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ANALYZING, CONTROLLING AND MODELLING THE HUMAN ERROR

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Abstract: *The human error, from time immemorial, seemed a guilty failure related to inconstancy of the human being able to do the best and the worst. In this paper, we propose an approach of modeling the human error while basing ourselves on modeling in company based on a global vision of the organization in order to explain the risky actions of the human. Indeed, we will inspire the multidimensional architecture of model GERAM (Generic Entreprise Reference Structures Methodology) to model the human error within a productive.*

Key words: *Human error, modeling, levels crossing, Safety, GERAM.*

1 INTRODUCTION

Man intervenes in all the cycle of life of an industrial facility, starting from the design, the realization until the exploitation, the maintenance and the downgrading of this installation. So the man constitutes an important component in man-machine system. It thus becomes necessary to take into account the human errors of design, calculation, assembly, control or maintenance while carrying out an assessment of human reliability.

Human error, from time immemorial, seemed a guilty failure related to inconstancy the human being able to do the best and the worst. It is at the same time an embarrassment for obtaining a regular, repetitive performance and the source of more serious failures which put in danger the integrity of the system.

The figures are many and convergent to confirm these reports: the analysis of the accidents charges from 65 to 80 % of the causes to the operators of first line in the sectors air, maritime, nuclear and medical [1]. If one refers only to the error rate, those usually reach 5 to 10 errors per hour, whose majority admittedly are immediately detected by the operator and are corrected without other consequences [2]. Still, it is, of course, necessary, to get along on the definition of the error. That which is subjacent with the figure previously quoted: it acts of a variation to the standards, it appears that what should have been done was not it (variation with the procedures recommended, with the usual practices of the profession...).

The complexity of the Personal element lies in the fact that after twenty-five years of efforts, the results remain always very unsatisfactory. Admittedly, the current level of safety can seem high (reduction of the errors, increase in the technical reliability and increase of the profits of productivity), but one must also admit the absence of improvement of the rate of catastrophes. One can wonder about the maintenance of the level of safety in the decades to come with the increase from the traffic, of the industrial production and thus increase in the request of the systems.

These are the relative disappointments which force to pass from normative models of prohibition of the error rather simple - even naive - to models more sophisticated much modeling of the human error requiring a major questioning of the dogmas of the human-Machine coupling and traditional ergonomics.

In this article, we propose an approach of modeling of the human error one basing itself on

model GERAM (Generic Entreprise Reference Structures Methodology) [3]. Indeed, we adapted the multidimensional architecture of model GERAM to model the human error within a system productive.

Indeed, we preserved two dimensions: instantiation and phases of cycle of life of model GERAM. While we replaced these four points of view by the four prospects relating to the study for the personal elements.

We will review certain milked of the personal element and we will clarify the elements which led us to resort to modeling in company to treat in a total and systemic way the human error. We will illustrate the step suggested by a model inspired of the modeling of GERAM applied a treating case of industrial study of the safety of the railway exploitation.

2 MODEL GERAM

GERAM is an architecture of reference developed by a ' think tank ' on architectures for the integration of companies (IFAC/IFIP Task force one Architectures for Enterprise Integration) [4]. After having analyzed principal architectures of reference available, namely CIMOSA, GRAI-GIM and PERA and of some other architectures (ARIS, ENV 40003 and IEM2), the group noted that it was necessary to preserve best methods of modeling and architectures existing to create a new architecture having qualities of its elder without their defects.

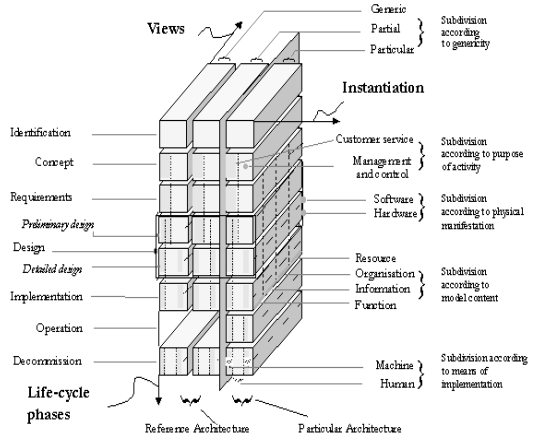

Fig. 1: GERAM Modelling Framework with Modelling Views

GERAM has several objectives [5]:

♦To provide a consisting environment of modeling which will possibly carry out to an achievable code by the computer.

♦To promote an engineering practises for reusable structures of the standard models.

♦To provide itself with a methodology detailed for the use, which's the personal development of any type of company, can easily rise.

♦To give the best possible treatment of the capacities of a company from a point of view of the systems.

♦To be generic A very standard of company without worrying about the complexity of industry and of its applications.

♦To provide a unification of the prospects for the production, treatments, development of the company and a strategic management.

♦The objective of GERAM is to provide a generic and reusable methodology, applicable to any type of company.

As proposed by [6], GERAM is a framework of work made up of six entities:

1.Generalised Entreprise Reference Structures (GERA), defining the cycle of life of the company proposes architecture at tree dimensions:

Cycle life allows taking into account the evolution of the company and kept a trace of what was made.

Generics (generic, partial, particular)

Seen (according to what one models): human (roles, organization, competences), Process (management and control), technology.

2.Generic Entreprise Engineering methodology (GEEM), allow to describing the various components to be developed to carry out the integration of a company.

3.Generic Enterprise Modelling Languages and Tools (GEMT&L).

4.Generic Enterprise Models (GEMs). They are characterized by concepts common to all the companies. The process of engineering of a company can use them like components of test for the construction of a model specific to a company.

5.Generic Models (GMs). They are standard implementations of components being able to be used in the integration of a company.

6.Generic Theories (GTs), they describe the generic aspects of the related concepts to the companies. They are also called theories of ontology and can be regarded as meta-models.

GERAM is based on a matrix graphic model of the cycle of life of a company, used as bases for the comparison and the evaluation of competences of each architecture studied. This model was

structured to include a presentation of the capacities and strong points of architectures [LUTH96].

3 PROBLEMS WITH THE LEVEL CROSSINGS LC

Level crossings are, from the safety point of view, critical points in the railways. Every year, more than 330 people are killed in more than 1200 accidents at road-rail level crossings in the European Union. This corresponds to about 50% of all fatalities caused by railway operations [7].

The accidents with the level crossings worry the organizations of regulation, the railway administrations and general public. The principal cause of these accidents is due to the personal element and the behaviour of the drivers. Successive generations of researchers are leaning on the problems raised by the level crossings.

The level crossing is a complex system utilizing the various facets of the personal element. The analysis of the personal elements intervening in the accidents with the level crossings was in the centre of several research projects, that it is in Australia [8], in Sweden [9] or the United States [10].

Aspects such as the visibility of the trains [8] [11], advanced traffic signs [12], the behaviour of the drivers [8], the distractions of the drivers [9] and the taking risk [13] were retained among the personal elements and different which frequently contribute so that occur of the accidents between a vehicle and a train with a level crossing. According to "National Transportation Safety Board", the majority of these accidents occur even in full clearness and under good weather conditions. It is the interaction of several contributively factors, of which the behaviour of the drivers and characteristics of the level crossings, which are with the source of the majority of the accidents [14].

The analysis of the personal elements constitutes an important progress in the knowledge of the accidents occurring with the level crossings (LC). It is a question of decreasing the number of accidents and the financial losses which result from this and consequently to decrease the number of deaths and wounds at the drivers and the passengers [15].

Our research task returns within the framework of a European project SELCAT "Safer European Level Crossing Appraisal and Technology". This project aims at contributing actively to the reduction of accidents to the level crossing whose objectives are:

- Collection, analyzes and diffusion of the existing results of research and the stimulation of the exchange of new knowledge as regards the safety of the level crossings between the Member States of the European Union and some countries except Europe;
- Reinforcement of collaborations between the sectors railway and road, to bring a significant contribution and co-ordinate with the reduction of accidents, damage and deaths with the level crossings;
- Analysis of the research existing and envisaged in the countries except Europe;
- Harmonization of the data bases accidents/incidents relating to the level crossings
- Research of new technologies to optimize the technical evolution to widen knowledge and the data bases.

On the level of the National office of the Railroads (ONCF), the level crossing presents a critical point of circulation. It is the place where vigilance must be multiplied. The public intervenes mainly and risks it with the Man is major. It thus acts of a particularly dangerous point which requires the maximum of precautions and attention.

In July 2007, the network of the railroads Moroccan counts 544 level crossings of which:

- 48 of first category (kept),
- 479 of second category (not kept).
- 17 for pedestrians.

One can classify his level crossings according to two categories:

- First category: includes/understands the crossings level provided with kept barriers day and night of which each one is coupled with a wicket for pedestrians,
- Second category: includes/understands the level crossings without barriers. As for the level crossings for pedestrians, though public, they are reproduced on the list of classification without definition of category.

To minimize the risk, two solutions were proposed:

- To replace the level crossings by made uneven passages,
- To remove the level crossings completely.

Is the suppression of the LC is a long-term undertaking because of its cost, between 30 and 45 million Dirhams on average (1 Dirham ≈ 10 €), times of study and relatively long achievements (approximately 5 years), finally the topography of the places does not lend itself always easily to the operation.

4 MODELISATION OF HUMAN ERROR INSPIREE OF ARCHITECTURE GERAM

GERAM architecture is constituted of three dimensions to knowing instantiation, the phases of the cycle of sight and the points of sights. The adaptation of the GERAM to the modeling of the human error consists in establishing an analogy between these dimensions and those relating to the study of the personal element (dimension social, technical, cognitive... etc).

The objectives sought by the adaptation of architecture GERAM to the modeling of the human error in critical sectors (e.g. Transport) can be synthesized as follows:

♦To provide a consisting environment of modeling which will possibly carry out to an achievable code by the computer.

♦To obtain a detailed methodology in order to acquire a better human performance.

♦To give the best possible treatment of approach of the studies of the personal elements.

♦To be generic A very standard of system without being concerned with its complexity.

♦To provide a unification of the prospects to study the personal element of the organisational level to the last operator.

For the adaptation of three dimensions of architecture GERAM, we've taken on:

1.Instanciation: In this dimension, we kept the same constitution while respectively transposing the three levels of generics;

▪ Generic: property of railway transport

▪ Partial: the ONCF "National office of the Moroccan Railway " (general strategy of the office, programs total intervention in safety with the stages regional and national, comprising the establishment of priorities among the countermeasures to be applied to the high-risk level crossings, required goals with short, average and long term).

▪ Private individuals: level crossings (Standard of LC, site LC, moment of circulation, installations of the LC).

2.The phases of cycle of life: The cycle of life of GERAM makes it possible to take into account the evolution of the company and to keep a trace of what was made. In our approach, as long as our study is interested in the personal element, we will replace the cycle of life of GERAM by the model Stepladder de Rasmussen (1986). This choice was fact of which the goal to follow the step of study of the human errors.

3.Typology of the sights: In this part, we modified the various points of sights present in modeling GERAM by the four prospects used usually to analyze the personal element:

Fig. 2: Stepladder model Rasmussen

♦Cognitive: this sight makes it possible to represent the mental activity of the individual for the decision-making. It calls upon its formation and its experiment.

It is via the mental activity (brain) that is made the Data processing according to a logic processing and/or a calculation of parameters, bringing into play memorized knowledge.

In this point of view, we will approach mental activity, the Resolution of complex problems and the Diagnosis of incidents or accidents.

We will also study: Charges (overload or under load) of work, manual variability, knowledge misses on the principles of use, knowledge misses on the consequences, intrusion of strong practices, inappropriate use of rules etc.

♦Behavioural: this sight represents the whole of the attitudes, the actions and the reactions physics of the operator following his decision-making. It describes the observable part of the error (forms and consequences).

Two kinds of behaviour can be exerted by the following functions; drivers and of the pedestrians, guards barriers and Brigade of train (figure 3).

♦Contextual: this sight describes the context and the situation in which the individual carries out his task.

In our case, the context to cross it LC depends on several parameters of which:

▪ Visibility of the train:

Weather conditions (Rain, wet Roadway, dazzling Sun, Wind and moment of the day)

Obstructions

Site of the LC: angle of the railway compared to the road, Presence of curve on the level of the road, rise in the level crossing, Intersection with

Trunk road, Intersection with minor Road, Close to a junction).

Behaviour Functions	No intentional behaviours	Intentional behaviours
Pedestrians and drivers of vehicle	Good knowledge of the LC, error of recognition or decision, handicap, eye trouble, state mental/emotion al, planning, experiment, age	Clashes of barriers, attempts to precede the train, skirting of the barriers, tires/stress, alcohol/drugs
guard barrier	State mental/emotion al, heart attack, experience.	Barrier open to the moment of passage of the trains, Tires/stress, alcohol/drugs, abandonnement of stations
Brigade of train	state mental/emotion al, heart attack, experiment, to pass up a station, lake of recognition of the train	Not application of the deceleration, Not respect of signals, tires/stress, alcohol/drugs

Fig. 3: Nature of behaviours by functions

▪ Constraints physical (Time, space, kinetics (speed of train and the vehicle).

▪ Distraction (interns and external).

▪ Nature of LC (kept LC, LC not kept).

▪ Nature of the vehicles (light vehicle, heavy Vehicle).

In our study, we go floor on the level crossing keeper, the brigades of train, the drivers of vehicle and the pedestrians.

♦Organizational: it represents a whole of individuals gathered within a controlled structure, having a communication system to facilitate the information flow. This system aims at meeting needs and to achieve given goals.

The organizational system corresponds to the organization of the various activities of working station and its interaction with the other stations.

The organization of work itself, the qualification necessary in technical terms for a station, the degree of autonomy and responsibility for the operator, the structure of the hierarchy of proximity and upstream are defined by the organisational system. The organization of work exerts an influence on the individual and modifies its lived. In our case, we will study the function of the guard barrier, in the case of the LC of first category, and its interaction with the functions of Chief of district, chief of cantons and brigade of train. While for the LC of second category, one will be interested only in the functions of brigade of train and chief of cantons.

The modeling of the human error one taking as a starting point the modeling GERAM, will be to apply according to dimensions' quoted beforehand. A three-dimensional study seems necessary in order to determine the personal elements which come into play the accidents occurring to the level crossings and to recommend countermeasures adapted to the current demonstrations of the probable causes of the accidents.

To this end, it is necessary to follow a structured approach of attenuation of the risks while analyzing on the one hand, the behaviour of the drivers, pedestrians and vehicles. On the other hand, by examining the personal element of the ONCF (Guard Barrier, Brigade of train, Chief of district, and chief of cantons).

5 CONCLUSION

The objective of the modeling of the human error aims to:

▪ To minimize the risks of errors with the LC, the levels individual and collective;

▪ To reduce the vulnerability to the errors of certain tasks;

▪ To identify, evaluate, eliminate the factor of production from errors to the LC (and of violations);

▪ To diagnose the organisational factors which create factors of production of errors (on the levels individual and collective);

▪ To improve the tolerance with the errors (working station, system);

▪ To facilitate the detection of errors;

▪ To make more visible the latent errors with the persons in charge for the system (operation and management);

▪ To improve intrinsic resistance of the organization to the human failure.

▪ To help to include/understand the mental context of the operator at the time of his interactions with the interfaces

The modeling of the human error is a very important step with an aim where it answers several problems in order to include/understand and to determine the human error. In the same

way the application of this step to the level crossings, makes this study very useful considering the number of collisions which reproduce with the level crossings and which worry the organizations of regulation, railway administrations and general public. Our research task returns within the framework of a European project SELCAT, to contribute actively to the reduction of accidents to the level crossing on a national and international scale while managing the human error which is at the origin of 64% of the rail crashes.

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АНАЛИЗИРАНЕ, КОНТРОЛИРАНЕ И МОДЕЛИРАНЕ НА ЧОВЕШКА ГРЕШКА

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ФРАНЦИЯ

Резюме: *От незапомнени времена човешката грешка изглежда като провал с вина, свързана с лекомислеността на човека, който е способен да направи най-доброто и най-лошото. В доклада се предлага подход за моделиране на човешката грешка на базата на моделиране в компанията въз основа на глобалното виждане на организацията, за да се обяснят рисковите действия на човека. Наистина при моделирането на човешката грешка ще насърчаваме използването на модела GERAM (Generic Entreprise Reference Structures Methodology) като структура с много измерения.*

Ключови думи: *човешка грешка, моделиране, прелез, безопасност, GERAM.*