# *On some issues related to the models of Human and Organizational Factors and their use in the Decision Making process*

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## 1. Background and goal of the work

The paper presents some results from a research on the best approaches to be adopted in order to evaluate the impact of various models used for Human and Organizational Factors (HOF) in nuclear field (nuclear power plants (NPP) and the infrastructure specific for their lifetime cycle - design, operation and extention of operation and decommissioning of a NPP). The work considers that modelling of HOF in integrated models for the whole NPP and its infrastructure was identified as an important issue by all the major accidents in the NPP (for instance, TMI, Chernobyl and Fukushima).

## 2. Methodology

### *2.1. Specific aspects of modelling HOF*

There are fundamental difficulties to develop models for systems with combined technical-social and economic aspects (HOF type). Previous models used for similar cases in the evaluation of the lessons learnt from major accidents and in the modelling of the security of energy supply aspects were used by the author. There are many possible methods to be used for the evaluation of HOF systems. The latest approaches are trying to model HOF using systems theory and/or approaches applicable to systems evaluations in general. A set of three types of models were reviewed so far as part of the current research, as follows:

- Operational research (using matrix approach) for describing the systems, their elements, the challenges and results of the challenges
- Expert type approach based on best practice and expertise included in documents and researches of holistic type
- Risk based evaluations based on methodologies fro the Integrated Risk Informed Decision Making.

The three type of approaches mentioned above were applied to various case studies for NPP and their infrastructures (NPPI) depending on factors like

- The lifetime stage of the structure
- The existence of certain type of events (technical or economical)
- The capabilities built in the structure to cope with challenges – related to the existing profile of safety culture and the type of leadership

### *2.2. Main aspects of the evaluation*

The methodology is based on the evaluation of the nuclear power plants experience as a technology development issues, considering the interface with other aspects of the society and the specific issues of science history from the systematic biases point of view. As illustrated in Figure 1, HOF is considered to have three components: management (as structure), safety culture and leadership. HOF elements interact between them and constitute a set of layers over the plant in hardware and software format.

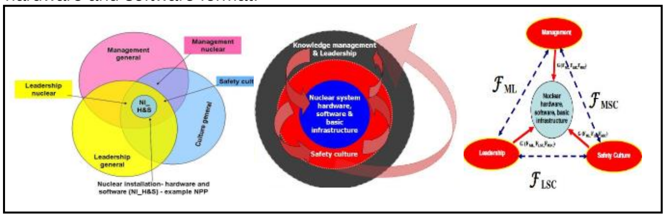

*Figure 1 Components of HOF*

A sample of the impact of HOF in the Defence in Depth is illustrated in Figure 2 based on a large literature of which the information focused on systemic modelling of HOF considering existing international standards is presented in [1 and [2]. As it is shown in Figure 2 the impact of HOF is increasing for the higher levels of defence. And therefore the accuracy of their modelling anis very impoartant to vcaluate the safety margins and to take decisions in high risk infrastructures like the nuclear field.

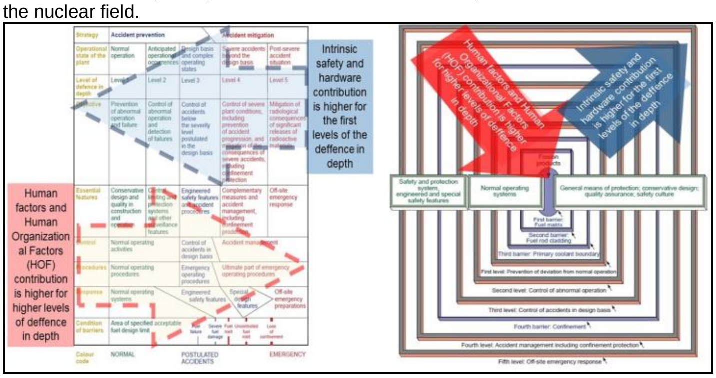


*Figure 2 Defence in Depth and the HOF impact on it*

In a systemic approach a nuclear managerial infrastructure, "amended" by its safety culture" may be represented as a structural function (defined for instance by an operator that shows the interrelations between the elements of the structure - administrative units, staff members and the relationships between the elements.

Figure 3 illustrates a decsription of a management system and its HOF elements in a system theory approach.

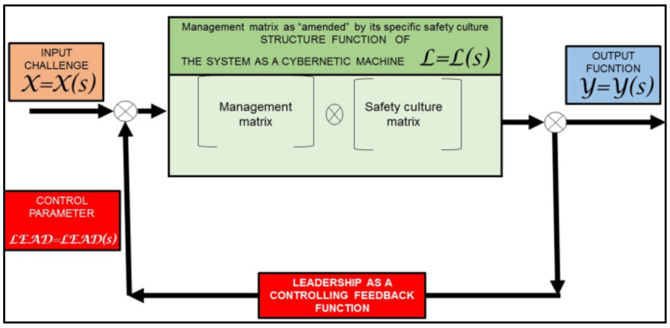


*Figure3 HOF matrix representation*

Management structure (L=L(s)) as described in Figure 1 and in referenced Documents ([1]; [2]) will react to a challenge (x=x(s)) and the new state of the structure (y= y(s) - that will take also into cponsideration the feedback that is assured by the leadership loop) will indicate the weak points. Operational calculations (in matrix format for instance) will generate quantification of the emlements that are to become the weak points of the new structure.

The principles and some important steps of the operational calculations for the functions describing the HOF elements are represented in Figures 4 and 5.

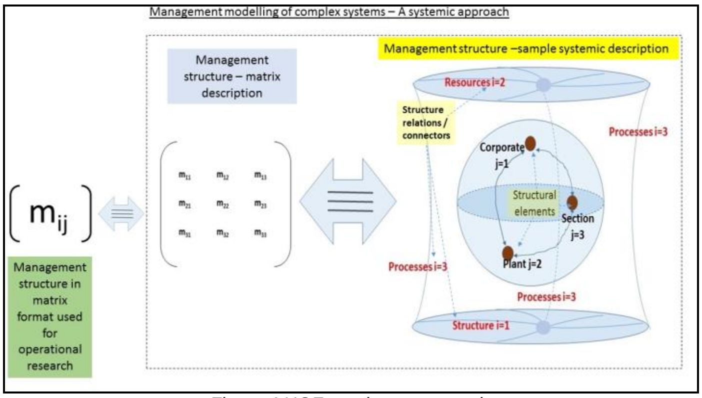


*Figure 4 HOF matrix representation*

One set of results of this operational research of the weak points of a managerial structure challenged by a technical, external, economical input is generated by the information given by the eigenvalues and eigenvectors of the resulted matrix describing the final state after the challenge, as represented in Figure 5.

The initial transformation of the elements of the management structure, safety culture and leadership figures are based on the features described in existing (formulated in words an) literature on the subject – in the case of this paper it was based on information from [1] and [2], that is guided by internationally recognized best practice and descriptions of the HOF elements. The level of importance and level of damage of each element is considered qualitatively and then the evaluation is translated in figures, used to define the matrices and vectors, which are further on used for the calculations.

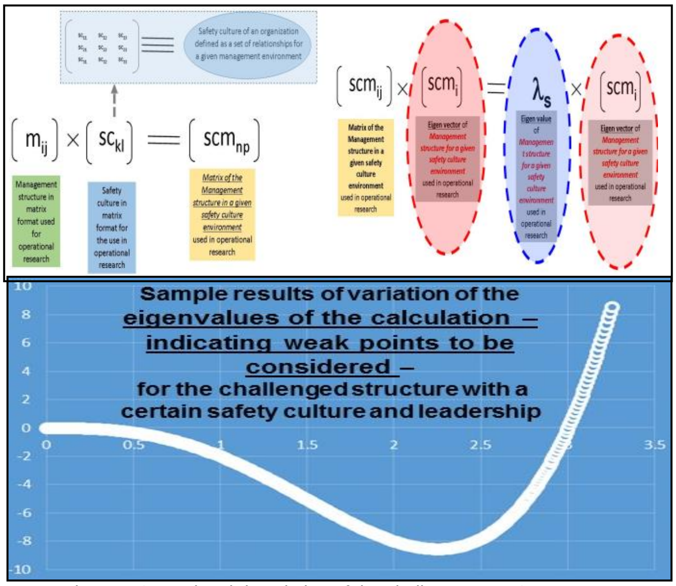


*Figure 5 Operational description of the challenges to HOF structure*

## 3. Results of the evaluation

If the analysis is focused on the reaction of a structure after major accidents, then the structure weaknesses may be defined as in Figure 6 (as described in detail in [4] and [5]).

A set of weak points as per Figure 7 may be defined after that and used for further in depth analysis and improvement of the structure.

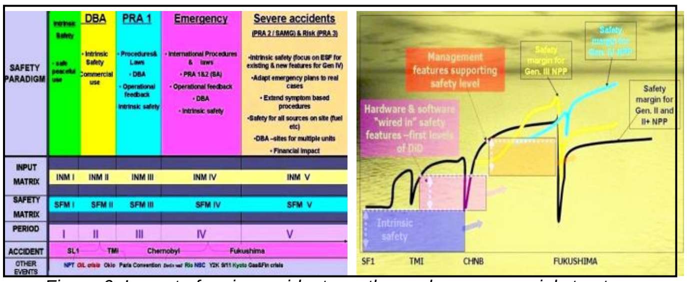


*Figure 6 Impact of major accidents on the nuclear managerial structure*

| | Issues to be evaluated/Priority in various evaluation options | CATEGORY | Option A | Option B | Option C | Option E |
|---|---|---|---|---|---|---|
| 1 | Defense in Depth – risk balanced RIDM as method reference IPE/IPEEE | M-DID&RISK | H | L | L | H |
| 2 | Evaluation and /or review of the requirements for classification of systems on various IE (SCC) and on seismic/flood | M-SCC&IE | H | L | M | H |
| 3 | Review if considered seismically induced fire/floods | M-S IE&INDUCED | H | L | H | H |
| 4 | Evaluation of safety margin for SBO in the case of DBA and BDBA | M-SM DBA & BDBA | H | H | H | H |
| 5 | Intrinsic safety and conservative design - Robust (redundancy, diversity, - portable etc) alternative sources of electricity for safety systems after DBA/BDBA | M-INSAF&DBA BDBA | M | H | H | H |
| 6 | Review SM for DBA on multiunit plants | M-SM MULTIUNIT DBA | H | H | H | H |
| 7 | Review ventilation in containments after severe accidents | M-VENT SA | M | H | M | H |
| 8 | Use of PRA level 2 and 3 for Emergency Planning | M- PRA L2&3 EP | M | H | L | H |
| 9 | Hydrogen control inside containments and other buildings (spent fuel) | M-HYD | M | H | M | H |
| 10 | Spent fuel cooling for DBA & BDBA and reduction of spent fuel inventories | M-POOL DBA & BDBA | M | H | H | H |
| 11 | I&C availability for BDBA and severe accidents | M-I&C BDBA | M | H | H | H |

| | Issues to be evaluated/Priority in various evaluation options | CATEGORY | Option A | Option B | Option C | Option E |
|---|---|---|---|---|---|---|
| 12 | Human factor during a complicated SA – research / guidelines | M- HRA SA | M | H | L | H |
| 13 | MCCI -research / guideline | M-MCCI | L | H | L | H |
| 15 | EP at multiunit sites for postulated IE and SA | PROC-EP MULT SA | H | H | H | H |
| 16 | EP for prolonged blackouts | PROC - EP SBO LONG | H | H | H | H |
| 17 | EP scenarios considering real site post SA conditions | PROC-EP REAL | L | H | L | H |
| 18 | Review process of regulatory oversight including relicensing | MNG-REG LIC | H | H | L | H |
| 19 | SA regulatory requirements – research/ guideline | MNG-REG SA+DBA | L | H | L | H |
| 20 | Small utilities coping with catastrophic events | MNG-SMALL UTIL EP | L | H | L | H |
| 21 | Site accessibility after severe SA | MNG-SITE AFTER SA | L | H | L | H |
| 22 | Decision process in catastrophic events | MNG-DEC CATSTR | L | H | L | H |
| 23 | Coordination of international cooperation/help in catastrophic events | MNG-INT EP | L | H | L | H |

*Figure 7 Sample representation of the safety issues for Fukushima phase*

A similar set of results (in the sense of a list of potential weak points in a HOF type structure) is illustrated for a case when no major accident is considered but rather challenges in corporate and general organizational safety evaluation. The identified weak points from Figure 8 result by using expert evaluations and systemic description of the management structure – the results are convergent.

| ITEM | GROUP | GROUP | GROUP WEIGHT | GROUP PROBABILITY | GROUP RISK | ITEMS OF A GROUP | ITEM WEIGHT IN A GROUP | PROBABILITY OF ITEM | RISK OF AN ITEM |
|---|---|---|---|---|---|---|---|---|---|
| 1 | I | REQUIREMENTS AT POLICY LEVEL | | | | Statements of safety policy | | | |
| 2 | | | | | | Management structures | | | |
| 3 | | | | | | Resources | | | |
| 4 | | | | | | Self-regulation | | | |
| 5 | | | | | | Commitment | | | |
| 6 | II | REQUIREMENTS ON MANAGERS | | | | Definition of responsibilities | | | |
| 7 | | | | | | Definition and control of working practices | | | |
| 8 | | | | | | Qualifications and training | | | |
| 9 | | | | | | Rewards and sanctions | | | |
| 10 | | | | | | Audit, review and comparison | | | |
| 11 | | | | | | Commitment | | | |
| 12 | III | RESPONSE OF INDIVIDUALS | | | | | | | |
| 13 | IV | TANGIBLE EVIDENCE | | | | | | | |
| 14 | V | GOVERNMENT AND ITS ORGANIZATIONS | | | | Corporate policy level | | | |
| 15 | | | | | | Power plant level | | | |
| 16 | | | | | | The working environment | | | |
| 17 | | | | | | Individual attitudes | | | |
| 18 | | | | | | Plant safety experience | | | |
| 19 | VI | OPERATING ORGANIZATION | | | | | | | |
| 20 | VII | SUPPORTING ORGANIZATIONS | | | | | | | |
| 21 | | TOTAL | | | | | | | |

*Figure 8 Sample of weak points in a management structure under a challenge (not of a major accident type)*

Alternative evaluations of management structures by using Risk Informed Decision Making (RIDM) are represented in Figure 9. Theya illustrate the fact that results may be different if the user of the results is different and therefore benchmarking of the evaluations for the same case performed by various teams and with various methods is a necessary approach for HOF dominated structures.

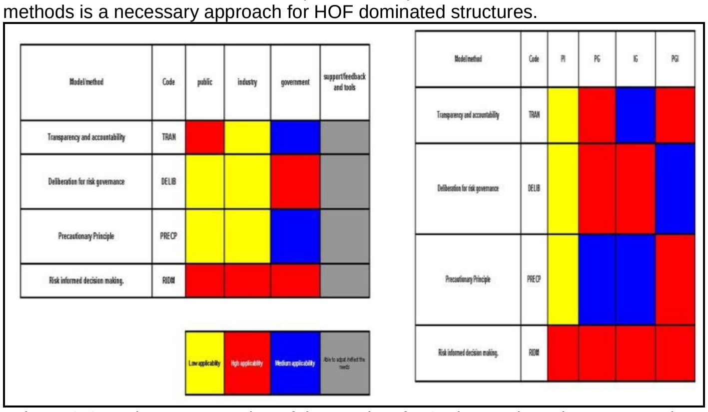


*Figure 9 Sample representation of the results of HOF impact by using RIDM tools {3]*

## 4. References


[1] Min Petre Referat teza sisemul de management in domeniul nuclear, UPB, 2016

[2] Risks and Human Organizational Factors (HOF) in nuclear power plants systemhttps://www.researchgate.net/publication/280545762 DOI: 10.13140/RG.2.1.2796.7844 Workshop on extended response to radiological emergencies CNCAN-IAEA Bucharest 27 - 31 July 2015

[3] Serbanescu, D., Vetere Arellano, A.L, WP1 – Risk-Informed Decision Making (RIDM) Safety, Reliability and Risk Analysis: Theory, Methods and Applications – Martorell et al. (eds) 2009 Taylor & Francis Group, London, ISBN 978-0-415-48513-5 SIXTH FRAMEWORK PROGRAMME Citizens and governance in a knowledge-based society COORDINATION ACTION Proposal/Contract no.: FP6-036720 Comparison of Approaches to Risk Governance

[4] Serbanescu, 2015c, Serbanescu D., Selected topics in risk analyses for some energy systems, Lambert, May 2015

[5] Serbanescu, D, Understanding major accidents -Shifting paradigms in safety and risk Safety Summit Vienna 27-28 Sept 2011, http://www.academia.edu/ 3763738/Understanding_major_nuclear_accidents_shifting_in_paradigms_for_safety_and_risk



## 5. Conclusions

- The evaluation of HOF impact and the use of results for decision making may be improved by considering the specific tools of the systems analysis
- However the benchmarking of methods and independent reviews are considered neccessary due to the complexity of HOF description in complex cases.