Improving Organizations by Replacing the "Mechanical" Model with the "Organic" one

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Organizations are currently viewed as artificial structures. However, in our opinion, organizations seem to match a biological structure much better. This paper explores this new approach with some interesting conclusions and results: organizations aim at perpetual existence and continuous adaptation. We advance the ideas of organizational "instincts", organizational pathology and organizational optimization using genetic algorithms. In competitive markets, organizations are in a natural selection process, which actually is part of a natural genetic algorithm. This process may be simulated in an artificial multidisciplinary optimization environment, based on minimizing a Total Costs and Risks objective function. Unlike the gradient optimization methods, the genetic algorithms may be applied to such problems with thousands of degrees of freedom. This opens the way to the organizational structure optimization through genetic algorithms.

Keywords: *organization, genetic algorithms, multidisciplinary optimization, organizational analysis, organizational structure*

Introduction

The goal of this paper is to advance a new vision on organizations, based on algorithmic modeling instead of mathematic modeling (Wolfram 2005), specifically the genetic algorithms (Holland 1975), taking advantage of the analogy between organizations and the living beings. The most complex and close to perfection structures known are the biological ones, and they were created together with the algorithms needed for a continuous adaptation to the environment, which may be extended to the organizational structures. There is an intense research for new organizational models (chaordic, ecological), and our work adds its very productive analogy, hopefully stimulating for the future organizational research.

1. The biological nature of organizations

At first glance, organizations seem artificial (human made) creations, however we would like to replace this mechanical vision with a "biologic" or natural one.

In our view, organizations are a structural form of the living world, nothing else than a network of individuals with specific objectives. There are beings which are not able to live individually, but in such networks: corals, bees, ants. The objectives of the organizations are the same as the living world: *perpetuation* (ensuring a perennial existence) and *adaptation* (optimization or maximizing adequacy to the environment conditions). Whereas in the living world, perpetuation is ensured by reproduction (1), in organizations it consists of expanding, multiplication and continuous renewal of the members of the organization without affecting it. In a bigger picture, both objectives serve to the same purpose: "the survival of the organization" (Drucker).

The first conclusion is that an organization is an entity by itself, beyond the component individuals, and we may discuss the "instincts" of organizations. The organization must not depend on its individual members to the extent of being at risk due to malfunction or disappearance of one member, not even of the leader. The leaders, who do not think their organization as surviving them, are in a conceptual error, which will develop into an organizational pathology, which we would refer to as "ephemeral organizational syndrome". This occurs at organizations with a short-term mission, with a limited time horizon (as for instance the State Property Fund in Romania). The ephemeral status contradicts the very primary instinct of each organization, the perpetuation, and may lead to

organizational dysfunctions. The ephemeral organization syndrome may be congenital (as in the case of the SPF), or acquired, in the case of an organization under threat (for instance, the current situation with Alitalia).
Our second conclusion is that organizations are genetically programmed to progress, to adapt continuously to the environment. The organization keeps those genetic traits, which bestow its force in the struggle with the environment, and in the same time modifies those genetic traits, which create vulnerability. This continuous perfection is specific to the living world (Darwin, 1859) and is achieved through the genetic algorithms, using genetic operators: mutation and crossover, under a selection mechanism, in a world of permanently competing individuals.

2. Information Streams

Starting from the analogy between an organization and a live creature, organizations should be designed to function *tolerantly to component defects* and to ensure the *organizational integrity*. The integrity in an organization represents a permanent bidirectional flow of relevant information from and to each member. The two ways of the information flow may be named as "sensory" and "motor". In an organization with an ideal integrity, any member could trigger a warning to mobilize the whole organization, and any member would put the interest of the organization above his own, when sacrifice is required. Examples of such organizations are the ants' colonies.
In principle, the integrity of the human organizations range from imperfection to the total absence, another typical organizational pathology, with the two partial variants: sensory and motor and also a generalized (compounded) one. The generalized lack of integrity is illustrated by the large majority of multinational corporations; their integrity is in inverted proportionality with their size. In our opinion, this symptom is the limitation factor, preventing corporations to grow to gigantic proportions, like the nervous impulse speed which limits the size in the animal world. In case of organizations, the evolution in the communications technology of the last decades (technology progress and the plunge of the communication costs, Gates 1995) triggered a leap in organizational integrity and facilitated the unprecedented size growth.
The sensory integrity of an organization may be tested by measuring the propagation speed and accuracy of a piece of information containing a threat for the organization, incidentally supplied to a normal member of the organization. The motor integrity may be tested by the capacity of a member to sacrifice for the benefit of the organization, by the propagation speed and accuracy of the rules, norms, commands in the mass of the organization.

3. Natural Adaptation of the Organizations

By analogy with the living world, in the world of organizations we may notice a process of slow natural adaptation to the environment using genetic algorithms. The convergence of the genetic algorithms, meaning the capacity to ensure that each generation includes better adapted individuals than previous generations, can not be mathematically demonstrated, and yet it is obvious in the living world (Darwin, 1859) and it requires five conditions:

- A "genetic code" of the organization, also known as "chromosome", which represents what, stays invariant when members change (structures, values, norms, rules, customs, standard operating procedures, beliefs, myths, decisional algorithms, methods etc.)
- The possibility of the organization to suffer "mutations" and perhaps "crossovers", not usual for rigid organization (for instance, the Catholic Church before the pontificate of Pope John Paul the Second)
- A competitive selective environment of organizations competing against each other ("selection"), which does not happen with organizations in dominant or monopolistic position (Microsoft for instance)
- The "genetic diversity" of the competing organizations, not similar and by no means identical ("cloning" is the greatest threat for

the effectiveness of the genetic algorithms, whereas management schools encourage copying successful organizational structures)

• An adaptation function ("fitness") like the objective function from the mathematical optimization; this function is ideally zero, whereas in practice we pursue its diminution; from the information entropy theory we search a chromosomal representation as close as possible to the theoretical limit of the entropy.

Like beings, organizations may suffer mutations, and at least for the economic organizations, the competition is the environment required by the selection. The acquisitions, mergers, strategic alliances, cartels etc. may be considered "crossovers" if the subsequent organization inherits from both "parents". It is important to remember that mutation and crossover operators, the selection mechanism and the genetic diversity are *sine qua non* conditions of the successful optimization through genetic algorithms.

The factors which inhibit or deteriorate the natural adaptation of the organizations are contributing de facto to their degeneration or decay. Unfortunately, due to the dynamics of the environment, there is no neutrality level between optimization (closing the gap from an ideal) and degeneration (widening the gap). If a "neutral" organization attempts a constant environment adaptation level whereas the other competing organization are in an optimization process, the "neutral" organization will degenerate due to the new competitive environment made of all other better adapted organizations.

If we adopt this ecological analogy, we may notice some consequences in the current trends:

• The economic globalization inhibits the natural adaptation of organizations by downsizing the genetic diversity, which will result in a reduced capacity of the global organizations to adapt to the environment in the future;

• The organizational "cloning" encouraged by many management schools contradicts the natural adaptation of the organizations, with catastrophic long term effects (organizational degeneration);

• The mergers and acquisitions between very similar organizations may also have an adaptation inhibitor effect in long term, like in the living world the crossover between close relatives lead to degeneration.

Thus, the natural adaptation of the organizations is threatened by economic globalization, and any other factor against the genetic diversity. A similar degeneration is to be found in dominant or monopolistic organizations. The symptom of degeneration is the increasing gap between the members and the goals of the organization, the offset between the individual and common interests, the alienation, decay of the financial performance, and ultimately the lower surviving probability of the organization.

The natural adaptation process is slow, long and very long term, and consequently may not be put to immediate practical use, however we can accelerate it by implementing genetic algorithms in a simulated environment for the multidisciplinary optimization of organizations, which is presented further.

4. The Multidisciplinary Optimization of Organizations

The genetic algorithms, also known as EMO (Evolutionary Multi-Criterion Optimizations) are inspired by the environment adaptation methods of animal and plant species. In 1975, John Henry Holland of the University of Michigan extended the scope of the genetic algorithms to artificial systems, opening the way to the large sized multidisciplinary optimizations (Holland, 1975).

Between the real and the imaginary worlds, there is a third party, the virtual world, made possible by the computer science. In the manufacturing and services life cycle, simulations play an increasing role. They have to answer the question: what happens if we take this action?

The simulator is an extension of the central neural system, at the executive level. Its purpose is to measure vectors of quantitative or quantitatively-encoded qualitative indicators for all managerial levels and organizational areas, which reflect the response to the external stimuli. These exterior stimuli are indistinct, with a vague boundary, difficult to measure, and affected by noise in the sense of the communication theory. Under these circumstances, the only certified algorithms are a class of heuristic ones called genetic, which may cover a wide area of data (multidisciplinary) and pursue the calculus of an adaptation function ("fitness"), which allows to add or to multiply the action of the influencing factors.

The implementation of the genetic algorithms in the virtual world is rather recent (Holland 1975), but has a considerable impact in many fields (Moldoveanu, Pleter, 2006). The genetic algorithms applied in a simulation environment allow a multidisciplinary optimization, and this calculus may be applied to organizations. Thus, the natural adaptation of organizations may be accelerated, leading to practical applications of organizational improvement with immediate effects. This method could be viewed as an organizational genetic engineering.

The genetic algorithms have several major advantages in organizational analysis:

- Work on non-linear models, which corresponds to the reality of organizations, where 80/20 type laws (2) are generalized, demonstrating the non-linear behavior of the problems in this particular sector
- Are heuristic (stochastic), which make them applicable on very complex models like the genome of a being, or likewise the "organizational genome", where the complete search is ineffective (3)
- Work with qualitative measures, under singularity and indetermination conditions in points and whole areas in the space of the solutions.

5. The Total Costs and Risks Criterion

The multidisciplinary optimization relies on finding the global minimum of a cost function, aggregated from elementary cost functions. Each elementary cost function is the representation of the optimization objectives of a discipline (criterion, aspect, and field). The elementary cost functions should be additive or multiplicative, which holds if they are expressed in the same currency unit, a natural unit for cost functions. The metric coherence is important and therefore we do not recommend the adimensionalization of the elementary cost functions. These functions are naturally non-linear, and constraints may be conveniently introduced as penalizing costs (using a method presented below, similar to the Lagrange multipliers).

The additivity of the elementary cost functions allow the aggregation of multiple criteria in a multicriterial cost function, and also aggregating the subsystems objectives into a whole system optimization function. This is particularly relevant for complex structures, like organizations.

To illustrate the issue with the total costs and risks function (TCR), let us consider an example of optimizing the investment in an office building. It becomes obvious that the least costly solution for the heating, ventilation and air conditioning (HVAC) system is the most risky one. This observation is generally valid for economic problems, where the most profitable solutions prove also the most risky (this is known as the second fundamental principle of finance - Brealey, Myers, 1996).

There are two possible ways to avoid this trap. The first one is imposing constraints to keep the solution within acceptable risk limits. For instance, we may define a minimum MTBF requirement for the HVAC system.

The second method is to include risks in the objective functions, expressed in the same currency units, as the value of the damage multiplied by the probability of occurrence. This way to express risks is often used in the financial management (Brealey, Myers, 1996). The constraints method proves artificial and in some cases unstable (small variations in constraints lead to great variations in the solution). Moreover, the constraints affect the overall derivability of the objective function, with a negative impact on implementing with all derivative-based optimization methods.

6. The Rational Biological Model

The "mechanical model", based on the linear evolution of the socio-economic phenomena, powered continuously by the organizational motor shaft, or the unique decisional center, represent a conception in need for replacement, because the conclusions of the organizational and managerial analysis may be wrong, ineffective of inefficient. For instance, current managers promote and rely on "tree"-type organizational structures, focusing on components, data accuracy, using linear (proportional) cause-effect relationship, using a discipline-oriented vision, all of this in a static thinking model (Brătianu, 2006a). The generality of 80/20 type laws (2) illustrate in fact the deep non-linear nature of the economic and social processes. The classic scientific management (Taylor) and the administrative theories (Fayol) rely on hierarchy or pyramidal organization lead by a single leader (the unity of direction principle, Fayol) and a rigid tree member structure (the centralization, line of authority and order principles, Fayol), each on a certain hierarchy level, with a single superior (the unity of command principle, Fayol). The subordination relationship is the fundamental link in a hierarchy organization (the authority and discipline principles, Fayol).

The hierarchy organization generates bureaucracy and is considered too rigid to be adaptable. Max Weber said that in a hierarchy organization the authority is transmitted through channels requiring rationality, belief in the integrity of processes at all hierarchy levels. These features lead to a deep experience curve and to inertia in organizational formation or reform. The rigidity ensures the rapid transmission of the leader's will in the entire organization, which is an advantage if the leader has integrity, is intelligent and has a remarkable vision. Unfortunately, history proves that such leaders are in short supply, and subsequently the advantage of rigidity is not effective. On the other hand, the rigidity of the organizational structure poses some threats, especially with a structural node defection, which may lead to the dysfunctionality of the entire substructure. Another danger is represented by the incapacity to damp the major perturbations, so common to a turbulent environment, and subsequently the exposure of the organization to excessive loads in turbulent conditions.

The premises of a new organizational theory are triggered by a new pattern of the organizational environment, characterized by high turbulence, ferocious competition, offensive clients, but also limited resources, the annihilation of resource waste (JIT), ecology etc.

These circumstantiate the formulation of the "organizations survivability" (P. Drucker) and there is an emergence of the embryos of the biological or neural model, with priority given to the flow instead of the state as in previous Taylorian, *staff and line* or even matrix models (figure 1). Now, there are values such as: the interaction between all organizational elements, between the organization as entity and the environment, the causality is "circular", the perception is global and the vision is multidisciplinary.

The time in the biological model is non-linear. The organizational life cycle in its stages (birth or emergence, transformations, liquidation or death) may be analyzed at a "dilating" or "contracting" time scale.

The next step to the biologic (neural) model is the rational biologic one, where survivability comes from the best adaptation to the environment, which is essential to both the current and the future organization. The gradual transition to the new model, considering the environment, may be done by reconsidering all managerial functions.

The structural subsystem (bone system) shows the features of the organic one, characterized by flexibility, top-down coordination (central neural system) and free way of action in the down area (specialists, direct execution workers etc.), the shortest interaction routes, parallel actions etc.

The structure configuration is "flat" instead of "tall", requiring a low number of hierarchy levels, accents on each neural center featuring polyvalence, innovation and action.

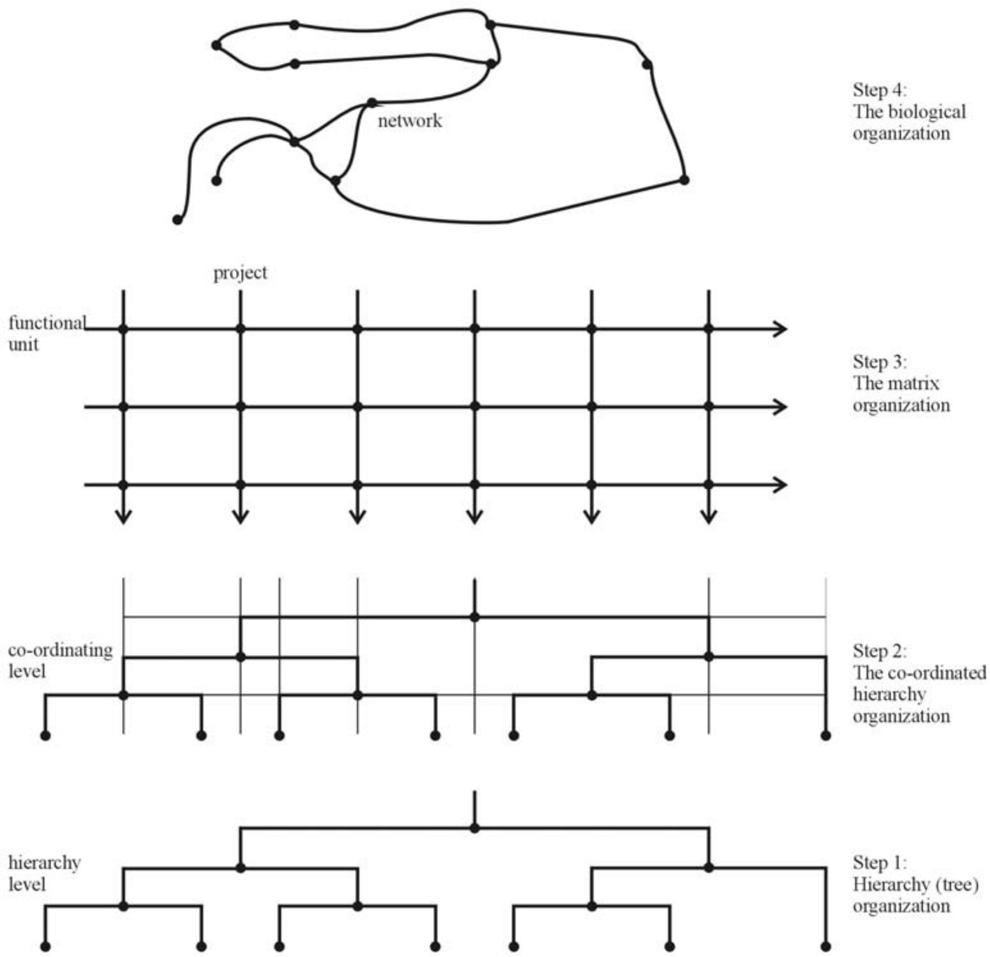

Fig.1. The Evolution of the Organizational Structures

Although the information subsystem supports the other subsystems, it is "created and developed" with respect to them, and primarily to the decisional one. The particular features of the new information component are:

i) The extension of the horizontal information flows, which ensures the process consistency instead of the action segments, at the level of the operations centers. These add to the value creation for the stakeholders (clients, consumers etc.);

ii) Keeping the vertical and diagonal flows, just as an exception for feedback and multiple reactions;

iii) The layout of all the information flows as "impulses" related to the system (body) objectives. Thus, "information networks" are created, which guarantee the body functionality all the way "top-down" or "central zone - peripheral zone" (figure 2).

The modules may be relatively autonomous (*small is beautiful*). The interactions are permanent inside the body (organization), but also between organization and the environment. In this context, there is an essential role for the internal processing and the relationship between the inputs and outputs. A body (organization) is a component cell of the mega environment. The boundaries between the components are vague.

The orientation towards order of the organization, considered as a biologic body, is traded off by the natural propensity for disorder, of the information entropy theory. The key issue is the system balance between "stability", rigidity and turbulence, which favors creativity and innovation from the members of the organization and sustains adaptability under complex conditions (4).

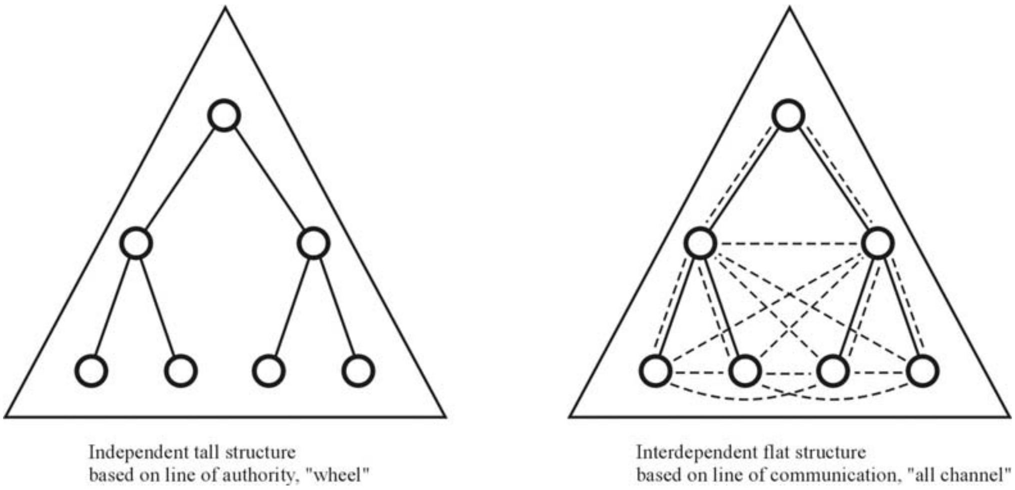

Fig.2. The structure of the rational biological model (on the right) compared with the classic hierarchy structure (on the left)

The above mentioned processes are run by neural networks (information networks). The local LANs (Local Area Networks) are developing into global WANs (Wide Area Networks). Also the decreasing efficiency law gets accomplished by the increasing efficiency law. The "positive" retroactive actions add to the "negative" ones, the feedback characteristic to the biology, and the circulatory system is engaged permanently.

New accents and changes will be noticed with the methodology subsystem in the context of these new types of organizations. For instance, the management by objectives (MBO) has to stress practically both stages:

a) The derivation of objectives in the entire scope between the fundamental and the individual objectives;

b) Harmonization of the objectives with all types of resources by distributive negotiation, in particular the integrating one.

The second stage may be run efficiently only in the framework of the presented model (the biologic, neural one). Moreover, the frequently cited MBO method requires for implementation four conditions, formulated by P. Drucker (5), which are fulfilled by this model.

As for the management by exceptions (MBE), what is essential for the current context of the organizations? At an in-depth analysis, the answer consists of lowering the control to the "peripheral neural" operation centers, without eliminating the "central headquarters" control as an exception. This condition is fulfilled, supported continuously by a neural system.

The examples may continue with all "mechanisms" of the methodology subsystem.

The decisional subsystem overlaid at the central zone neurons of the organization, which guard permanently, could be developed by using genetic algorithms within a multidisciplinary optimization framework.

All processes mentioned above require a background typical to the organizational excellence (6) as a top element of organizational culture, which identifies a powerful, positive culture, based on a net of its components (axioms, values, norms, beliefs etc.).

Conclusions

The paper advances a prolific analogy of the organizations with the living world. From this perspective, the paper explores to what extent the genetic algorithms may be adapted naturally or implemented in simulation environments to optimize organizations, known that the genetic algorithms ensure perpetuation and adaptation (finally the survival) in the living world. Out of the preliminary results, we might shape several elements of an organizational model named "rational biologic", which is structurally more adaptable.

In the organizational design we try to create a *fault tolerant* system with an important feature: the *integrity*, trying to avoid the various forms of *organizational pathology*.

The size of organizations is limited by the sensory and motor integrity criterion. This ensures the cost effective and prompt communication, and also quick and effective reactions. The plunge of the communication costs facilitated the organizational trend to reach gigantic proportions, but the resulted economic globalization leads to the organizational degeneration, by reducing the genetic diversity. Similar degenerating factors are the organizational "cloning" encouraged by most management schools, as well as the mergers and acquisitions between similar organizations. All these conclusions validate the biologic model of organizations and signal new possible ways in the organizational analysis. Also, the organizational design may benefit from multidisciplinary optimizations with genetic algorithms, implemented in simulation environments, using the total costs and risks criterion (TCR).

Explanatory Notes

(1) There are the "conservation" and the "reproduction" instincts, but we consider the conservation instinct as a component of the reproduction one.
(2) Pareto analysis type laws (80% of the problems are generated by only 20% of the causes) or the Augustine laws (Augustine, 1997)
(3) The classical determinist methods based on gradient have a calculus complexity of N! order, which prevents their application for living beings. For instance, the human genome consists of approximately 40,000 relevant genes, and the optimization problem has the same number of independent variables (degrees of freedom), with a computational effort in a simulation environment to the order of $40{,}000! = 2.09\times10^{166713}$. Consequently, the genetic algorithms stochastic optimization remains the only applicable at this level.
(4) For instance, the human being (the organization) at the limits of chaos invents, is creative and grows
(5) The subordinates are enough independent in their operational area to deal with superiors (a unique base of power action, all are taking risks, superiors in delegating power, subordinates in accepting responsibilities, subordinates are free to demonstrate what they can do, an increased degree of individualism, all parties consider performance as important (an increased degree of masculinity) and therefore a low degree of incertitude avoidance.
(6) See the eight attributes if excellent companies (Peters, Waterman 1982) such as the involvement of the executive in all problems, simple structure, harmonization of the central values with the individual ones etc.

References

Augustine, N. R. (1997) "Augustine's Laws", Sixth Edition, *American Institute of Aeronautics and Astronautics*, Reston, VA
Brătianu, C. (2006a) "Un model de analiză a capitalului intelectual organizaţional", *Management & Marketing*, Anul I, Nr. 3
Brătianu, C. (2006b) "In Search of Intelligent Organizations", *Management & Marketing*, Anul I, Nr. 4
Brealey, R. A, Myers, S. C. (1996) "Principles of Corporate Finance", 5th Edition, *McGraw-Hill Companies*, New York, NY
Brown, A. (1995) "Organisational Culture", *Pitman*, London
Buchanan, D, Huczynski, A. (1997) "Organizational Behaviour", 3rd Edition, *Prentice-Hall*, London
Darwin, C. (1859) "On the Origin of Species by Means of Natural Selection" (http://www.talkorigins.org/faqs/origin.html)
Darwin, C. (1871) " The Descent of Man, and Selection in Relation to Sex" (http://www.zoo.uib.no/classics/descent.html)
Gates, B. (1995) "The Road Ahead", *Viking-Penguin*, London
Hesselbein, F, Goldsmith, M, Beckhard, R. - (editors) (1997) "The Organization of the Future", *Peter Drucker Foundation*
Holland (1975) „Adaptation in Natural and Artificial System" *University of Michigan*
Moldoveanu, G. (2000) "Analiza organizaţională", *Editura Economică*, Bucureşti
Moldoveanu, G, Pleter, O. T. (2006) " Optimizarea multidisciplinară în managementul serviciilor", *Simpozionul "Abordări moderne în managementul şi economia organizaţiei"*, Academia de Studii Economice, Bucureşti
Moldoveanu, G, Pleter, O. T. (2004) "Capabilitate vs. Performanţă Managerială", *Simpozionul Internaţional "Management şi Competitivitate"*, Academia de Studii Economice, Bucureşti
Nicolescu, O, Plumb, I, Pricop, M, Vasilescu, I, Verboncu, I. (coordonatori) (2003) "Abordări moderne în managementul şi economia organizaţiei", Vol. 1-4, *Editura Economică*, Bucureşti
Nicolescu, O, Verboncu, I. (2001) "Metodologii manageriale", *Editor Tribuna Economică*, Bucureşti
Peters, T, Waterman, R. H. (1982) "In Search of Excellence", *Harper & Row*, New York
Pleter, O. T. (2004) ""Optimizarea numerică simultană în managementul zborului şi al traficului aerian", teză de doctorat, *Universitatea Politehnica din Bucureşti, Facultatea de Inginerie Aerospaţială*
Pleter, O. T, Ştefănescu, I. B, Constantinescu, C. E. (2006) "Simultaneous 4D Trajectory Optimization Using Genetic Algorithms", *Proceedings of ICNPAA*, Budapest
Wolfram, S. (2002) "A New Kind of Science", *Wolfram Media*, Champaign, IL