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*V.A. Kasianov, Dr, A.V. Goncharenko, Dr*
*(National Aviation University, Ukraine)*

# Subjective analysis theory application to the transport system management optimization in conditions of available alternatives preferences uncertainty

**Abstract:** *Application of the described approach allows formulating and solving the main problems of the transport system management optimization, including conflict management, in conditions of available alternatives preferences uncertainty. These are the problems of the conflicts forecasting, diagnostics, the conflicts induction and damping, control of transitions from one kind into another, required resources assessment for control of conflicts.*

**Keywords: subjective analysis; entropy paradigm; subjective preference; subjective entropy; transport system; management; optimization; uncertainty; active system.**

## Development of the theory

The presented paper is devoted to the application of the entropy methods to the transport systems management optimization theory. The management is realized in conditions of multi-alternativeness, which makes the systems' operational situations uncertain with respect to the managers' preferences distributions upon the sets of available alternatives.

The measure of the subjective preferences functions distribution uncertainty is the entropy.

Entropy and variational approaches are very popular in science [1-3]. **Subjective Entropy Maximum Principle (SEMP)** was proposed in [4-7], in the analogous to the *Jaynes'* principle [8, 9] way, in order to describe quantitatively the processes occurring in the human psych. Subjective entropy is a very convenient measure of the psychological situation uncertainty. Subjective entropy equals zero in the case when only one alternative is chosen; and it reaches its maximum value if all alternatives have the same preferences from the point of view of the subject.

As to the genesis of the principle SEMP a few moments need highlighting. The cornerstone of the principle is a supposition that human's psych works in an optimal, in a certain sense, way in any multi-alternative situation. It was proposed to use the *Jaynes'* formalism, developed for the field of physical problems in the middle of the last century [8, 9], as a mathematical envelope of this psychological principle. In order to apply this formalism to the psych processes, it was necessary to introduce preferences of the first and second kinds. The preferences resemble probabilities, however they are not them. It was introduced the definitions of what the subjective entropy is as well as the subjective information.

Genesis of such a property of human's psych is not absolutely clear. Nevertheless, if we stay on the evolutionary position we have to acknowledge that history of evolution had a sequence of some sort of jump changes and periods of slow changes. In this case, we hope to explain what the reason of the entropy maximum principle is.

Besides introducing the preferences, it was proposed the so-called psych temperatures and the scheme of a non-uniformity of the entropy space.

The main topic of the presented paper is one of the examples of the mentioned principle application.

It has occurred that this principle has a very wide area of applications in different directions. Here we would like to overview the most important and obvious directions. We will describe a sense of such a direction and possible ways of corresponding solutions. The principle itself is described in the simplest form in the monographs [4-7, 10-15].

Talking about the principle's genesis it is indispensable to note (mention, point out) its major origins.

In fact, there were two main of them. These are the *Jaynes'* principle [8, 9] from statistical mechanics, and works in the field of information theory. In works [4-7] there was an implementation of the *Jaynes'* principle into the sphere of psychology.

Later on, the **Entropy Paradigm** adopted from the publications of the predecessors revolutionized imaginations about human's (subject's, individual's) activity in any sorts of systems. Thus, there appeared **Subjective Analysis** [4-7], **Subjective Entropy Maximum Principle** [6], application to the active systems theory [7], and a few applicable branches [10-237].

The principal conceptual framework of the discussed in the presented paper approach was developed to a level of scientific theory in a series of the main previous publications [4-7].

Now it looks like the principle deals with the economy, psychology, sociology, politics, education, medicine, of course engineering, safety issues, conflicts of any types etc.; wherever a subject's preferences have a crucial importance and play significant role [1-279]. Figuratively speaking we see the main practical value of the theory in the vast majority of the scientific disciplines; however the presented paper is dedicated to the transport system management optimization theory concern which is considered hereinafter.

A few more words about initial cornerstones of the theory. In this introducing Section we just mark the main moments of the concept. First of all, we were forced to introduce two kinds of preferences: object preferences and rating preferences. The principle and its different variants were introduced in monographs [4-7] and a lot of other publications and papers [10-237], but the main notions of the theory are the preferences of the two kinds.

Object preferences are determined on the set of material or information objects (stuff). And, a subject relating to this is supposed to be able to make a choice on the set.

Rating preferences are determined on the group of some subjects; and it is supposed that somebody could make a choice of one or several subjects from the group. As a particular case, it could be set a problem of a group leader choice. Then, it has been introduced the so-called *mutual utility*. This theory has a lot of common properties with the generally accepted *utility theory*, but at the same time the proposed theory has several essential differences from it.

Mutual utility theory is the basement of aggregation of preferences in a social group. The utility transfer from one subject to other subjects could lead to the change

of the available utility of the given subject. For example, if it is going about a transfer of some financial utility, then the transfer could lead to the change of the value of the available utility. Otherwise, if it going about, for instance, a scientific or political or economical knowledge, then such a utility could remain unchangeable for the delivering subject.

Mutual utility could be considered as a possibility of the given subject to give her/his own utility to some political party in the course of an election campaign. These contemplations are incomplete (not full). However, the notion of mutual utility gives a possibility to arrange some schemes of preferences aggregations. The sense of our maximum principle differs from the well-known *Jaynes'* principle [8, 9], with the circumstance that in our form it contains subjective entropies [4-7, 10-237].

**The scientific fields of the principle possible applications**

Let us consider some particular directions of the proposed principle applications.

**Economics**

If there are several alternative ways of economical development, there could be an object of the subjective choice by someone who is a participant of the economical game. One of the examples of such a choice is given in monographs [10, 11, 13-15].

An obvious area of the theory application is the economical crisis theory, dynamics of economical development, money theory and so on. Calculations for supply and demand are given in the monograph [5]. Corresponding dependencies are found theoretically basing on the principle. It is proposed the so-called theory of *"living points"*.

In the general case subjective information has been introduced as a difference between two entropies: unconditional and conditional after some events happened. It is shown how to calculate the cost of the subjective information and how it could be used in economical calculations.

**Crisis theory**

In some sense, "crises" and "conflicts" are the synonymous notions with respect to particular problem specifics.

This theory is also an object for subjective entropy maximum principle. A crisis is considered as an interaction of some different distributions of preferences. One of the main suppositions of the theory at all is the statement that all preferences distributions have their own determined carriers. In addition to this supposition, there are following ones: entropy spaces are not uniformed; they are divided with some borders which we name *"entropy thresholds"*. One of such a threshold has following property: if the corresponding subjective entropy is higher than the level of the threshold, the subject is not able to make a solution, to choose an alternative, because he/she hardly distinguishes the differences between the alternatives. If entropy crosses the threshold *from top to bottom (downwards)*, a solution could be made. This condition is a necessary condition of a decision making.

It is supposed as well an existence of a certain very low subjective entropy threshold. We name the threshold a zombie level. No one has resources to get back out from that area.

It has been proposed some entropy cards to illustrate a crisis development. In addition to the subjective entropy, subjective risk has been introduced. Simultaneous study of the entropy and risk allows discussing a crisis development in any case.

We distinguish *"cold"* and *"hot"* crises. Also, there are inner crises and inter-subjects' crises. One of the problems is a crisis between groups of subjects, particularly between one subject and a group. In such sense, a crisis can be considered to be a conflict in the conflict's any kind manifestation.

**Safety of active systems**

One of the directions tightly connected with the crisis theory could be named a problem of *"safety of active systems"*. Here it could be given some definitions of this topic. Firstly, we have to determine the levels of safety, like it is done in the problem in the aviation safety. Let us remind here that it is introduced five types of states: *"normal"*, *"complicated"*, *"dangerous"*, *"damage without casualties"*, and *"crash"* – *"damage with casualties"*. In ICAO documents there are two kinds of events distinguished: *"incident"* and *"accident"*.

Applicably, in general sense, to general active systems, in particular to aviation systems, we have to determine:

1.What are active systems? There are several definitions of an active system. For example, *Burkov* and his collaborators (*Novikov*, *Petrakov* et al.) [238-244].

We are going to get a position that all systems, in activity of which there is someone who can make a decision in a multi-alternative situation, are active systems. In our living activities we deal exclusively and only with active systems, whatever and whenever we do. It gives us a right to see the theory we discussed as a quite general approach.

In particular problems investigations, we use all tools about which we have already told. A set of alternatives, distribution of individual preferences of the two kinds, subjective entropies (corresponding with the object, rating preferences, and aggregated preferences), functionals of problems we need to maximize, entropy bars or thresholds, subjective risks (*Bayes'* type) and the critical levels for the risks are introduced and developed in the models of investigations [4-7, 10-15].

Notions of information and entropy death were also introduced in [5].

2.It was developed a *Hybrid Theory* connecting *Subjective Entropy Paradigm* [5] (*Subjective Analysis*) and *Kolmogorov's* model of *Markovian* stochastic process. In these models it has been used a so-called cognitive function which is connected with the subjective risk and the models of subjective probabilities [245, 7].

As a particular case, a hybrid theory of models of mass service systems theory has also been developed.

The developed theory has been applied to the investigations of several very complicated aviation events (crash of Il-62 in Sheremetevo, incident of Il-86 in Simferopol, crash of Polish Government Tu-154 by Smolensk and so on).

It was investigated the probability of wrong decisions made by two or three persons (cockpit crew).

**Social events (information wars, psychological wars)**

A lot of social events could be described in terms and methods of the *Entropy Paradigm Analysis* [4-7, 10-15], which opens new possibilities to see, understand, and forecast what is happening in social groups of different kinds.

Here, we again take the supposition about a carrier of the preferences but in addition, we consider some model of a collective intelligence, which is supposed to have its own individual carrier. All factors and psychic processes studied in the subjective analysis are supposed to belong to the individual carrier's psych.

In order the principle of the individual carrier be strongly fulfilled, we must suppose the existence of the information exchange between the subjects. As a result, the reflection of the other interacting subjects' preferences distributions appears in each subject's psych. Thus, formally, the inter-subject conflicts could be theoretically represented as a set of the inner-subject conflicts.

One large section of the *Social Entropy Analysis* is an entropy theory of a crowd behavior. Investigations in this direction are at the very beginning at the moment. One of the essential problems is a problem of emergence of the leader of a group.

In this general social system dynamics, we are interested in the following question: *"Could the subjective entropy of an isolated (in material and informative resources) system decrease?"*

We found some examples when such development is realized. Nevertheless, it could be said that the system is not absolutely isolated from its states memory in time. *"Today's"* distributions depend upon *"Yesterday's"* distributions and influence *"Tomorrow's"* ones.

We could forecast what will happen to an isolated group if it is *isolated* for some time.

These effects depend upon the so-called *Psychological Temperatures* that appear in distributions of subjects' preferences and rating preferences. In the case of rating preferences, this temperature is called the *Social Temperature*. The level of such a temperature determines the state of the social group. For example, high social temperature corresponds to the *Social Hysteria*.

Here we consider different kinds of the social conflicts (crises). For instance, we are interested in how an inner conflict turns into a social one and backwards.

**Application to educational problems**

The presented theory is rather productive in applications to higher education problems. Here, we have relations between professors and students.

Another problem arising at teaching and studying process is a permanent overdoing of the relating documentation.

Modifications of educational curricula and programs are usually made under the influence of the responsible persons who elaborate and develop the changes to the educational documents (thus, their preferences play some important and sometimes crucial role in the academician system of education).

Furthermore, the system is functioning in a cyclic style and that pertains not only with a daily routine lectures, practical and laboratory classes, seminars, and sessions. But, it also touches the problems of every semester examination periods, practical trainings, year-to-year grade transferring, yearly graduation from the university, as well as the regular university's joining campaign. All these processes of the short-, medium-, and long-term prospects are accompanied with subjective preferences distributions and, not seldom, with different collisions of the subjective preferences distributions of the participants of the processes.

In order to resolve the troubles that may appear, the ministry, rectorate, directorates, and managing staffs try to elaborate normative documents (statute, provisions, rules, regulations, directives, orders etc.) helping in this.

An accumulation of the corresponding information, its processing, and generated reflective influences have unambiguous and definite features of a managing or governing process elements (likewise in a controlled process in engineering systems of control) with a feedback, subjective preferences being determining factors at every even the smallest portion of the process and each just the tiniest piece of that.

Influence of students it is a separate theme of the research that has to be conducted through the prism of subjective analysis and at the angle of the subjective preferences entropy maximum principle. The point is that the students' influence gradually becomes more and more significant and it can be both positive (stimulating) and negative (degrading) in the sense of their intelligence evolution. That is the problem.

The closely adjacent problems are certain problems of relations between either the students within their academic groups, inter-groups, intercourses or the students and professors. In any case they are people and people interact via their individual preferences distributions.

Professor's and Student's distributions of their own subjective individual preferences can have a form of a unison (agreement, harmony) when the process of the academic knowledge propagation by the Professor and perception and digestion by the Student goes more active, faster, and more effectively or the subjective preferences distributions may have a form of a dissonance (disagreement, disharmony, conflict) as a result we may observe a collision leading to a poor effects of educational endeavors. All in all, it even may result in a crisis between the Professor and the Student, which, surely, much better to prevent than uselessly strive to resolve afterwards if it has already happened.

The numerous examples of the presented in the monograph theory we can prolong endlessly. We would rather publish a separate book in regards with the remarkable educational applications of the principle. Herein we are going just to list briefly the principal types of possible applications.

The idea of module structure of educational process was proposed a few decades ago. It was introduced the notions of effectiveness and qualities of a deductive (an educational) module and corresponding numerical measures of the effectiveness and qualities. At the same time it was introduced the so-called deductive invariants.

The deductive invariants and modules suggested to represent the educational process were considered as some principal bricks in the whole structures of the educational planning.

Another kinds of the problems with subjective preferences in education are a dynamical class of problems involving taking into a consideration the issues connected with forgetting the studied information and transformations of preferences in time, as well as a statistical class of problems dealing with the estimations of the canonical preferences distributions parameters and solving the arisen problems in the stochastic settings.

The investigation of the students' preferences distributions, with respect to the different questions of the educational process, is one of the simplest and achievable

ways of the subjective analysis laws verification. In such investigations, there is no need of the special kind equipment. The presence of the a-priory preferences distributions gives us the possibility to construct the schemes of the corresponding stochastic measures.

This approach is tightly connected to the idea of the problematical education. It sounds like a proposition of a set of alternatives to the students, out of which he/she has to make a choice of some of them.

**Application to medicine (and engineering) for strategies of diagnostics**

It is a typical problem of subjective analysis and theory of entropy methods. Generally, the object of studying is considered from the point of view of the entropy paradigm. Of course, we have to choose not only the right diagnosis (as a solution), but also to select the correct strategy for a cure from the available ones.

First problem is the correct diagnosis and second is and appropriate treatment with a suitable remedy / medicine or a proper surgery.

Risk is higher the higher probability of a wrong decision (strategy of treatment, cure) is. Healing effects are under the threat of the wrongness of the doctor's individual (subjective) preferences.

There is a very close analogy (similarity) in medical diagnosing and engineering objects maintenance. We can see here a clear role of the alternatives number at the engineer's (or doctor's, if we talk about medicine) disposal. All developed provisions of the subjective analysis theory could be successfully used in the field of both medical and engineering diagnosing.

The results of the theoretical research would help take into account the diagnostics parameters (such as temperatures, for example) in combinations within corresponding effectiveness functions in order to obtain subjective preferences in an explicit view.

In the process of engineering (medical) diagnosing, the problem of a diagnosis choice out of several alternatives is usually resolved. Then, it is chosen an alternative strategy for restoration (remedy).

All these systems are active; and, apparently, the developed method based upon the principle of the subjective entropy maximum is perspective in the areas.

**Application in engineering operation**

One of the main possible implementations of the principle is to an operation of active transport systems in conditions of multi-alternativeness and uncertainty, likewise in the second co-author's Manuscript of the Dissertation and its Author's Summary.

Theoretical indexes of subjective preferences certainty / uncertainty were developed, which on the opposite of the traditional entropy show the individual preferences directions as well as they are more convenient tools for research and measures of the preferences certainty / uncertainty through their relative values and the sign of the certainty / uncertainty inclination.

Generalized models that reflect the principle dependence between individual preferences of subjects, who are the active elements of the operational control systems, and objective functions of effectiveness and safety in cases of discrete and continuous alternatives were developed.

Complex technical-economical-social criteria of transportation means operation and repair control, which take into consideration the existed multi-alternativeness and possible conflictability of operational situations explicitly, were developed.

When one deals with a process of operation, object of operation, the one conditionally extremizes the one's subjective entropy either consciously or subconsciously. Then, the proposed in the subjective analysis theory mathematical model explicitly yielding individual preferences may be used. Problems of flight safety optimization can be solved with the use of the principle as well [16-237]. In order to obtain the extremals of a variational problem one can apply the principle.

**Application developed herein**

In the presented paper, the attention is centered upon the theory provisions ensuring any types of transport system management optimal conflicts description in terms of the entropy paradigm [13-15]. The uncertainty is modeled in a few simplified illustrative problem settings likewise [130, 137, 141, 142, 144].

The hypothesis of an individual carrier is also justified when a model of the collective intelligence is considered. In that case, it is assumed that a fictive subject, introduced into the system as an additional active factor [5-7], exists.

In the given work, we use variational principles in applications to the solution of the managing and control problems in active systems, activating an entropy paradigm and postulate of optimality, which found a reflection and could be implemented in works of [1-252].

In the given work, as well as in [1-252], tightly adjacent to them other publications, the approach to the solution of the problems (including and conflicts, economical) of managing and control the active systems supplements the theory of subjective probability [245, p. 86], originating form works [253], also [11, p. 46]: " by *Frank Ramsay*, *Bruno de Finetti*, *Leonard Savage* and others, widening possibilities of the expected utility theory up to … ", cases taking into consideration utility functions. [11, p. 46]: "At the same time, previously, in economics, it was generally supposed that humans behave as rational agents, and, thus, the theory of the expected utility also moved forward the theory of the real human behavioral making decisions at risk. The work by *Maurice Alle* and *Daniel Elsberg* showed that it was not so obvious.".

In the direction of preferences taking into account, there were already attempts of their verbal formulations made. Examples, about a player preferring a more trustworthy winning, and an ordinary United States citizen preferring become president [245, p. 80], at introducing into consideration subjective probabilities, are in concordance with our examples, represented at the explanation of the difference between probabilities and preferences in our understanding. Such difficulties arise at the degree of trustworthiness estimation for events, which according to *Ramsay* (1926) are not ethically neutral.

In the given case, a postulated in this and in [4-7] works optimization principle helps overcome a difficulty of a numerical estimation. Following this principle, canonical distributions of preferences are derived mathematically. Thus, moving by the pass by *Frank Ramsay*, *Bruno de Finetti*, *Leonard Savage*, introduction of the subjective probabilities in work [245, Part II, Chapter 6, p. 74 and on] for a numerical expression of the statistician's opinion and information, as well as the notion of *utility*

serving for numerical expression of tastes and preferences [245, Part II, Chapter 7, p. 92 and on], leads to introduction of the subjective preferences, which is in concordance with the general doctrine of the fundamental scientific visions development [246, p. 96], where: "*an informational approach*, developed in the latest decades of the $XX^{th}$ century, will become the core of a new already now being formed paradigm of sciences about human.".

Variational principles of subjective analysis, owing to taking into account cognitivity, allow engaging a more extravagant, than the *Bayesian* one [254], approach at the subjective risk assessment, moreover, they give a possibility of an uncertainty correct taking into consideration at a decision making on the opposite to the voluntarism of the introduction and interpretation of the possessiveness functions view in the fuzzy sets theory [255, 256].

Theoretical studies in the given area, going out of the framework of the mentioned above limitedness, inter-call with the principal provisions of synergetics [249-251, 257-263, 264]; since we are speaking about a control of engineering-social-economical systems functioning with studying the qualities, properties, and mechanisms of their activity which is stipulated by the realizations of these systems participants' activity [243, 244, 265-279].

The essence of the principle is that the human consciousness (or psych) functions in some optimal way. There is a necessity to introduce the criteria of the optimality. It is proposed to use entropy.

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