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# Human Risks Classification with the Method Analytical Hierarchy Process

**Lotfi AZZABI, Dorra AYADI**

ESSCA Rue Joseph Lakanal 49000 Angers, LASQUO/ISTIA, 62, Avenue Notre Dame du Lac, 49000 Angers, France

**Abstract** In their competitive nesses research, and facing an uncertain environment, the firms search more and more to attain again objective. For that, it is necessary to minimize risks and unforeseen in their systems give complexes by the analyses of security; this one has been envisaged a long time of the technical point of view, as a first tentative to minimize risks and accidents. Then, the adoption of the security analysis on the flat engineering only for the risks elimination endures to run out of him taken in account different demonstrated variability by the human operator.

The human operator as the basic postulate of events appearance of catastrophes and failures.

However, issuing finders of diverse currents have to apply different methods to minimize risks of human errors, some have used combined methods taking counts him personals factors and engineering, others himself are supported on estimations probabilities to calculate trials of workers. The objective of this communication is to analyze human risks by application of multicriteria method to help the decision AHP (Analytical Hierarchy Cases) for to minimize human errors and to make firm a level of improvement of the long-term security. The application of the method Analytica lHierarcy process for classification the risks and causes will be assiduous as a first practice in a tunisian industry in order to visualize his importance level.

**Keywords** Human Risks Classification, Analytical Hierarchy Process

## Introduction

The actual systems are more and more complex, because they integrate a variety of technologies. The system need often long period of development. When we take a change on requirements, the objectives are to improve the functionality, the cost or the delay of systems; but unfortunately, this modification can be affect a problem with others requirements those involved with the safety of the system.

The requirements change occurs in two main cases. The first concerns revising/updating existing requirements that led to an actual version of the systems to adapt to new environment [1].

The second is when new technology is being developed and new requirements are implemented consequently for reasons of cost or feasibility.

Then, the change of requirements has the effect of the change the level of the risk in the system.

Those major risks cover well secure accidents to technological character, but more generally everything susceptible events to pledge the timelessness of the co Analyses him technical risks has been a first tentative of answer to those new exigencies, who brings up a system of rules permitting to write down technical problems. Then, this analysis technical risks have procured several scantiness, provided that the human operator would not been bought in account. [2]. Indeed, different generated sucking accidents complex systems are mostly the issue of a chain of events of which each link taken isolation appears as minor, and of which some links are human errors.

The concept of human error is very elusive. At a closer look, the frequent allocation of accidental causes to human error appears to be subjective and guided by the tool box of the analyst. This is a simple reflection of the nature of causal analysis and the fact that no objective stop rule exists to terminate the causal back tracking in search of a root cause. The search stops when an event is found for which a cure is known to the analyst. A deeper analysis of accident causation indicates that the observed coincidence of multiple errors cannot be explained by a stochastic coincidence of independent events. Accidents are more likely caused by a systematic migration toward accident by an organization operating in an aggressive, competitive environment. Commercial success depends on exploitation of the benefit from operating at the fringes of the usual, accepted practice [3].

Then, the proposed paper permits to contribute an answer concretes to waits improvements of the security with minimization human risk for application of AHP methods to help decision of the important and catastrophe risk in the complex system.

**Reviewed of the Literature**

Work of searches delivering on the method of the human systems security give complexes to write down risks and accidents problems are recent, one can quote:

D. John and al [4] describes a model –oriented approach for safety analysis using fault trees. It advocates that a safety analysis of a system should start with a systemic study of the physical model of the system and as a result, construct a system safety model based on the physical model.

G. Jason and al [5] describes the incorporating a user- focused failure modes and effects analysis-like technique into the design of safety critical systems by a Programmable User Modelling Analysis (PUMA). The approach is based on the premise that the user has knowledge about the current state of the system, about actions and their effects, and about the task, and that the user behaves rationally.

D. Sylvain et al [6] Have analyzed the interactions complexity enters a model of security and a model of organization, of which the objective is to propose an explicative manager permitting to put up to date organizational phenomena who can drive a fall of the levels of security of a system

B. Marco and al [7] describes the application of the Enhanced Safety Assessment for Complex Systems ESACS methodology and on the use of the ESACS platform to a case study. The main characteristic of the ESACS methodology is the capability of integrating the system design and the system safety assessment processes by providing an environment in which formal notations are the common and shared language to be used both during system design and safety assessment.

G. Fabrice and al [8] Have analyzed a reliability estimation of a mechanical product method by accelerated fatigue tests is proposed. Like all accelerated life testing methods, this process enables to estimate a lifetime distribution for low strain levels from to failure at higher levels.

In the continuity of those works of searches, this paper propose the methodological of classification of important and catastrophic risk for improved human systems security in order to minimize risks of accidents and problems of dysfunctions.

**Underlying Models**

Human performance has been a key component of incidents and accidents in many industries. Recently, the role of human error was documented in a number of well studied, high-profile events in the nuclear power industry [9].

Then, the model proposed minimizing Human risk analysis is an evolving field that addresses the need to account for human errors when is who runs out in our gait methodological as follow:

**Step1: risk identification**

to collect indispensable dates to serve as low working for all the project, for our gait method collected data concern risks and met accidents by the worker; after that to decompose working axles, after to have to collect all indispensable information that cut down the level of security. Then, the generation possible solutions for detected human risks and this on the tool brainstorming.

**Step2: Causes analysis human risk**

This step to analysis causes of human risk is realized by application of Fault Tree Analysis (FTA) of which the objective is to determine causes responsible to the appearance the human risk.

Fault Tree Analysis (FTA) is one of the most widely used techniques in this context, it is intuitive for practitioners due to their hierarchical structure and the familiar logical symbols. They allow a variety of qualitative and quantitative analyses. Fault Tree Analysis (FTA) has been used for several decades in the context of mechanical or electrical systems. [10]

Fault Tree Analysis (FTA) are a widely accepted model that graphically shows how influence factors (in general component failures) contribute to some given hazard or accident. They provide logical connectives (called gates) that allow decomposing the system-level hazard recursively. The most fundamental gates are the AND gate and the OR gate. The AND gate indicates that all influence factors must apply together to cause the hazard and the OR gate indicates that any of the influences causes the hazard alone. Both gates are shown in Fig. 1, More gates have been proposed in literature, but some of them (e.g. NOT, Inhibit, Priority-AND) have been continuously under discussion, because they cannot be mapped correctly onto pure propositional logic or pose difficulties to some of the used evaluation algorithms. [11]

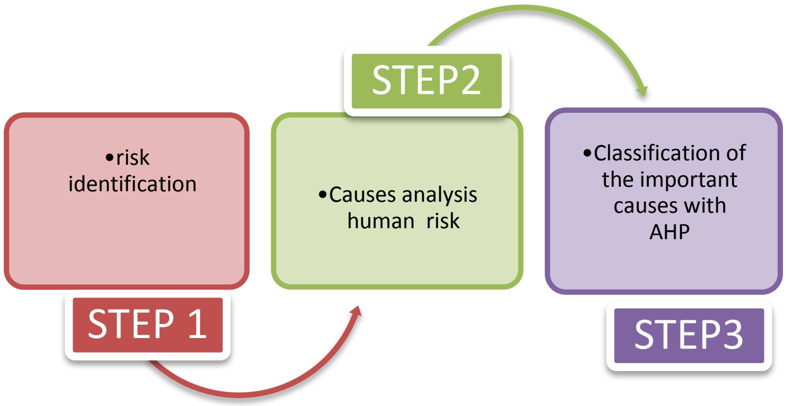


*Figure 1: Model of analysis risk human*

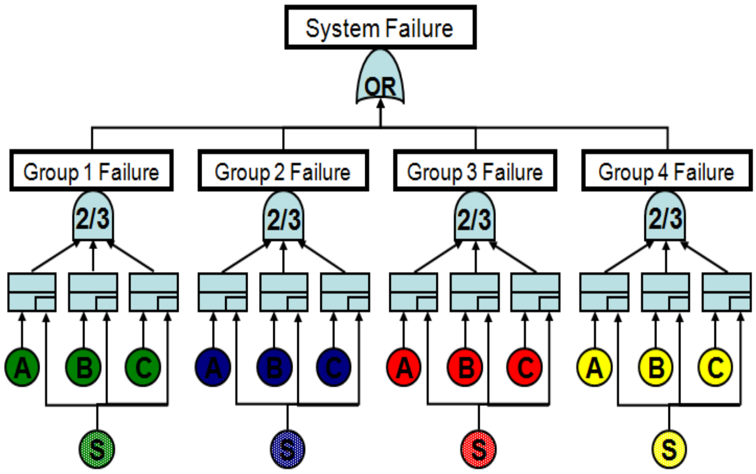


*Figure 2: Structure of Fault Tree Analysis*

**Step 3: Classification of the important causes with AHP**

in this step, it is important to identify from a causes of what is more imported for the appearance of the risk, that, it is impossible to correct all causes at the same time , causes classifications is done by the multicriteria method of taken of decision AHP.

Analytic Hierarchy Process (AHP) is a powerful and flexible method used for making decisions that help determine the priorities, and leads to making optimal decisions in cases where aspects of quantity and quality are being taken into consideration [12].Reducing complex decision making to a comparison between alternative pairs, and synthesizing the obtained results, AHP not only helps to make decisions, but leads to the rational decision.

The Analytic Hierarchy Process (AHP) for decision-making is a theory of relative measurement based on paired comparisons used to derive normalized absolute scales of numbers whose elements are then used as priorities [13].

Matrices of pair wise comparisons are formed either by providing judgments to estimate dominance using absolute numbers from the 1 to 9 fundamental scales of the AHP, or by directly constructing the pair wise dominance ratios using actual measurements. The AHP can be applied to both tangible and intangible criteria based on the judgments of knowledgeable and expert people, although how to get measures for intangibles is its main concern. The weighting and adding synthesis process applied in the hierarchical structure of the AHP combines multidimensional scales of measurement into a single “uni-dimensional” scale of priorities. In the end we must fit our entire world experience into our system of priorities if we are going to understand it [13]. Steps of the method AHP are as follows:

- Construction of the hierarchy, it’ s an abstraction of the structure of the used problem to study; the interaction with components of problem and their effect on the final solution, she permits to decompose the problem in a hierarchy of data inter-bound. A top of the hierarchy, one finds the objective, and in inferior level, elements contributing to fetch this objective, the last level are that of actions.

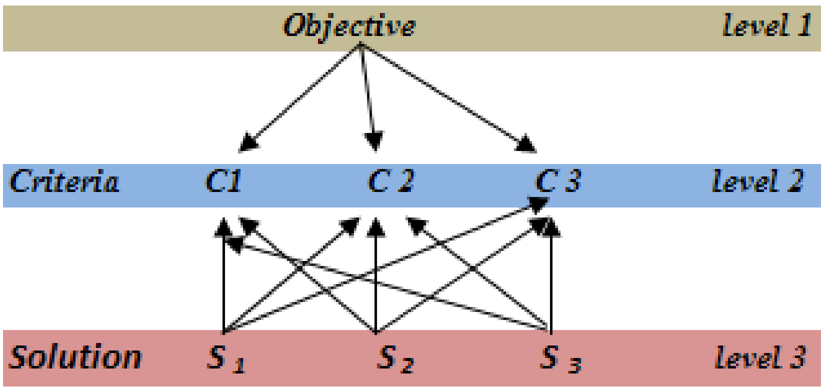


*Figure 3: Construction of the hierarchy*

- To proceed to comparisons by elemental pairs of each hierarchic relative level to an element of the hierarchic superior level. This step permits to build matrix of comparisons. Values of those matrix are obtained by the judgments transformation in numerical values according to the ladder of Saaty (Ladder of binary comparisons), everything respecting the principle of reciprocity

$$(Ea, Eb) = \frac{1}{Pc(Eb,Ea)} \quad (1)$$

**Table 1:** Saaty scales

| Importance grade | Define |
|---|---|
| 1 | Importance equalizes of both elements. |
| 3 | Importance weak person of a relative element to another. |
| 5 | Importance strong or determinant of a relative element to other. |
| 7 | Importance attested of a relative element to another. |
| 9 | importance absolved of a relative element to another |
| 2,4,6,8 | Intermediate values with two values neighbor. |

- To determine the relative elemental importance calculating primary vectors to correspond of the maximal values of comparisons matrix.

- To verify the judgments coherence. One to calculate at first, the indicator coherence IC

$$IC = \frac{\lambda max - n}{n-1} \quad (2)$$

Where: λ max is the primary maximal value running in matrix of comparisons by pairs

And n: is a large number of comparative elements.

Then; the ratio of coherence (RC) defines by:

$$RC = 100.\frac{IC}{ACI} \qquad (3)$$

Where: ACI is the means coherence indicator of obtained generating aleatory matrix of judgment equalizes height.

The means of indicator coherence is identified in the following table:

**Table 2:** Means coherence indicator

| Matrix dimension | Aleatory coherence ACI |
|---|---|
| 1 | 0.00 |
| 2 | 0.00 |
| 3 | 0.58 |
| 4 | 0.90 |
| 5 | 1.12 |
| 6 | 1.24 |
| 7 | 1.32 |
| 8 | 1.41 |
| 9 | 1.45 |
| 10 | 1.49 |

A value of RC inferior to 10% is generally acceptable; otherwise, comparisons by pairs must be examined again to reduce the incoherence.

-to settle the relative performance of each action:

$$P_k(e_1^k) = \sum_{J=1}^{nk-1} P_{K-1}\ \left(e_i^{k-1}\right) P_k\ \frac{e_i^k}{e_i^{k-1}} \qquad (4)$$

With: $P_k(e_1^k) = 1$

And: $nk - 1$ are a large number of elements of the hierarchic level k-1,

Pk ($e_i^k$) is the terms priority to the element $e^i$ to the hierarchic level k. [15]

**Solving Risk Human Problem by AHP**

The manipulation of chemical manufactured articles must not ever be engaged lightly. Spilt accidentally, they image a danger potential - and frequently well real - for the life and the environment.

Although the one could be tempted to put this type of accidents on the account of the bad luck ("It is fatal that arrives once or the other "), it must not ever forget that if adequate measures are engaged in time , the generality of industrial accidents can be forestalled, or at the very least their efficiencies considerably relieved.

Then, the method proposed to analysis human risk and classify there causes, is applied in the Tunisian chemical industry, when the objective is to minimize the dangerous accidents.

**Step1: risk identification**

From a sitting of brainstorming the whole risk following is detects:

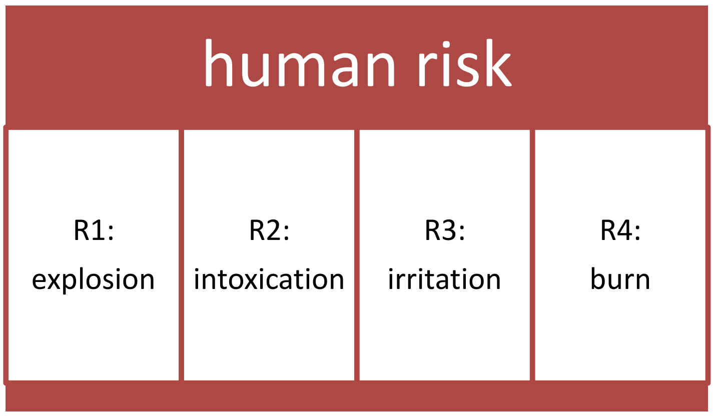


*Figure 4: Identification of human risk*

**Step 2: Causes analysis human risk**

The fault trees synthesized using this approach show how functional failures or malfunctions at the outputs of the system are caused by logical combinations of component failures. These fault trees may share branches and basic events in which case they record common causes of failure, i.e. component failures that contribute to more than one system failures. [16]

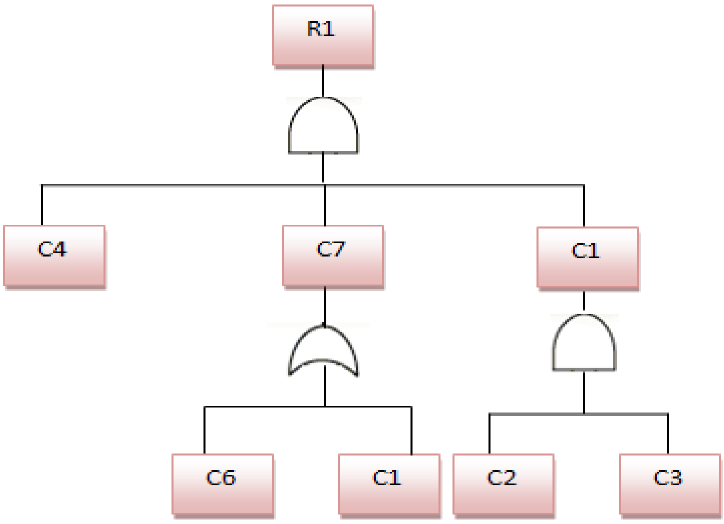


*Figure 5: Fault tree analysis causes of human risk R1*

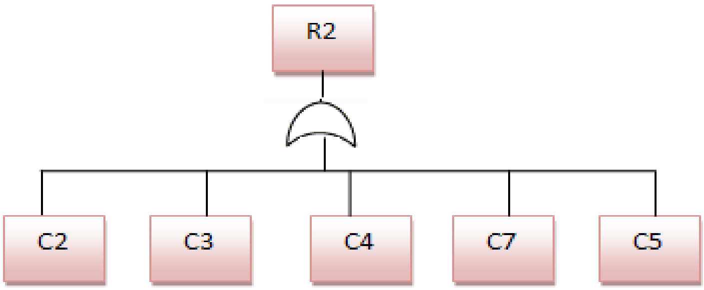


*Figure 6: fault tree analysis causes of human risk R2*

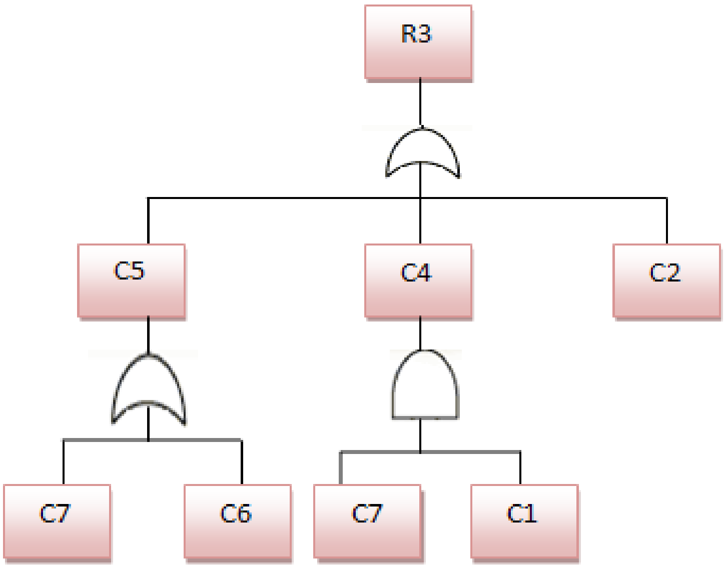


***Figure 7:*** *Fault tree analysis causes of human risk R3*

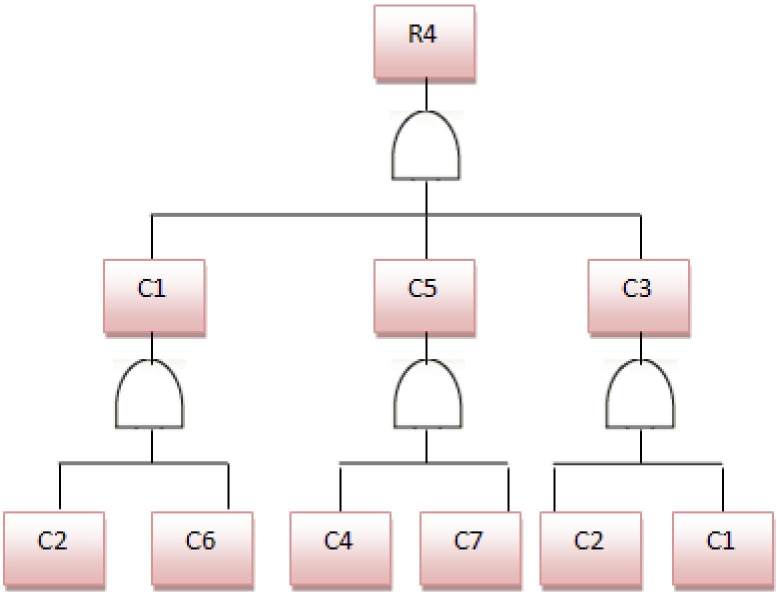


***Figure 8:*** *Fault tree analysis causes of human risk R4*

With:

C1: Direct manipulation of tetrachloride manufactured article of carbon,

C2: Manual manipulation of the loading of the cut-off the manufactured article,

C3: Taken of a standard dimension by release of vapours,

C4: Automatic mechanism of machine,

C5: Introduction of a produced containing of the solvent in the kiln to mould,

C6: Disruption of the manufactured article,

C7: projection of the cover of the manufactured article on the face,

On bases of fault tree analysis, one arrives to determine important causes of appearance risk human.

**Step3: Classification of the important causes with AHP**

After implementing the AHP evaluation criteria analysis, the first domain expert concluded that a conceptual model must possess the option of presenting all the variables in the system,

From the figure 9 to present a classification risk, we can consider that the risk the most importing and the most sink for the accidents extraction is R1: explosion (0.317); but, R4: burn passed as negligible relative to the other risk


*Figure 9: Evaluation criteria priorities*

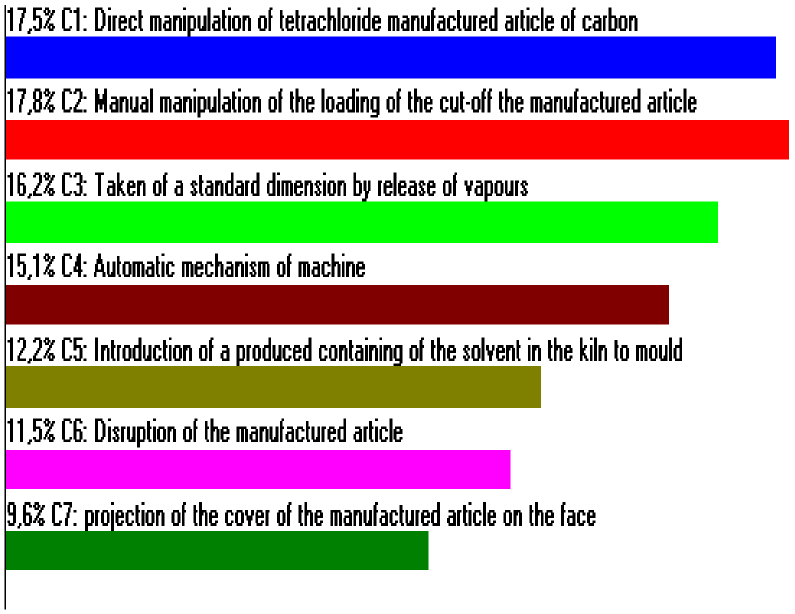


*Figure 10: Comparison of the alternatives according to the evaluation criteria*

After analyzing the assessed alternatives it was established that human risk, we can consider the causes C2: Manual manipulation of the loading of the cut-off the manufactured article is the priority of appearance the dangerous risk, otherwise, the causes C1: Direct manipulation of tetrachloride manufactured article of carbon, is considered very important hen to produced the accidents; but, the causes C7: projection of the cover of the manufactured article on the face, is not important with compared of others causes.

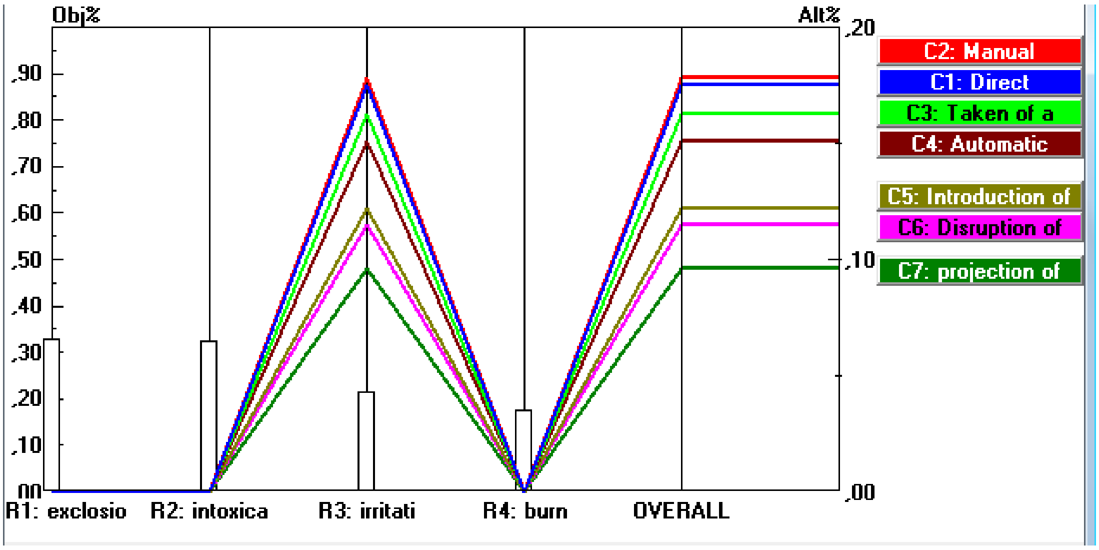


*Figure 11: Comparison of the alternatives according and the criteria priority*

The figure 11, constitute the abstract of the comparisons of the risk human and the principal causes to appearance this priority risk.

From this figure, the priority human risk is R1, and the principal causes to appearance this risk is C2.

**Conclusion**

The study of the human security in complex systems, having capacities of reconfigure, or else specimens of dependences, comes for the tools utilization and methods very sophisticated in order to write down to the risks maximum and human errors. [17].

We have shown that if inconsistency is allowed in a positive reciprocal pair wise comparison matrix (which we have shown it must), the principal eigenvector is necessary for representing the priorities associated with that matrix, providing that the inconsistency is less than or equal to a desired value [18]. We also mentioned three ways and illustrated two of them, as to how to improve the consistency of judgments and transform an inconsistent matrix to a near consistent one.

The advantage of the AHP method is modelling of the problem decision by hierarchic structure and the utilization of a semantic ladder to express preferences of the settler.

Although she would be very popular, the method AHP has done the article of several critiques:

- A score of element in the problem of decision dones to explode a large number of comparisons by pairs.
- The problem of reversal of row (two actions can see their major order himself to reverse order to a modification: addition or suppression of a several actions) of the actions whole.
- The partnership of a numerical to scale semantic ladder is restrictive and introduces skew [19].

The method AHP has done the paper of several extensions such that the taken counts him of the uncertainly (AHP stochastic) and of the woolliness (AHP fluffy) in the judgments expression.

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