 

# DEVELOPMENT OF AN EFFICIENT SAFETY AND LEARNING CULTURE IN ROMANIAN SMALL AND MEDIUM ENTERPRISES (SME'S) THROUGH VIRTUAL REALITY SAFETY TOOLS

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Small and Medium Enterprises (SME's) are the most dynamic in the Romanian economy. Adapted to the rapid market changes, Romanian SME's are a booster for the whole industry. Unfortunately, SME's are not so lucky regarding incidents and occupational accidents. More than 75% of the accidents recorded in 2006 were located here. Taking into account these aspects, our research was oriented constantly towards the development of new and efficient safety tools for SME's. After various studies we focused on two specific problems: the design of an efficient safety and learning culture developer together with the development of a multi-role assessment system. The two instruments are built around virtual environments which could realistically model almost every work situation- allowing the SME work teams to develop and exercise specific safety skills and also to define reference models for assessments. These two instruments were included in the Integrated Safety Management Unit – a complex safety management structure for SME's. This paper presents the most important aspects regarding these efficient solutions for improving safety in SME's.

## THE INTEGRATED SAFETY MANAGEMENT UNIT (ISMU)

ISMU is the management centre of the safety solutions for a SME[1]. In this respect it stores and manages the developed knowledge and optimises the informational flows assuring an efficient usage of all these tools in order to improve safety into SME's[2]. ISMU schema is presented below:

## THE VIRTUAL ENVIRONMENT BASED SAFETY AND LEARNING CULTURE DEVELOPER

Safety Culture (SC) could be defined as "A general term for the degree to which the culture of an organisation promotes and cooperates with safe and healthy work practices[3]".

[1]Zhang H., Wiegmann D.A., von Thaden T., 2002, SAFETY CULTURE: A CONCEPT IN CHAOS?, Proceedings of the 46th Annual Meeting of Human Factors and Ergonomics Society, Santa Monica Human Factors and Ergonomics Society 2002

[2]Stefan Kovacs 2007, SOME RESEARCHES REGARDING CBT USAGE IN THE TREATMENT OF WORK DISORDERS, in Abstracts of the WCBT (World Congress on Behavioural and Cognitive Therapies), Barcelona 2007

[3]www.edp-uk.com/glossaries/terms.htm

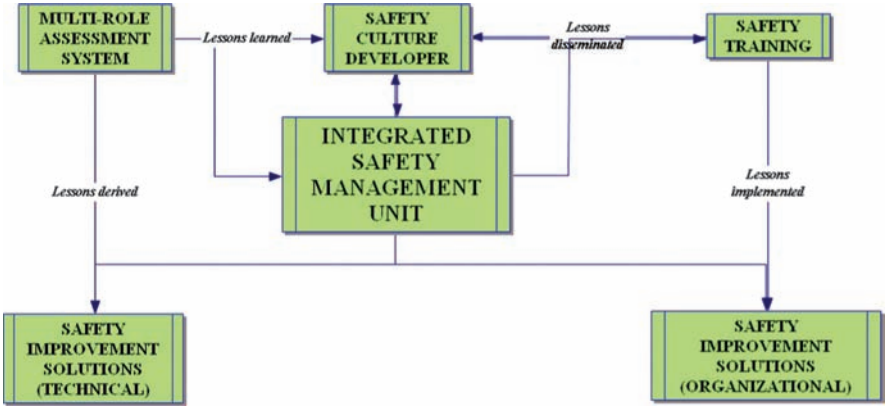


**Figure 1.** Integrated safety management unit

A difference must be made between Safety Culture – which is developed in time – and Safety Climate – which captures the immediate safety state[4]. The main idea of the Virtual Environment Based Safety and Learning Culture Developer (VE) is to develop and improve safety skills and attitudes in a virtual, controlled environment. After these skills are imprinted correctly the worker or the work team could use them into the workplace. The worker and the work team have at their disposal the virtual environment in order to **learn, try, test and eventually implement the germs of an effective safety culture**.

## MECHANISM OF THE VIRTUAL ENVIRONMENT (VE)

The mechanism of the VE is shown in the next image.

This mechanism is very straightforward. For example, Safety Culture Framework (SCF) 1 manages safety culture aspects regarding dangerous behaviours. The framework is based on role playing, the person with the dangerous behaviour seeing directly the most negative consequences of his/hers behaviour; the same person could also play the role of the team leader which must take immediate measures to prevent an accident and so, understood the responsibilities of his/hers supervisors.

## DEVELOPMENT AND USAGE OF THE SAFETY CULTURE VIRTUAL ENVIRONMENT

The safety culture development instrument is seeking continuously in the workspace for safety problems. Once identified, these problems are transposed in the virtual environment

[4]Cooper M.D. 1997, Evidence from Safety Culture that Risk Perception is Culturally Determined, The International Journal of Project & Business Risk Management, Vol 1.(2), pg. 185–202

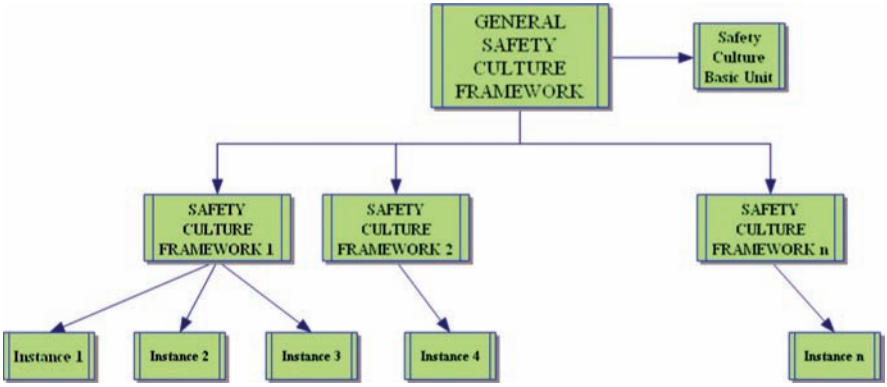


**Figure 2.** Mechanism of the virtual environment

in order to use them as interactive lessons for the development of a better safety culture. The development of the virtual environment includes the following main steps:

- analyse – identify problems, needs arising from these problems, facilitators – people who could make the difference between safety and non-safety;
- develop Safety Culture Frameworks(SCF);
- build instances – instances are built using the SCF on specific unexpected events that occur in the workplace and could degenerate into incidents or accidents- instances are saved as interactive use-cases which workers could exercise with;
- use – use the virtual environment already defined by the frameworks and instances in order to improve safety culture through the cycle:
  - learn about:
    - effective and efficient safety rules and procedures;
    - own commitment to safety;
    - team commitment to safety;
    - good organisational skills;
    - management involvement;
  - interact and try the learned aspects on the use – cases existing in the virtual environment;
  - develop the necessary safety culture skills and attitudes;
  - became confident in using these skills;
- discard or save- discard use cases when they are no more relevant (for example at the radical change of a technology) or save them in a case-base

VE is based on a "frame of reference"[5]

[5]Marek J., Tangenes B 1985, Experience of risk and safety, Work Environment: Stratfjord Field, Universtetforlaget, Oslo

The following picture shows the interaction between the real world inside the SME and the virtual environment.

All starts with SME existing safety culture. At the beginning, in order to establish how valuable it is, a complete safety culture assessment[6] is performed at the global level. In this process, based on the identification of the problems, assessment of needs, etc. the main SCF's are developed. Next time, the starting point could be a post-mortem assessment of actions in the past (previous day, month, year). The SCF's are then inserted in the VE and together with the results of the post-mortem analysis are used at instances development – as interactive use – cases that would be effectively used in the improvement of the safety culture.

As seen in Figure 3 the VE is based on the following pillars:

- **identify probls** – problems could be identified through various assessment systems[7];
- **identify the needs** arising from the problems – could be knowledge needs, attitude needs, organisational needs, etc.;
- **identify the facilitators** – facilitator could be anyone at the workplace- but generally they are people that through their own qualities could act as developers of the safety culture inside SME's. An ideal goal of the system is to transform every work team member into a facilitator.
- **identify the needed actions** – actions that would be performed in order to solve the problems; these actions could be like:
  - train;
  - re-organise;
  - allocate more resources to the facilitators;
  - interact more frequently the work teams with line management or upper management;

Now is the time to see if the existing safety culture could be improved or must be radically changed Radical changes are using the Safety Culture Basic Unit which could even give a optimal safety culture embryo if there is no viable safety culture in place.

## THE VIRTUAL ENVIRONMENT AND THE INDIVIDUAL USER

At the individual level the improvements/changes regarding SC are based on three main subjects of SC development:

a) risk understanding: if causes, actions and effects of risks are not well understood by the worker he will be not able to identify, prevent/mitigate them;
b) training – SC training in the VE is focused on acquiring risk related skills, mainly through interactive simulation using best – worst case scenarios. Navigating through these scenarios will motivate the worker to be risk efficient in order to protect him and the others;

[6]Reason J. 1997, Managing the risks of organisational accidents, Alsweshot, Ashgate
[7]Transports Canada 2007, TP 13844 - Score Your Safety Culture, http://www.tc.gc.ca/CivilAviation/system-Safety/Brochures/Tp13844/menu.htm

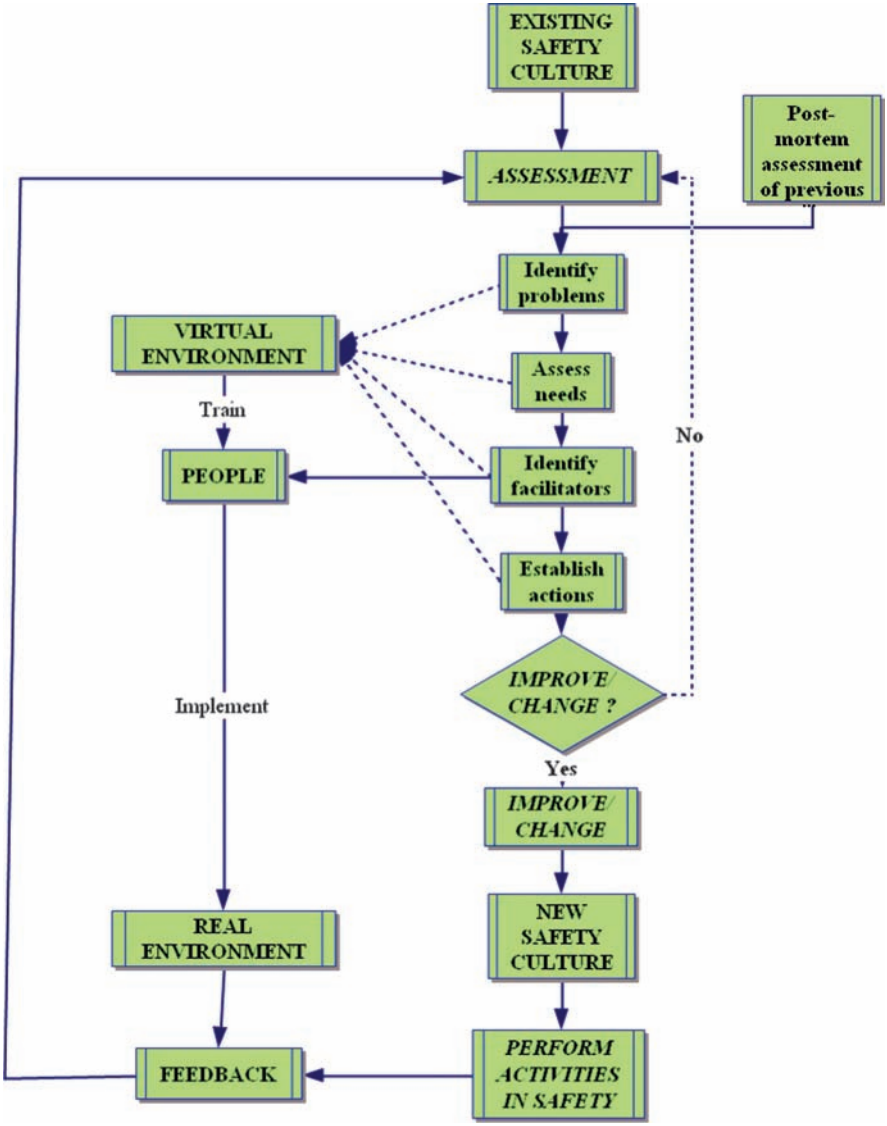


**Figure 3.** The interaction between the real world and the virtual environment

c) improvement of team work; if there is no cooperation inside the team or if the cooperation is not efficiently enough then VE will focus on role playing in order to optimize this cooperation.

Improvements or radical changes into the SC must reflect into the improved safety of the worker in simulated actions performed inside VE in interactive case studies. The leader of the VE process (usually the line manager) shall observe if these actions are performed correctly and in the spirit of SC improvement; if so, the worker has the OK to proceed to the real world and the developed SCF's and instances are stored into the knowledge base for reuse. If not, the feedback shall provide corrective changes in order to improve SCF's and instances; for example, a workplace is not well enough described by the instance – because this, the worker forgets an important safety step having no sufficient details. The corrective change consists in the development of the instance by adding these details. Our experience showed that these are the most significant failures of SCF's and

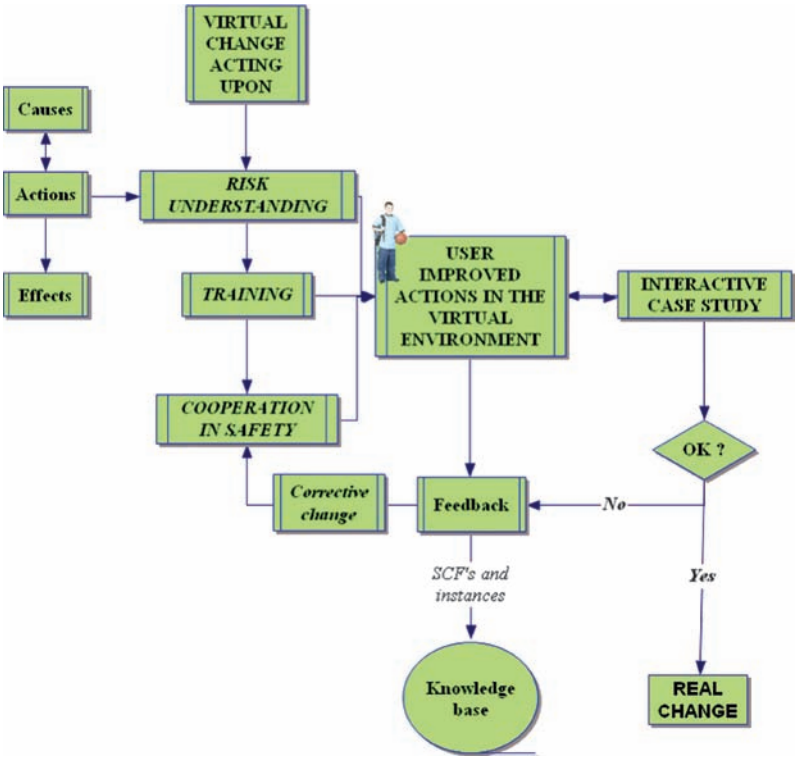


**Figure 4.** The individual user and VE

instances- the absence of the necessary details or quite contrary, the presence of too many details that could confuse the user. After the training in VE the user (worker) should be able to exercise his newly acquired skills and perform similarly in the real life. Figure 4 shows the interaction between the individual user and VE.

Inside the VE there could be also planned SC improvements/changes on a large scale – in the event of radical changes at the workplace.

## THE MULTI-ROLE ASSESSMENT SYSTEM (MRAS)

MRAS was developed so that SME's which usually are not well resourced in order to sustain an extensive safety assessment – could benefit as much as possible from this operation. So, MRAS performs quality, safety and environment assessments.

MRAS is starting with an ideal image given by the VE for the main activities performed inside SME – using as a reference base the main safety, quality and environment documents that the SME must comply with.

MRAS is conceived as a three levelled structure-like in the following image.

**Table 1.** Summary example of a MRAS assessment

| | Action | Attributes | | | | | |
|---|---|---|---|---|---|---|---|
| MRAS | Waste tanker load | Worker or work team | Task | Machine | Environment | Interaction | Score |
| Strategic points | Pre-action (action preparing)- fixing the hose coupling to the exhaust pipe | 4 | 5 | 5 | 5 | 3 (Chief of the work team failed to explain the correct pipe manoeuvring) | 4.4 |
| | Action- emptying the exhaust pipe into the waste tanker | 5 | 5 | 5 | 4 | 4 | 4.6 |
| | Post action- de-coupling the hose from the pipe | 3 (worker was careless in the de-coupling of the pipe) | 4 | 4 | 4 | 5 | 4 |

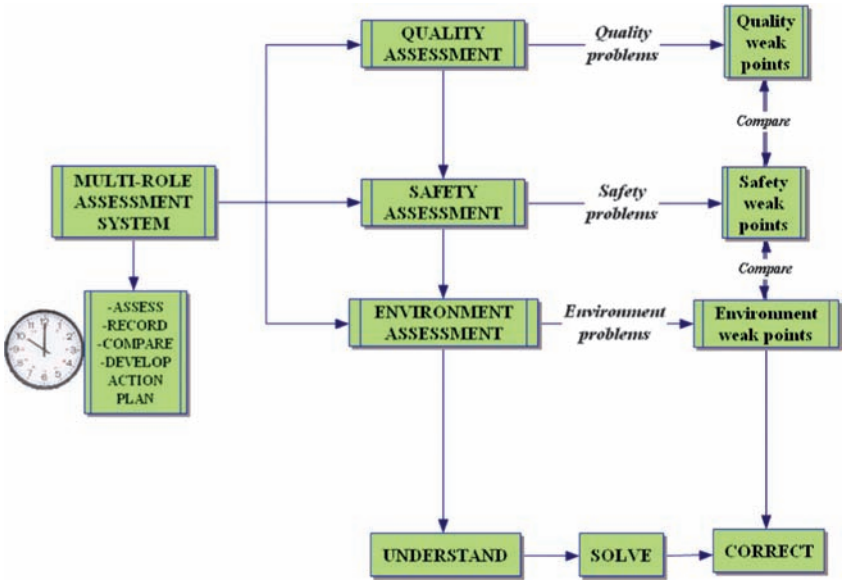


**Figure 5.** MRAS structure

MRAS is assessing the main activities performed by the SME- so this is a dynamic assessment. MRAS is performing its assessment taking into account attributes and strategic points which describe, together, work situations. A number of checklist items are defined for each situation. Every item could be assessed on a 0 (most unfavourable) ... 5(most favourable) scale. A summary example of such an assessment is presented below.

All the items equal or below 3 are considered as weak points and must be corrected. If the item is assessed equal or below 2 points an immediate correction must be made.

**Table 2.** MRAS benchmarking

| | Quality | | | Safety | | | Environment | | |
|---|---|---|---|---|---|---|---|---|---|
| MRAS BENCHMARKING | L1 | L2 | L3 | L1 | L2 | L3 | L1 | L2 | L3 |
| Preparation of ingredients for the chemical process | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 3 |
| Performance of the process | 5 | 4 | 5 | 5 | 5 | 4 | 4 | 4 | 3 |
| Transport of the main resulting products | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 |
| Waste removal | 4 | 4 | 5 | 4 | 4 | 4 | 3 | 5 | 5 |

The score is computed as an arithmetic mean of the attributes. All weak safety points must be documented. A cumulative example for quality, safety and environment benchmark is given in Table 2.

L1..L3 were three similar locations of petrochemical units (Bucharest, Piteşti and Craiova). It is very easy to see that L3 is a little behind L1 and L2 and must be helped in order to overcome its deficiencies.

MRAS MODULARITY

MRAS could be adapted accordingly with the size, activity and objectives followed by the SME in the assessment. A general image of this aspect is presented below.

A template of a MRAS report is presented in Table 3.

**Table 3.** MRAS report template

| | | |
|---|---|---|
| | **QUALITY, SAFETY AND ENVIRONMENT AUDIT REPORT** |  |
| Auditor: | Date:<DD/MM/YYYY> | Place of audit: |
| MRAS level:<br>B M E | I agree with the results<br><Manager> | I disagree with the results<br><Manager> |
| A.VULNERABILITY ANALYSIS | | |
| B.QUALITY ASSESSMENT<br>B.1.Quality weak points;<br>B.2. Operational plan to optimise quality<br>B.3. Connections between quality and safety *(for example Internal Document 23A is common)*<br>B.4.Compliance with ISO 9001;<br>B.5.Compliance with other quality documents (please name the documents); | | |
| C.SAFETY ASSESSMENT<br>C.1.Safety weak points<br>C.2.Immediate operational safety plan *(for weak points below 2)*<br>C.3.Operational safety plan *(for weak points equal 3)*<br>C.4. Common quality and safety weak points<br>C.5.Conexions between safety and environment *(example: Operation X is dangerous for safety and environment)* | | |
| D.ENVIRONMENT ASSESSMENT | | |
| E.COMPLIANCE ASSESSMENT<br>E.1.Compliance with quality documents<br>E.2.Compliance with safety documents<br>E.3.Compliance with environmental documents<br>E.4.Operational plan to solve compliance problems | | |
| F.QRA *(if needed)* | | |
| G.GENERAL BENCHMARKS | | |
| H.CONCLUSIONS | | |

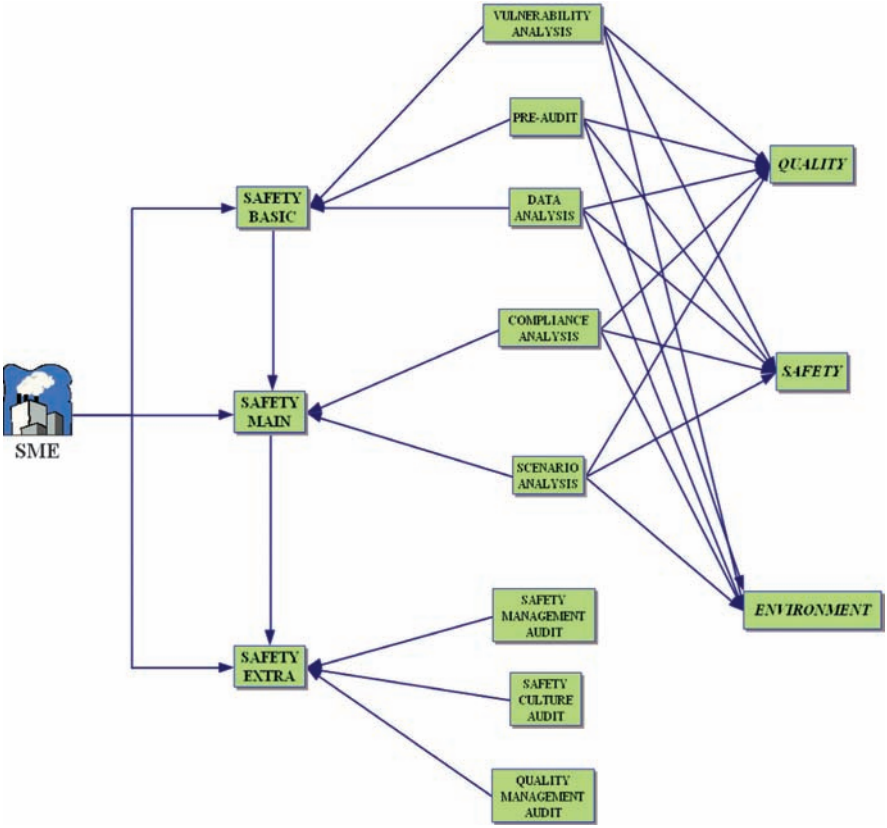


**Figure 6.** MRAS modules

## IMPLEMENTATION ASPECTS

Implementation was performed till 2000 through two channels:

- The Romanian Centre for SME's; it implemented the system in more than 1000 Romanian SME's from various industrial activities;
- The Romanian Institute for SME's implemented the system in 200 SME's from the research and learning domain. The system was implemented gradually, starting with the safety culture developer. Benchmark criteria were developed in order to assess the efficiency of the system. The main benchmarking criteria are given in Table 4.

**Table 4.** Main benchmarking criteria

| |
|---|
| **Safety culture development inside SME** |
| Previous (5 year media if possible) registered work related complains |
| Test period work related complains |
| Previous (5 year media if possible) registered safety related sanctions |
| Test period safety related sanctions |
| Test period actions regarding safety |
| Previous safety culture global index |
| Test period safety culture global index |
| **Multi-role assessments inside SME** |
| Previous (5 year media if possible) registered quality problems |
| Test period identified quality problems |
| Previous (5 year media if possible) registered safety incidents |
| Previous (5 year media if possible) registered safety accidents |
| Previous (5 year media if possible) registered safety problems |
| Test period identified safety problems |
| Previous (5 year media if possible) registered environmental problems |
| Test period identified environmental problems |

The set of established criteria[8] gives the possibility to have an objective feedback regarding the efficiency of the developed system not just globally but also for a specific SME or group of related SME's. The benchmarking set includes all the significant data that could be used in order to assess the interesting aspects.

## RESULTS

The process industry SME's that were included in our test lot had given some interesting results. These results were computed for a reference process industry SME and are presented in Table 5 as median values

It is possible to see an evident improvement of the criteria that are defining safety culture through the implementation of the system.

## CONCLUSIONS

The developed solutions had, as the main advantage their operational efficiency, together with a special adaptability regardless the specific type of economic activity. They are affordable even for Romanian SME's and could facilitate-through VE – the modelling of

[8]Stefan Kovacs, Apostol George 2006, Meme Based Cognitive Models Regarding Risk And Loss In Small And Medium Enterprises, in Proceedings of the Seventh International Conference on Cognitive Modelling, Trieste 2006, iccm 06 pg. 377

**Table 5.** Obtained results

| Criteria | Value |
|---|---|
| Safety culture development inside SME | |
| Previous (5 year media if possible) registered work related complains | 30 |
| Test period work related complains | 11 |
| Previous (5 year media if possible) registered safety related sanctions | 22 |
| Test period safety related sanctions | 6 |
| Previous ( 5 year media if possible) number of persons trained in safety matters | 10 |
| Test period number of persons trained in safety matters | 30 |
| Previous (5 year media if possible) registered actions regarding safety | 5 |

every major SME activity. The multi-role assessment system contributes not just at the safety improvement in the SME but allows also a general economic improvement through quality and environment. The Integrated Safety Management Unit (ISMU) is conceived in order to integrate not just these tools but every new computer-based tool developed for SME safety. As the solutions were implemented gradually into the SME safety structures from 2000, their performance shows us that they are viable. This integration could be performed easily, with the final objective the preservation and development of safety knowledge inside SME. As SME are the most risk prone enterprises in Romania their safety protection is of vital concern for our safety research.

We could estimate that our research was succesfull, leading to a decrease of incidents and accidents produced in the Romanian SME's by 20% in 2 years of reference (2004–2006).