NONLINEAR FUNCTIONAL APPROACH: PEOPLE BEHAVIOUR DESCRIPTION IN CASE OF EMERGENCY SITUATIONS

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ABSTRACT

Nonlinear functions are proposed as descriptive expressions of the social behavior of the affected groups of people in case of the extreme critical situations (generated by natural hazards, industrial accidents or terrorist attacks). Five functions are identified up to now, called respectively: "solidarity", "panic", "rumors", "media" and "enthusiasm". The systematic table is created reflected the average time duration, sensitivity of the respected function, its interruption/non interruption behavior and the possibilities of the respective process management. This is a new approach to present the social behavior of the affected groups of people during the extreme events using deterministic functions. The nonlinearity of the functions is clearly expressed. The possibility to use these functions in the risk analysis and the risk management practice of the extreme situations is a strong tool for the investigation of the possible influence of the people's behavior. The increased security and safety policy of the EU coincides with the targets of this research. The only graphic expressions of the functions are presented. The main difficulties obtained are the data collection and verification. The analysis performed shows that frequently the combinations of functions can appear making the decision-making and management processes rather complicated and difficult.

INTRODUCTION

The development of a strict mathematical approach for the description of the social elements like social behavior and social movements started not very long time ago. Now this is a modern approach used for many social applications, even for the analysis of emotions (Swarts 2004). This approach is much more coherent with the modeling and the different trend analysis. To describe the personal/group behavior and/or to predict the big social groups behavior in case of extreme events is a difficult task (Blaikie et al. 1994). Many mathematical expressions have been built up frequently on different non-linear basis like the theory of chaos, turbulence, attractors, etc. Almost all approaches have been generated using as samples many and different natural and/or technological disasters.

The target in this study is more practical and humanistic – using both - the technological/the mathematical booms, to try to represent mathematically (which means rather objective) the general human population social behavior in risky situations – e.g. natural hazardous events, terrorist attacks, industrial accidents, etc., which can affect relatively bigger groups of the society (Kovachev et al. 1997).

COMMON CONSIDERATIONS

If such approach is effective – large possibilities appear using the recent technology and communications for the effective risk management of the crisis events like: human behavior in case of emergency situations in different cases (for example - teracts, industrial accidents, natural catastrophes, etc.). It is known that to find out and to apply (only on the intuitive basis and some personal field observations) the deterministic approach to the social behavior in the risky situation is a really hard task (ISDR 2002). It is important to mention that to collect real relevant data in such situations is really a very difficult, hard, frequently impossible task.

This is due to several reasons (objective and subjective):

- Relatively short time of the influence of the hazardous event and/or the threaten agent (if such exists and could be possibly triggered).(Kovachev et al.1997).
- More important safe-life actions then the data collection. (It is really impossible to "put" in such situations data collectors or interviewers). So, main sources for the relevant information are the investigator's location at the spot of the event and its impressions, occasional photos, pictures, movies, shots, etc. at the moment of the event.
- In the everyday practice the post-event analysis is targeted to discover the generator of the event, and the consequences (mainly the economic part), but almost never to follow the social momentum behavior of the people involved in the hazardous event.

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On the basis of the general considerations, personal or shared experience of the "field" observations, data appearance in different sources, lessons learnt publications (NEDIES Reports 2001-2004), etc., to try to define reasonable mathematical functions (sometime even descriptive) of the social behavior of the groups of people involved in such emergency situations is the main task of this research. There are not so many options concerning the group behavior in the risky situations (Sundnes and Birnbaum 2003) – there were identified up to now – several – solidarity and enthusiasm, panic and rumors, mass-media behavior. Probably some others exist, but they could be deal with in the future.

All of the described functions have a common property – clearly expressed nonlinear behavior. This is due to the very complex and complicated factors acting during the emergency situation.

The main reasons considered, are the instability and sensitivity of the group behavior in the extreme situations – very small changes in the input situation could generate big amplitudes of the output function behavior.

METHODOLOGY

Methodology is based on several assumptions and simple principles:

- Graphical expression of the functions based on the different case studies and general lessons learned.
- Time duration estimations of the functions behavior based on the physical measurements and considerations related to the emergency situations generated by the natural or man-made hazards.
- Estimations of the possibility for the situation management.
- The functions are considered valid only for the groups of people located in the epicenter of risky event (i.e. direct players).
- It is considered that different people react in different way in any risky situation.

GRAFIC PRESENTATION AND DESCRIPTIONS OF THE FUNCTIONS

All derived functions and their presentations are represented as follows:

The panic function:

This is a time-intensity function (Figure 1), impulsive, relatively short in time (seconds to minutes), generated always in population (group) society, when a serious threat appears. The initial event (e_0) usually generates relatively slower increase of the intensity comparatively the next (e_1, e_2, etc.). Each new event triggered more intensive and faster increasing of the function. Short time plateaus could be observed. Decreasing phase is longer for each following event. Interruption of the function is possible. If the next event is closer in time domain and the effect of the previous event is still lasting, cumulative effect could be observed (case e_i on the graphic). Going very fast up to the initial phase, slowing down calmly. The trend analysis shows (dashed line), that trend has a slow increment to a certain moment and then going down with time development, but plateaus also could be observed.

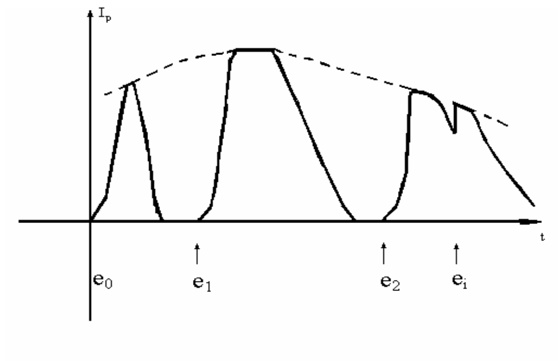

Figure 1: The "Panic" Function

The solidarity function:

Usually long lasted intensity function (days – weeks). This is a probabilistic function (Figure 2), very sensitive to new threats, and very irregular, depending on the new threats – events (e_i), after initial event e_0. The events e_i could be of different character – natural or man-made. Function increases very fast after the first event and have relative smooth plateaus. Any new threat leads to very fast decreasing (the "safe-life" syndrome), even interruption. The recovery time is also fast. The trend analysis shows slow decrease in time due to people accommodation to the threat, but this is not significant decrease.

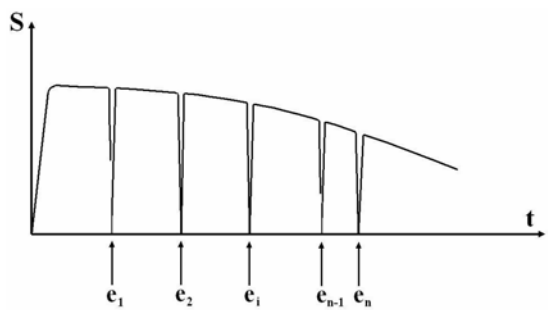

Figure 2: The "Solidarity" Function.

The media function:

This is a cumulative probabilistic function, which describes media reflectance to the risky events and their consequences (by publications and other different forms and reactions – interviews, direct emissions, public and/or expert opinions, public presentations, etc.). The function (Figure 3) is a long lasted function (weeks-months). Several similar, but always increasing functions, could be different for different mass-media – Radio (mainly news emissions – fastest and shortest resonance, sometimes (rear) short analytical notes) (curve No1); TV (also the shortest resonance, a little bit longer time coverage) (curve No 2); newspapers (longer stage) with some technological delay (with morning and evening editions) – sometimes analytical articles appear in longer time domain (curve No 3) – but sometimes could be more intensive); Internet – longest stage of reflectance – (curve No 4) with more analysis and opinions, but less primary information. All functions of mass-media behavior is going earlier or later to "saturation" (dashed line). The trend analysis shows faster increasing during initial phase and then slower decreasing. Interim events can trigger "bursts" of increasing number of publications, or fluctuations of the function. These functions usually have "maximum maximorum", and significant fluctuations mainly in the decreasing part. This is one of few cases, when functions are relatively easily "measurable". The representative data extract could be possible mainly in country (countries), where the hazardous event has occurred and has significant consequences.

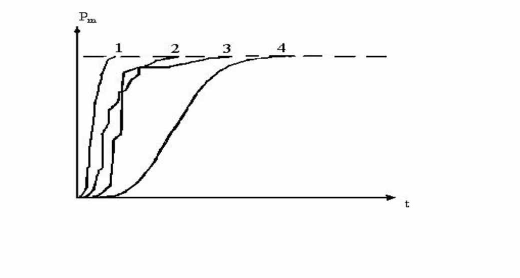

Figure 3: The "Mass-media" Function

The "rumors" function:

This is an intensity function, reflecting the generation and spreading of the rumors, which always appear in the society affected by the risk event (Figure 4). Usually this function started with some delay relatively to the initial event. Function is relatively long lasted – weeks to months (even years). The trend (dashed line) is faster increase at the beginning and slower decrease during the latest phase. Intermediate events can trigger the "bursts" of rumors, to create plateaus or local maximums (event e_i on the Figure 4). If no more events occurred function is going down slowly always. The function usually has the maximum maximorum. Collection of data is possible for this function sometimes. Number of different rumors could be collected, but they are not always reliable due to the collection difficulties and very fast deviations in content of the rumors. The problem of rumors spreading is very complicated and difficult to be investigated. Generation of the "secondary" rumors, which consist some information of initial rumor, frequently have more "details" and sometimes deviate so much from initial "information" that's impossible to recognize if it is the "new" or modified rumor. That's why it is very difficult to calculate the original number of the rumors.

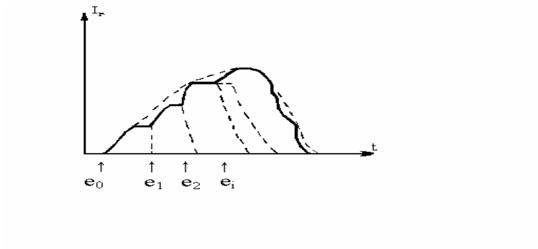

Figure 4: The "Rumors" Function

The "enthusiasm" function:

This is a relatively simple time-intensity function – Ie (Figure 5). Appears in relatively "better" social conditions, then other functions, because this is more or less a "post event" function. The "enthusiasm" itself appears usually amongst not affected by the hazard event groups of people or in some groups of people affected by the event (most frequently – not strongly), but in both cases among people willing to help the strongly affected groups of people. The function is usually long lasted (months even years) with sharper phase of increase, plateau and slow decrease in time. This function is practically not sensitive to the following events, but some fluctuations could be observed. Gives the possibilities for some quantitative measurements (for example by funds or different aids collection).

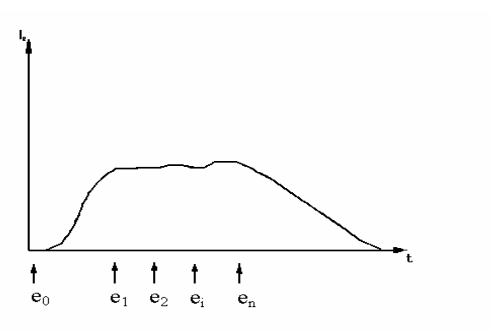

Figure 5: The "Enthusiasm" Function

All functions usually started immediately after the first event (e_0), only the rumors and the "enthusiasm" functions could be shifted to the later time.

All described above functions have some common properties:

- Strong nonlinearity – this means that (as it can be seen on the figures) exponential and/or

logarithmic) behavior of the functions are the most frequent cases;
- Strongly event dependence – this means that each next hazardous event more or less affected the group's behavior. This is the normal psychological reaction;
- Strongly affected group's dependence – this means that the "soil is fertilized" by the initial event. This fact contains also the normal psychological reactions;
- The time durations are different, which is supported by many field observations and lessons learnt analysis; sometimes the coincidence of the action of several functions could be expected. This is the most difficult situation for the risk management.
- The bursts of cases are considered, which means, that each case could be described by a separate function

ANALYSIS

For the analysis following table (Table 1) has been created, summarizing the main properties of the functions. The most important of them are:

Table 1. Main properties of the suggested non-linear functions (in average).

Functions/ Properties	Time duration (minutes)	Sensitivity of the function	Interruptive	Manageable
"Panic" Function	seconds-minutes (10^{-1}-10)	high	yes	yes
"Solidarity" Function	days-weeks (10^3-10^4)	high	yes	yes
"Media" Function	weeks-months (5.10^4-10^5)	low	no	not easy
"Rumors" Function	weeks-months (5.10^4 -10^5)	middle	no	not easy
"Enthusiasm" Function	months-years (5.10^4-5.10^5)	very low	no	yes

- The time duration – it is important to know the average time of the validity of the functions, as they are time dependant. This is an important property for the practical reasons. If in some hypothetical emergency situation there is a mixture of several (or all) functions, the time effectiveness is of a crucial importance for the management practice.
- The sensitivity – means that the function is strongly sensitive to the next dangerous events. An important property from theoretical and practical point of view.
- Interruptive (or non interruptive) – an important element. Any kind of functional analysis could be implemented during the "existence" phase of the function. This is an important property for the mathematical modeling, because any reliable solution could be obtained for the phase of existence of the respective function.
- Manageability - a very important property from practical point of view. It gives the level of the possibility to influence the function, using different measures.

The "sensitivity of the function" means sensitivity to the next following dangerous events with different (but significant) magnitudes.

"Interruptive" – means has (or not) points (phases) of interruption.

"Manageable" – means the possibility of management influence.

The "time duration" as average value is given in minutes.

The analysis shows that some difficulties could be expected in several directions. The main one is the data collection. In such situations to put the interviewers or data collectors using questionnaires, interviews, etc. is practically impossible. That's why the comparative analysis between the theory verification and the practical realization is a significant difficulty. Always in such cases of the hazards influence the more important activities then the data collection exist (to safe the people lives, to protect the affected population, to perform rescue operations, etc.) Afterwards the influence of the event and the people's behavior is forgiven and to reconstruct the people group's behavior is very difficult. That's why the verification of the approach is really difficult. Another difficulty could appear in case of the multiple risk situations. Most of the factors are acting simultaneously and the exact estimation of the intensity of the functions or their probabilistic behavior is difficult, even sometimes impossible.

GENERAL RISK MANAGEMANT MEASURES USING THE FUNCTIONAL ANALYSIS

It is very difficult to take real measures for management of the people's social behavior in case of the emergency situations, because of the lack of real data. For our approach we use the analogy with the army and/or police groups for emergency actions, because these teams are frequently acting in similar environment:

- "Panic" function. The practice shows (according to the army, police, emergency teams trainings) that good training decrease the value of this function.
- The "Solidarity" (and the values of the respective function). It could be increased among the trained team, due to exercises in the real environment of similar (as in case of the disaster) conditions.
- The "Rumors" function is not easy to be managed. The commander's responsibility and the "strong hand" of the commander could decrease (but not to stop fully) the values of this function. That's why in the affected regions the organization based on highest single personal power and responsibility is of significant importance. All case studies show that if a good organization is created, the number of rumors decreases. One way to influence this function is also to provide widely the relevant and reliable information without delay.
- The "Media" function is hardly difficult to be managed. It is a very difficult task to manage the media response. Media always likes sensations and frequently do not reflect and interpret the available information in the proper way, creating sometimes panic, rumors or other people reflections, which do not help the proper management.
- The "Enthusiasm" function is the most promising function from the point of view of risk management practice. This is due to the positive circumstances existing in similar environment – people who like to support the affected people, cultural heritage, different structure reconstructions, etc. The response could be managed in long or short time intervals by good motivated and organized persons.

CONCLUSIONS

Several nonlinear functions are presented. They are used as formal mathematical descriptive elements about the group's people behavior affected by the emergencies of different origin. Their graphical expressions are suggested together with the analysis of the different expected cases. The functions are suggested on the base of field experience, lessons learnt, case studies and general considerations. The systematic table of main properties of these functions is created helping the analysis and the practical performance. Some general management measures are proposed, which could be useful in everyday management practice or in case of the mathematical modeling of such situations generated by natural hazards, terrorist actions of industrial accidents.

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