) (Brans, 1996).

If the Mind of the Decision-maker includes the origin we have a hard Decision problem. The PROMETHEE decision axis can be oriented in all possible directions. It is then very difficult to conclude (Fig. 12).

On the other hand if the Mind is not including the origin the decisions located in the direction of the Mind are appropriate decisions for each feasible weight distribution. It is quite easier to decide. In case of (Fig. 13), the decisions a_3, a_6, a_5 seem appropriate, the others should be ''rejected''.

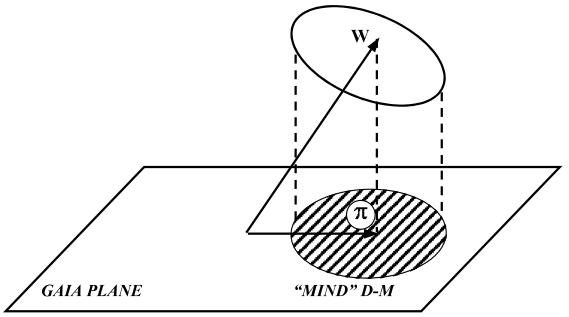

Fig. 11. ''Mind'' of the Decision-maker.

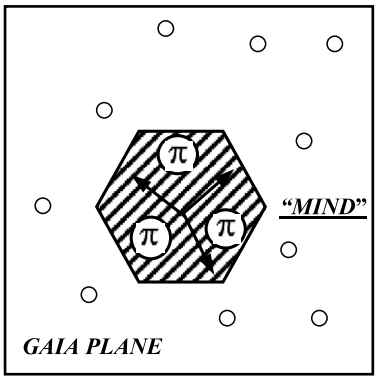

Fig. 12. Hard MCDA problem.

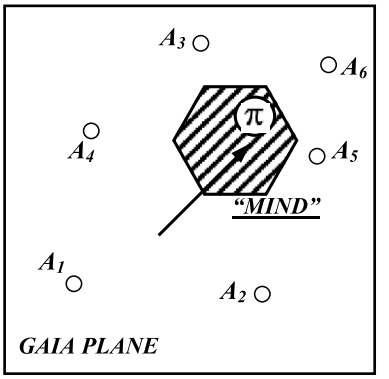

Fig. 13. Easy MCDA problem.

Because in practice a multicriteria problem includes actually good and bad solutions, the Mind is not including the origin and it is rather easy to conclude.

On the one hand this multicriteria technique allows to take the Subjectivity of the Decision-maker into account and to provide him with freedom, on the other hand it is also possible to include Ethics. Suppose that it is asked to *Independent Ethical experts* to fix the weights. There is usually no unique Ethical Behaviour. Ethics of course also offers freedom. Consequently the experts will not recommend a unique weight distribution but a cone of acceptable Ethical weights. The projection of this Ethical cone on the GAIA plane may be considered as the ''*Ethical Conscience*'' with regard to the problem. The PROMETHEE Decision axes oriented to the ''Ethical Conscience'' indicate how to decide Ethically (Fig. 14).

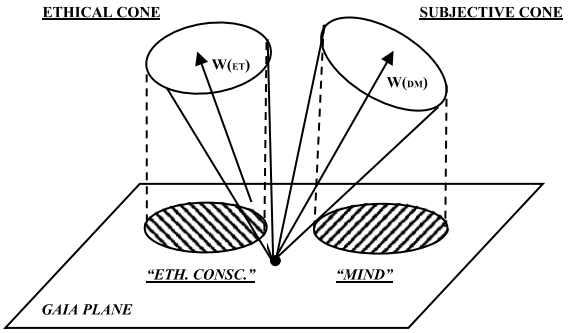

Fig. 14. Ethical and Subjective cones.

If the "Ethical Conscience" and the "Mind" of the Decision-maker intersect it is then possible to select decisions which are convenient to both the personal feelings of the Decision-maker personal and an Ethical Behaviour (Fig. 15).

On the other hand if the Ethical Conscience and the Brain of the Decision-maker have no intersection, there is a conflict and no decisions are convenient for both (Fig. 16). Any conflict resolution or Negotiation procedure can then possibly start. It is the field of Group Decision Support Systems (GDSS). The negotiations between Management and Trade Unions are examples of the opposition between the Subjectivity of the Managers and social Ethical requests of the Trade Unions. The conflicts are often solved by GDSS techniques including possible additional government moderators.

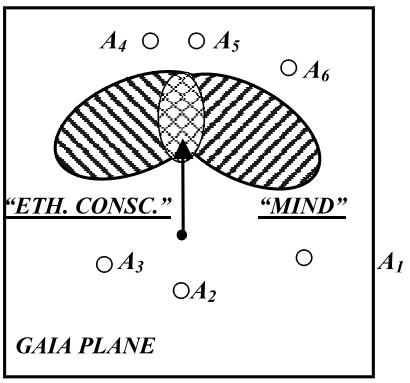

Fig. 15. Decision: possible.

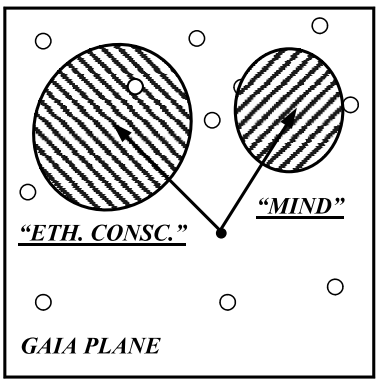

Fig. 16. Conflict.

Of course it is crucial to have the Ethical weights well defined. Who is going to fix them? What a responsibility!

A group of Independent Experts can possibly advice the Decision-makers. But this solution is expensive and only large International Organisations will be able to cover the costs. On the other hand the OR analysts in charge of the problems can by their own suggest to take into account the Ethical pole and try to convince the Decision-makers to do so (add some Ethical criteria and provide them with reasonable weights). It is a question of Education, a question of appropriate Teaching Programmes, a question of sense of Responsibilities. Let us hope that Responsible persons will dare to say "NO" when Ethically requested.

An Ethical charter for OR analysts could be set up, a kind of Hippocrates oath for scientists in the Decision field. A nice purpose for EURO?

4. Conclusion

We have tried to show in this paper that decision-making for Human Socio-Economic processes is submitted to various influences. The complexity of the problem requires to take into account qualitative approaches based on perceptions and quantitative approaches based on measurements. The quantitative approaches can be particularly useful for Decision Aid, but they should now include and combine Rational, Subjective and Ethical requests. A well-balanced decision is to be found *within* the decision triangle, all the decisions close to the extreme points should be considered as suspicious. We tried to show in this paper how OR progressively evolved from pure Rationality (optimisation problems) to Subjectivity (MCDA approaches). It is now the time to include Ethics in our methodologies. The PROMETHEE–GAIA procedures can be used for such purposes. Of course this MCDA procedure is not a final answer to the problem, it is just a particular contribution. For sure, many other procedures are possible. Henceforth, each scientist, each researcher, each consultant, each expert, each Decision-maker should try to include Ratio-

nality, Subjectivity and Ethics in his own contributions. Undoubtedly it is possible, it is a question of good will, a question of Education. It is crucial for the harmonious development of OR, for sustainable development, for the future of mankind.

Let us remember the beautiful sentence, expressed 40 years ago by A. Malraux:

LeXXI^{e} siècle sera sacré ou ne sera pas

which presently be translated as:

The next century will be Ethical or Mankind will collapse!

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