

SAFETY AS A NEED/ENVIRONMENT PROTECTION AS A DEED

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The paper presents the experience of a national (process industry) research institute in checking and balancing the safety needs and also the environmental needs into the design activity. This experience is interesting especially considering the transition towards a market economy and also the various research profiles (including military ones).
The problem was that, taking into account the four main components of the Man-Machine system, the human operator, the task that is done, the machine and the work environment, to fine-tune them so as to obtain maximum safety and a reasonable degree of environmental protection.
In this spirit, a crosscheck assessment system was designed. This system assesses in a first step, the safety at the workplace, and in a second step the environment protection. Using this system, can be defined some specific crises, crises that can further be used at the development of various scenarios and mainly at the development of counter-strike measures. Such crises can be: human- environment crisis, task-environment crisis, machine-environment crisis and work environment-environment crisis. Training can diffuse the human-environment crisis, the task-environment by redesigning the task, the work environment-environment and machine, –environment crisis can be diffused by technical means.
Using statistic casualty and environment data, the paper shows that the work environment-environment crisis and the machine- environment crisis are the most serious and are determinant, if preventive actions are not quickly taken, to major accidents, with human losses and environment irreversible damage.
The developed assessment system is a quick, efficient and objective way to follow safety and environment together.

Keywords:
Safety assessment, environmental assessment, interactions, expert systems

GENERAL ASPECTS

In the design process the designer takes a great responsibility, especially for the future. The designed product will be manufactured, used and when its life cycle is over will be disposed .
All these life stages involves safety risks for the manufacturer, user and disposer and also environmental risks for the work environment and also for the surrounding environment.
The majority of research institutes in Romania are product developers, with design activities. Regarding this aspect, the paper presents the essential aspects of a multi-assessment system,

for safety and the environmental protection, which was developed jointly by the Romanian National Institute for Turboengines Research(INCDT COMOTI RA) and the Romanian National Institute for Safety Research (INCDPM)

THE SAFETY AND ENVIRONMENT ASSESSMENT PROCESS

The simplest way to make a safety assessment for a design is to use checklists so as to verify all the significant safety aspects of the design. A more complex method, named "Safety Integrator" [1] was developed and was presented at SafeCon, in Athens, in June 2000.

When assessing the safety in the design stage, the four components of the Man-Machine system(man, machine, task and environment) must be taken into account. Also, the three main stages of the future product or technology, manufacturing, usage and disposal must be analyzed.

The next figure presents the general schemata of the safety and environment assessment system

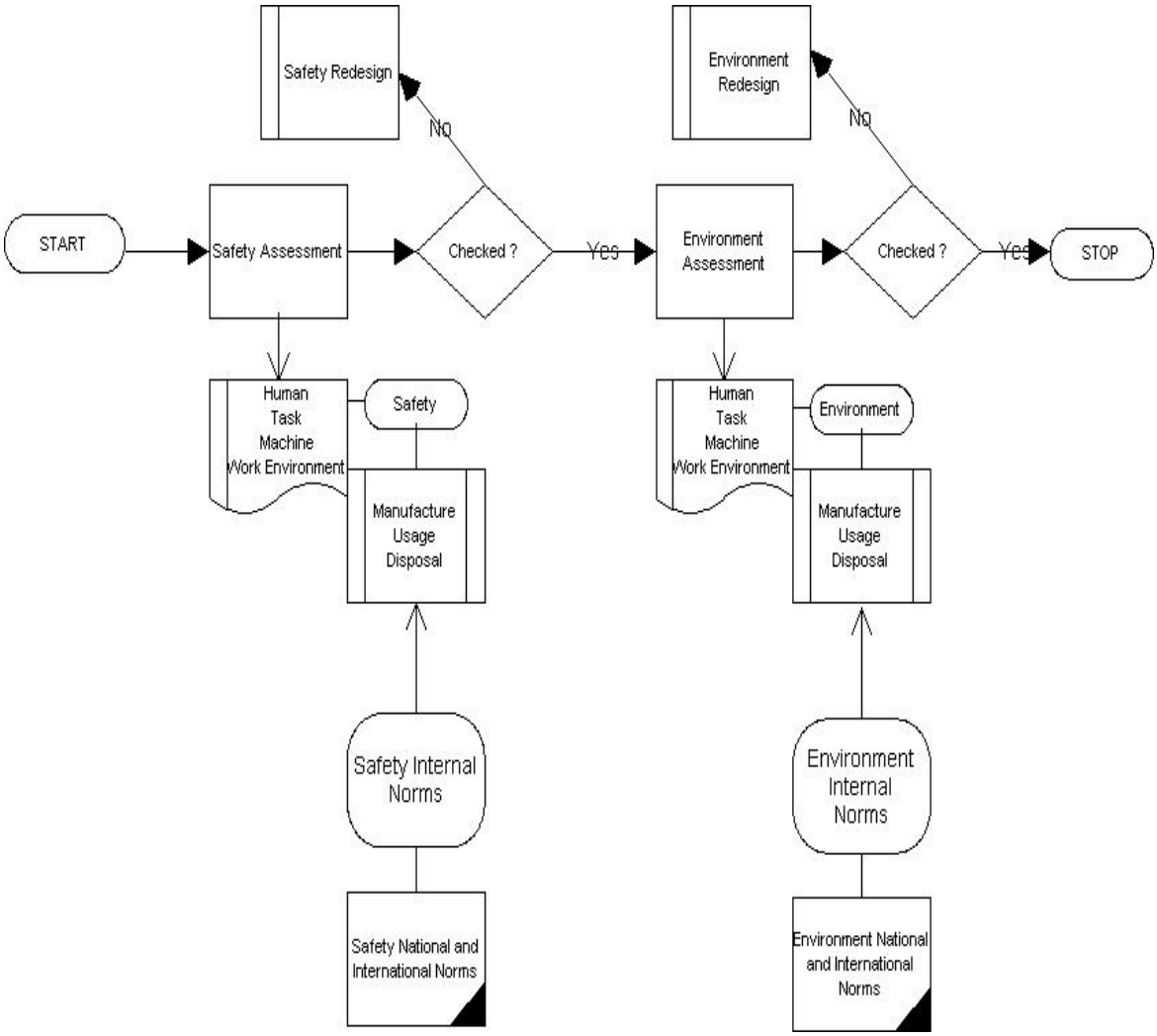

Figure 1.General schemata of the COMOTI assessment system

Undesired events are produced by interactions. The main goal in the safety assessment must be the human operator, so the interactions between various components must be analyzed from this point of view.

The general schemata of the safety assessment is presented in the figure 2

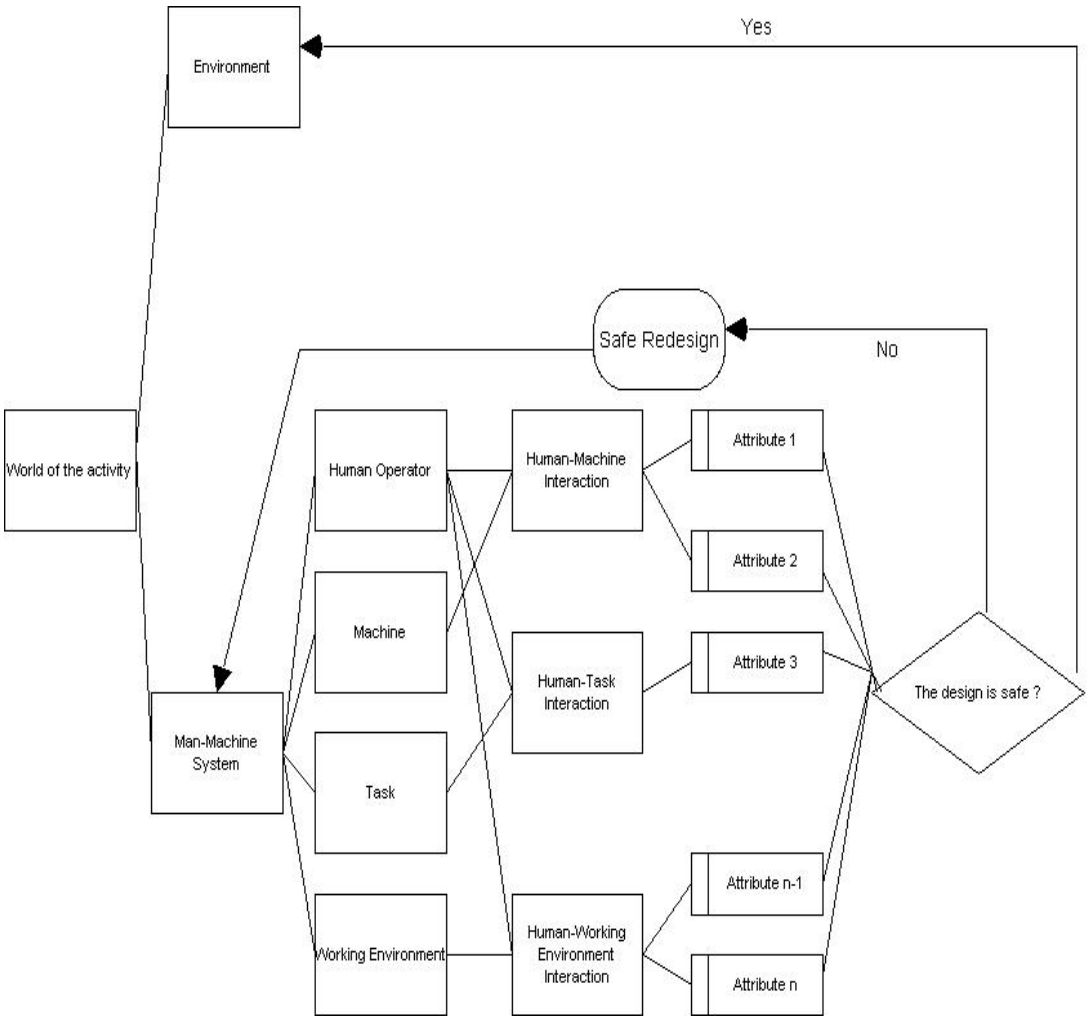

Figure 2. General schemata of the safety assessment process

In this research, the Human-Human and Human-Task interactions could be partially eliminated, because it is difficult for the designer to assess specific workers at the manufacturing point or specific users, without having the necessary data. So, regarding these interactions , the designer must develop the manufacturance specifications and also the user manual in accordance with the safety principles .The important safety problems for the designer are given by the Human-Machine and the Human-Working Environment interactions . These interactions are detailed in the following table.

Table 1.a) Problem identification regarding Human-Machine and Human-Environment Interactions in the three main life stages of a product

Component	Manufacturing	Usage	Disposal	Observations
Human-Machine	Manufacturing risks, design problems, manufacturer's training, experience and responsibilities	Specific risks in usage, design problems, User's training, attitudes, skills, experience and responsibilities,	Specific risks at disposal regarding human operators, Materials, Disposal training, attitudes, skills, responsibilities, experience and environmental attitudes	Main goal: to optimize the design of the product or technology so that the risks resulting from the Man-Machine interactions will be acceptable
Human-Working Environment	Manufacturing risks, design problems, manufacturer's environmental training and responsibilities, organization's environmental attitudes	Environmental training and Environmental attitudes	Disposable materials, Environmental training, environmental responsibilities, environmental attitudes	Main goal: to optimize the design of the product or technology so that the risks resulting from the man-working environment intractions will be acceptable and the working environment will be relatively safe

Going further , we can eliminate the manufacturing phase from the table, considering that manufacturing engineers are responsible for this phase. A more detailed analysis will led us to the following tables:

Table 1.b) Problem identification regarding the Human-Machine(Product)Interaction in the usage and disposal phases

Component	Usage	Disposal	Observations
Human-Machine	-Specific risks in usage independent from the design; -Risks caused by design problems; -Other risks; -Ergonomic aspects;	-Specific risks at disposal independent from the design; -Risks caused by the design, involving product	Main goal: to optimize the design of the product or technology so that the risks resulting from the Man-Machine (product)interactions will be acceptable. Risks can be identified using the risks list contained in EN

Component	Usage	Disposal	Observations
	-User's training, attitudes, skills, experience and responsibilities,	materials and disposal technologies; -Disposal worker training, attitudes, skills, responsibilities, experience and environmental attitudes	1050

From this table, we could identify two main problems, regarding the human-product interaction at usage and disposal:
-assurance of safety at usage and disposal (including various types of risks and their prevention measures and also the human operator capacities regarding the product);
-assurance of comfort in usage and disposal;

Table 1 c) Problem identification regarding the Human-Working Environment Interaction in the usage and disposal phases;

Component	Usage	Disposal	Observations
Human-Working Environment	-Specific risks independent from the design; -Design problems concerning the work environment; - Environmental training and Environmental attitudes	-Disposable materials; -Environmental training, environmental responsibilities, environmental attitudes	Main goal: to optimize the design of the product or technology so that the risks resulting from the man-working environment interactions will be acceptable and the working environment will be relatively safe

From this table we could identify the two main problems that could be summarized as:
-assurance of the safety regarding the work environment;
-assurance of the comfort regarding the work environment;
It is possible to see that in developing the safety assessment are taken into account some attributes that are described more detailed in the following table.

Table 2. Significant attributes that are influencing the safety assessment

Principal attribute	Description
Specific risks independent from the design	Existing or very probable risks at manufacturing, usage and disposal, risks that are influencing the human operator,

Principal attribute	Description
	excepting the design influence. For example: at the manufacturing process, the processed material is very breakable, splashing with debris
Risks caused by design problems and design problems	Problems connected with ergonomic design or with bad design
Training	Specific activity training so as to perform efficiently
Responsibilities	Responsibilities that must be assumed by the worker and his team to perform optimally the activity
Manufacturing risks	Risks implied by the manufacturing process
Usage risks	Risks implied by the usage of the product
Disposal risks	Risks implied by the disposal of the product
Materials	Component materials of the product;

The final result of the assessment will be the conclusion that the designed product or technology is safety compliant or the necessity to redesign it.
If the safety assessment is acceptable, the next step will be the environment assessment.
The environmental assessment will indicate if the product (or technology) is environmentally friendly or will lead to the definition of specific crisis scenarios, like those presented in the following table.

Table 3. Man-Machine components-environment crisis scenarios

No	Name	Definition	Provoked by	Observations
1	Human-environment or Environment-human crisis	Historically, the first crisis from the apparition of the mankind. The socio-technological crisis caused by the human operator actions with direct or indirect results on the environment; the crisis caused by environment manifestation against the human operator	-the intentional actions of the human operator upon the environment -the accidental actions of the human operator on the environment -the environment adverse influence on the human operator	Could be diffused by : -training, for the part regarding the active actions of the human operator; -using the Personnel Protective Equipments or other specific protection against the surrounding environment;
2	Task-environment or environment [2] task crisis	The technological crisis developed because the execution of specific tasks with impact on the	-the execution of specific tasks with results on the environment	Could be diffused by redesigning the tasks or by specific protection against

No	Name	Definition	Provoked by	Observations
		with impact on the environment ; the crisis developed because the impossibility to execute a task or the deficient task execution because the environment	-the impossibility to execute a task or the deficient task execution because the environment	protection against the surrounding environment; also, could be diffused by changing the task schedule
3	Machine-environment or environment-machine crisis	The technological crisis developed because the improper functioning of the machine (s) involved in a process with adverse effects on the working environment; the crisis developed because the environment effects on the machine	-the improper functioning of the machine -the environment effects on the machine	Could be diffused by a proper maintenance of the machine and adequate protection against environment
4	Working environment-environment crisis	The techno-environmental crisis developed because the mixing between working environment and environment	-improper containing of the working environment	Could be diffused by an adequate separation between the two environments

THE EXPERT APPROACH

We used an expert approach [3], firstly to model the safety and environment assessment process, secondly to capture the heuristic knowledge from the safety and environmental experts and finally to develop expert system modules for assistance in the assessment process and also in the improvement of the situation. Also, the expert approach allows the usage of fuzzy data.
We have chosen an object oriented expert approach. This allows the definition of the following hierarchical structure:

WORLD OF INTEREST-- > CLASSES--> OBJECTS--->ATTRIBUTES

The class components of our model are detailed in the table 4

Table 4. Class components

Man-Machine system	Human operator	Human operator-Environment Interaction	Human operator-Environment crisis	Man-Machine system and environment are general static classes. All the interaction and crisis classes are dynamic ones
	Task	Task-Environment Interaction	Task-Environment crisis	
	Machine	Machine-Environment Interaction	Machine-Environment crisis	
	Working environment	Working environment-Environment Interaction	Working environment-Environment crisis	
Environment				

It is possible to see that from this composition a complex hierarchical structure is born, structure that can satisfy all the major needs of a model.
For the safety assessment, there could be defined specific objects that are describing a part of the world that is assessed. For example, the following table presents some of the objects for the human operator.

Table 5. Objects specific to the Human Operator Class

HUMAN OPERATOR CLASS	Object name	Object possible ranges	Object description
	General training	0..10 or yes/no	Specifies the operator's training regarding the performed activity
	Safety training	0..10 or yes/no	Specifies the specific safety training of the operator regarding the activity being performed
	Physical state	0..10 or yes/no	The state in which the operator is at the beginning of the work, relatively to his physical attitudes
	Mental state	0..10 or yes/no	The state in which the operator is at the beginning of the work, relatively to his psychical attitudes
	Safety responsibility on him/herself	0..10 or yes/no	Responsibility to assure personal safety
	Safety responsibility to co-workers/others	0..10 or yes/no	Responsibility to assure other's safety

The interaction classes have objects that are defining specific parts of environmental aspects. Some of these are presented in the following table:

Table 6. Example of objects specific to the Man-Machine-Environment interactions

Interaction	Specific objects	Description
Human operator-Environment Interaction	Specific environmental training	Describes the necessary training for the human operator so as to conform to the ecologic rules
	Environmental sense	The necessary sense to assure ecological protection
	Preventive attitudes	The possibility to take rapidly preventive attitudes in case of an incoming event
Task-Environment Interaction	Environmental design	The task design that is taking care of ecological aspects
	Task execution	If at the task execution the environment is polluted
	Environmental control	If there is any control after the task fulfillment
Machine-Environment Interaction	Machine design	The environmental correct design of the machine
	Machine maintenance	The maintenance of the machine that is avoiding ecological problems like spills, etc.
	Machine environmental control	The environmental control of the machine output
Working environment-Environment Interaction	Work environment maintenance	The environmental maintenance of the work environment

The following figure shows the graphical representation of the classes that were built inside the model.

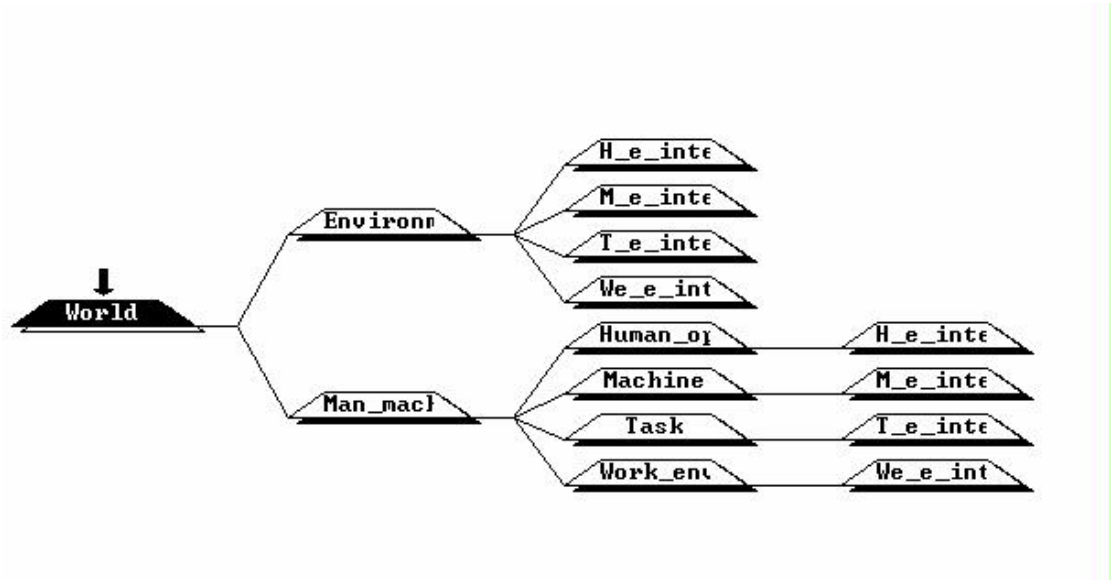

Figure 3 Component classes of the model

The Human-Environment, Machine-Environment, Task-Environment and Work Environment-Environment Interactions were defined with both Environment and Human Operator, Machine, Task and Work Environment as their parent classes. This definition allows the inheritance of all the general properties dependent on the Environment and also on the Man+Machine components.

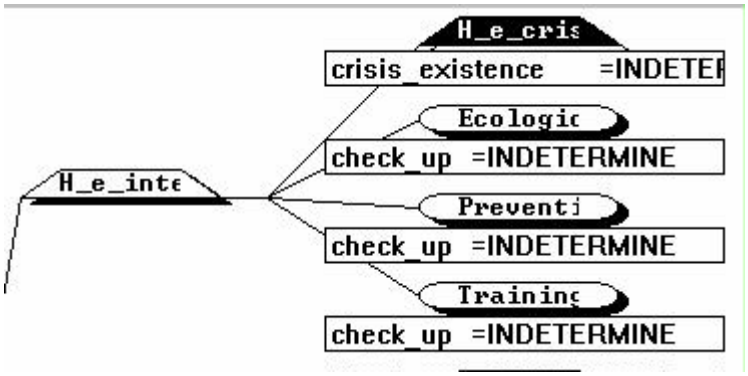

Figure 4. The components of Human Operator-Environment Class

In the previous figure the resultant class, Human Operator-Environment Crisis appears. The attribute for this class, crisis_ existence is activated when a specific rule is triggered, as in the next figure.

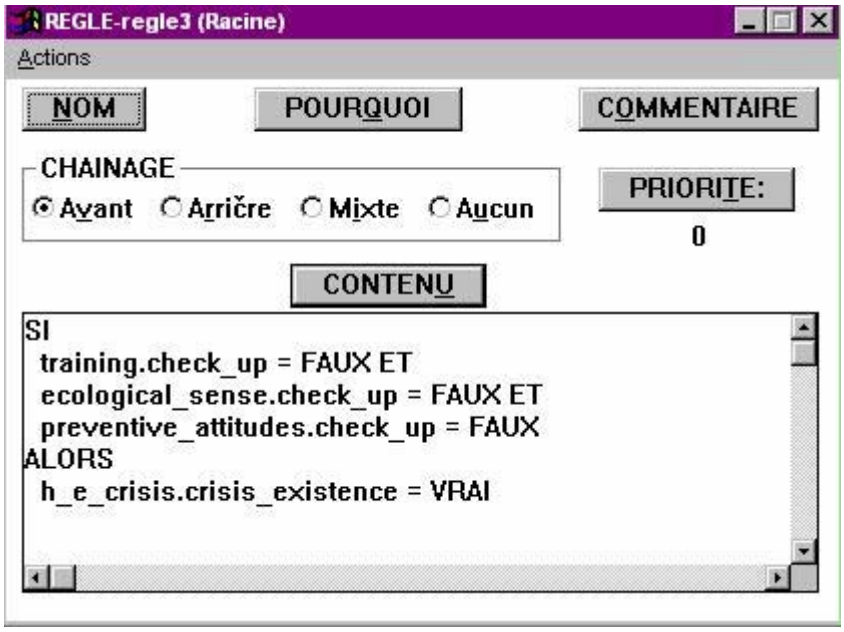

Figure 5. The rule that triggers the activation of the Human Operator-Environment Crisis Class

It is possible to see that there were introduced some example attributes for exemplifying the rule, attributes that are defined as belonging to the Human Operator-Environment Interaction; these attributes, by taking the No (FAUX) values are activating the class Human Operator-Environment Crisis with its attribute crisis _existence.

The next figure shows parts of the tracing process of the trial run

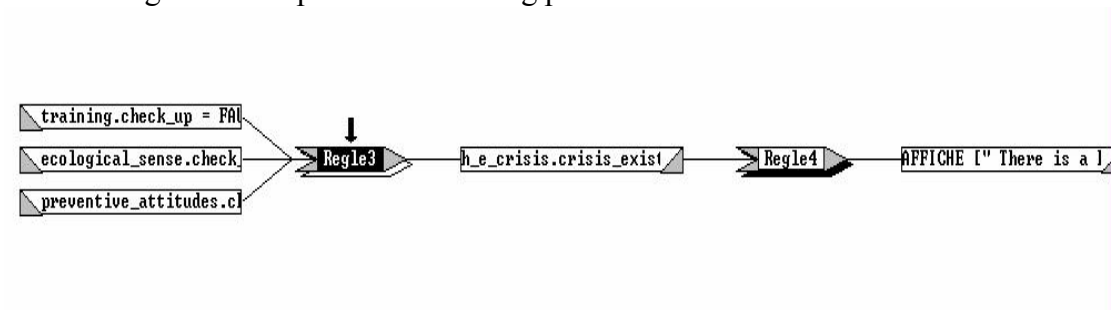

Figure 6. Part of the tracing process of the trial run

STATISTICAL ASPECTS

Putting together occupational accidents and environmental accidents data it is possible to see that machine –environment and work environment-environment crisis are the most serious from the environmental point of view.
We would present just some case examples to confirm our theory, in the following paragraphs.

A)MACHINE-ENVIRONMENT CRISIS
In the metal processing industries, significant ecological incidents are resulting especially from the lead processing industry located in the northern part of the country.
Because of the environmental unfriendly design of the lead processing installations, serious and irreversible damages were caused not just to the environment but to the health of the population living in the area ,especially children.

B)WORK ENVIRONMENT-ENVIRONMENT CRISIS
Uncontained cyanide spills from various chemical plants in the eastern regions have reached the rivers, killing the fish and poisoning the local population that was eating the dead fish.

The next table is showing the transformation of local incidents into serious ecological and occupational accidents, for the last three years

Table 7.Incidents vs. serious accidents [4]

Year	1998	1999	2000
Reported incidents	20	25	30
Serious accidents	5	11	19

The next table makes the connection between the reported incidents and design causes

Table 8.Incidents caused by design problems [4]

Year	1998	1999	2000
Reported incidents	20	25	30
Design caused incidents	15	21	26

CONCLUSIONS

Some aspects of the development and functioning of an assessment system for multi-stage assessment were presented in this paper.
In the first stage, the system is assessing the safety design of a product ,technology or service, respectively the safety at the manufacturing, usage and disposal of a product or service.
In the second stage, the system is assessing the environmental outcome of the usage of the product , technology or service and is developing (or not, if it is not the case) crisis scenarios for the interactions between the components of the Man-Machine system and the environment.
If the product is safe and environmental friendly it could be developed further, being manufactured, distributed and used accordingly with the indications.
If the product is not in conformance with the safety and environmental established rules, it is redesigned till it becomes conformant.

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