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**ARIADNE –
Internet Based Error Risk Management and Prevention System**

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Abstract

Official statistics state „incorrect behaviour“ as cause of most road, air or working accidents, e.g., and conclude that there is hardly anything to do about that. Experts, however, ask why even experienced operators control inadequately or make incorrect decisions. This paper gives an overview over 8 years of related accident and risk analysis research. The underlying accident emergence and risk management model treats human error as accident cause. Those errors emerge from causal factors that are already present in any environment and cause latent risks. The analysis of this complex network leads to the prediction of causal factors` risks and cost. Preventive measures are formulated and risk changes predicted on the basis of “What-If” algorithms. An internet application was realized that covers more than 2000 descriptors including 30 cost categories, 35 action, perception and cognition errors and 130 causal factors. The article presents model, methodology as well as the internet application and some results.

Keywords: accident, incident, human error, causal factor, cost calculation

1 Introduction & Problem Statement

Accident statistics show that incorrect behaviour causes more than 50% of road, air, or working accidents and incidents, e.g. Publicity is at ease and concludes that there is nothing you can do about that. Experts, however, know that this may be not the last answer in risky high technology environments because accidents cause:

- System loss
- Know-How loss
- 25.000 €cost per working accident.

They ask why even experienced operators control inadequately, ignore rules and regulations knowingly, oversee important information or make incorrect decisions. They conclude that always when humans operate or decide they mould risk, safety and security of any system, and that not only technology, but also organisation and personnel are the keys to risk and reliability.

And here is the link to human error. The human error concept does not only address faulty behaviour in the actual accident situation but also identifies errors and causal factors in the underlying network (Reason 1990). It treats errors as a common product of behaviour in human-machine-systems and organizations (Senders & Moray 1991).

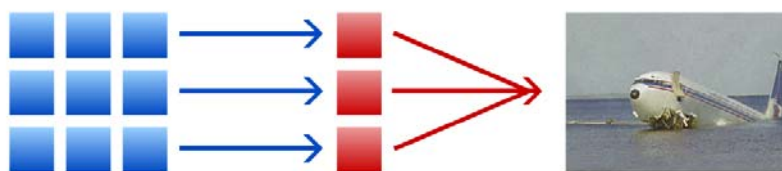
The idea of the current project ARIADNE was to focus on errors and to document and analyse them as well as causal factors and their interactions in order to identify risks involved and formulate preventive measures with this information. ARIADNE states the following hypotheses:

- You may prevent errors
- You may tolerate unavoidable errors
- You may toy with errors
- You may learn from errors.

Or, with Frieling & Sonntag (1991), “Human errors are a substantial source of knowledge with respect to technical, organisational and personal preventive measures”.

2 Methodology

Following this idea the Three-Level-Model of accident evolution in Fig. 1 was developed. Basically, a number of causal factors lead to human errors that may result in an accident or incident.



Causal Factors

Errors

Accident

Fig. 1: Three-Level-Model of accident evolution

The underlying working model shows details in Fig. 2. A pilot like any other operator acts according to task and information, gets feedback and produces output. The personnel, organizational and technical as well as environmental conditions shown on

the left side of the Fig., i.e., causal factors, are already present in any environment and cause latent risks promoting or impeding performance and error evolution given on the right side of the Fig.

Causal Factors

- Working Organization
- Communication
- Personnel & Qualification
- Quality Management
- Attitude
- Behaviour
- Physiology
- Environmental Conditions

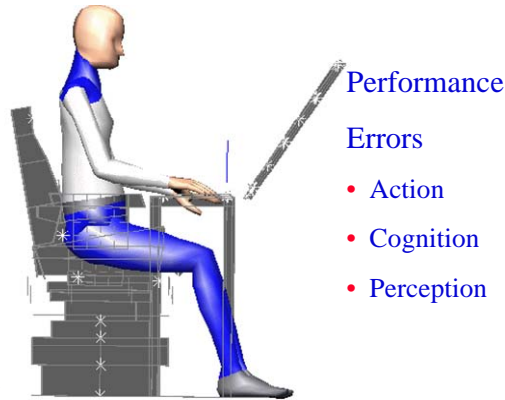


Fig. 2: Working model

The aim of prevention was achieved as follows. The underlying accident emergence and risk prediction and management algorithmic model was developed according to K ppler & Dalinger (2005). It uses human errors and causal factors as predictors of the criteria accidents` and incidents` cost, injuries and casualties. ARIADNE, the accident and incident data recording and analysis as well as risk management and prevention system was designed accordingly and realized as a modern LAMP internet application, see Fig. 3 (LINUX operating system with APACHE server, MySQL data base and PHP language). The system is accessible via internet from any client computer using a standard explorer. A Virtual Private Network VPN, user keys and passwords, certificates as well as the https connection provide up to date safety standards.

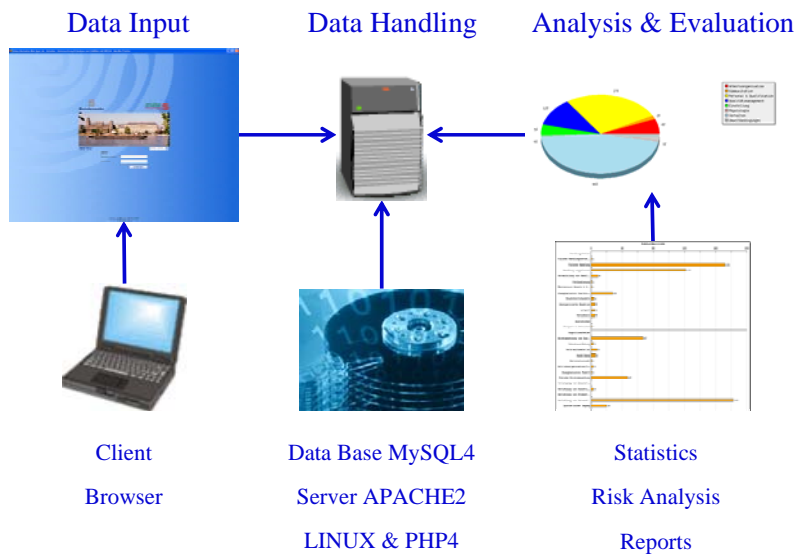


Fig. 3: ARIADNE risk management and system analysis

ARIADNE provides more than 2000 accident and incident descriptors to the analyst that may be selected from pre-defined key-tables. These cover casualty and personnel as well as material damage cost in 30 categories. Action, perception and cognition errors may be selected from a list of 35 errors together with 130 causal factors in the categories shown in Fig. 2. Probabilities presence of errors` and causal factors` as well as their causal effect are judged by the analyst on a five point scale in the categories “not at all, less probable, eventually, rather probable, definitely”.

The statistical analysis of this complex network is provided on line and shows histograms and diagrams of objective accident descriptors (e.g., time of day, age, location, etc.), errors` and causal factors` frequencies and cost. The risk calculation model predicts risks and cost of both, errors and causal factors. Related preventive measures aiming at improvements of performance, safety, reliability, humanity or cost reductions are formulated in terms of organization, technology and personnel. Expected risk changes are simulated and predicted on the basis of “What-If” algorithms in the model.

The quality management section of the internet application provides control tools for implementation, control and validation of preventive measures.

3 Results

This chapter gives an overview over typical results from the actual investigation of accidents with weapons & ammunition. All results below were calculated online and the Figs. are internet downloads. 855 related events had been documented and analysed. In total, 1976 errors and 3658 causal factors were found. Their total cost amounted to 9.75 million Euros. Fig. 4 shows that 5% of the events caused 80% of the total cost.

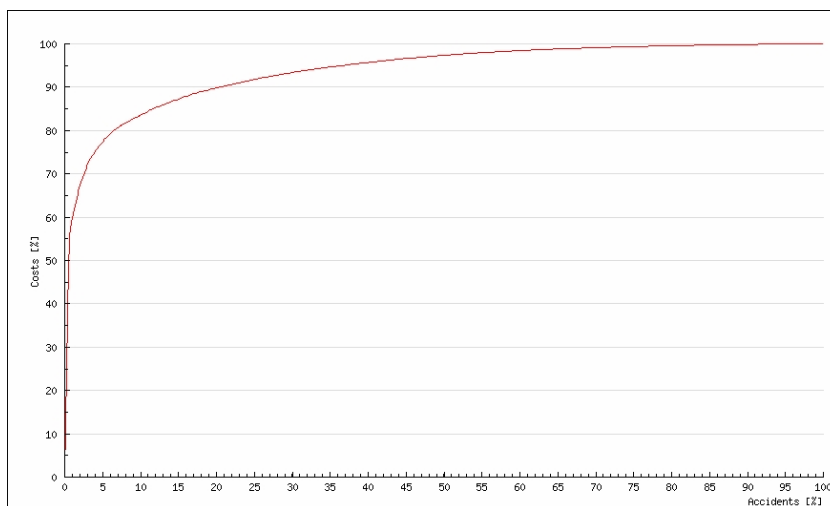


Fig. 4: Rotated Lorenz-function of cost vs number of events in %

Fig. 5 shows the number of events as a function of weekdays. 25% of events occur on Wednesday, commonly the accident prone day in working environments. The Figs. 6 and 7 show error and causal factor distributions. More than half of the errors are cognition type errors, and nearly half of the causal factors detected are behavioural.

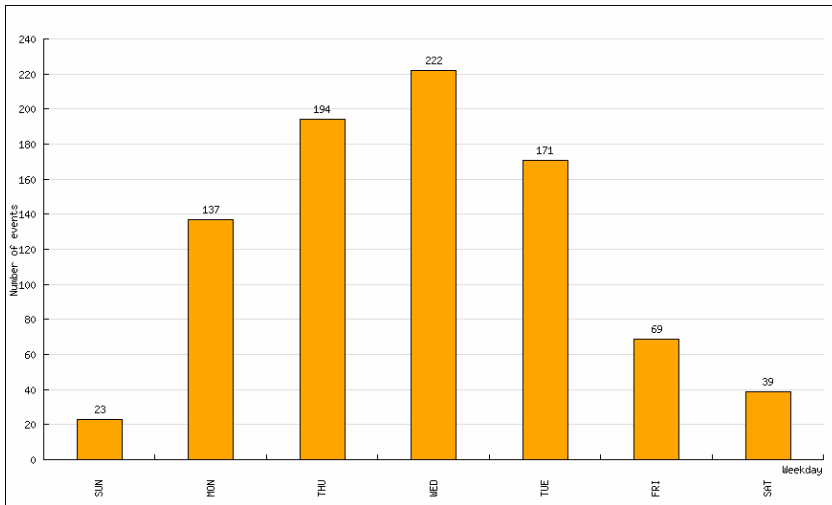


Fig. 5: Histogram of events as a function of weekdays

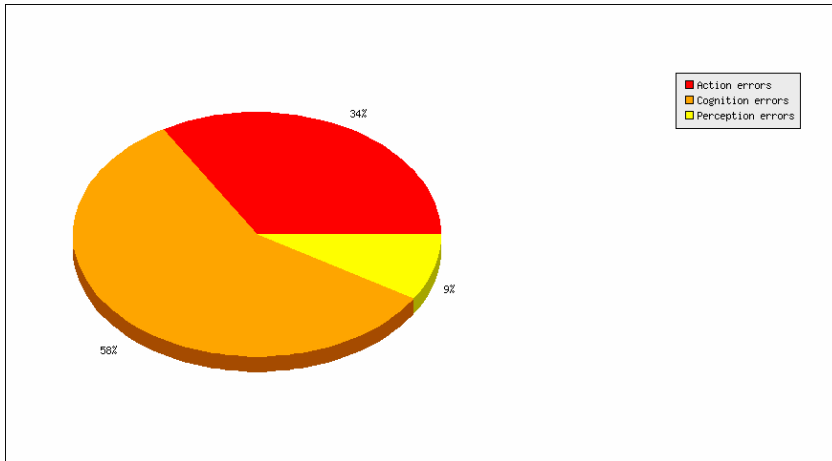


Fig. 6: Distribution of error types

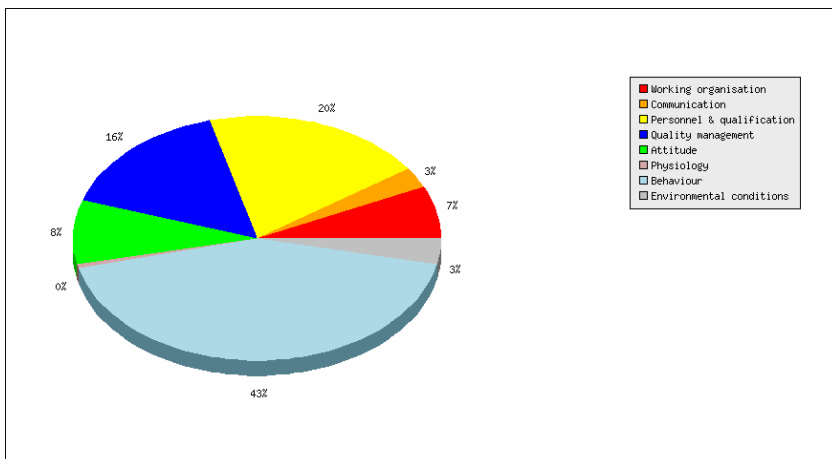


Fig. 7: Distribution of causal factor types

More detailed information may be derived from the risk and cost analysis. Figs. 8 and 9 break the cost risk assigned to cognition errors and to behavioural causal factors down

to subcategories. Nearly one third of the events` total cost risk is caused by rule violations. Within behavioural causal factors the lack of knowledge causes 15% of the total cost which is the highest cost risk.

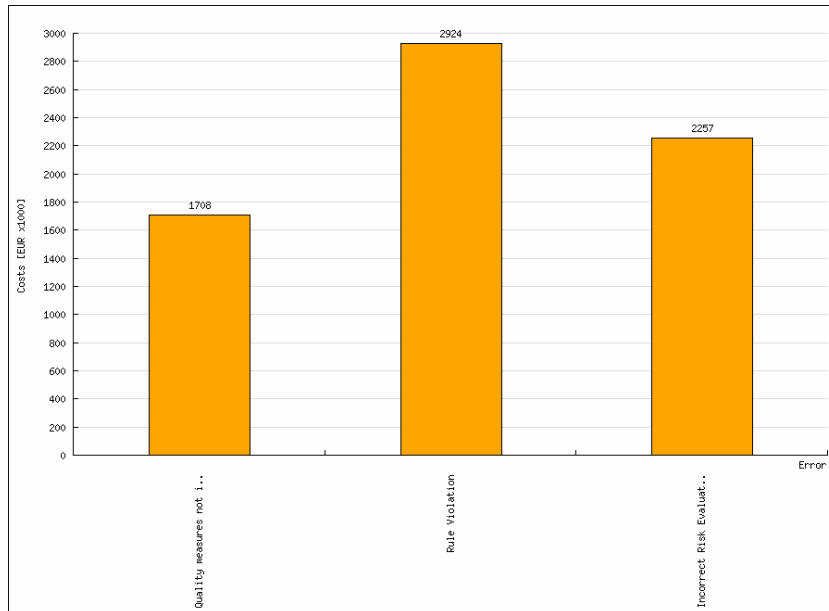


Fig. 8: Cost risk associated to cognition error subcategories`

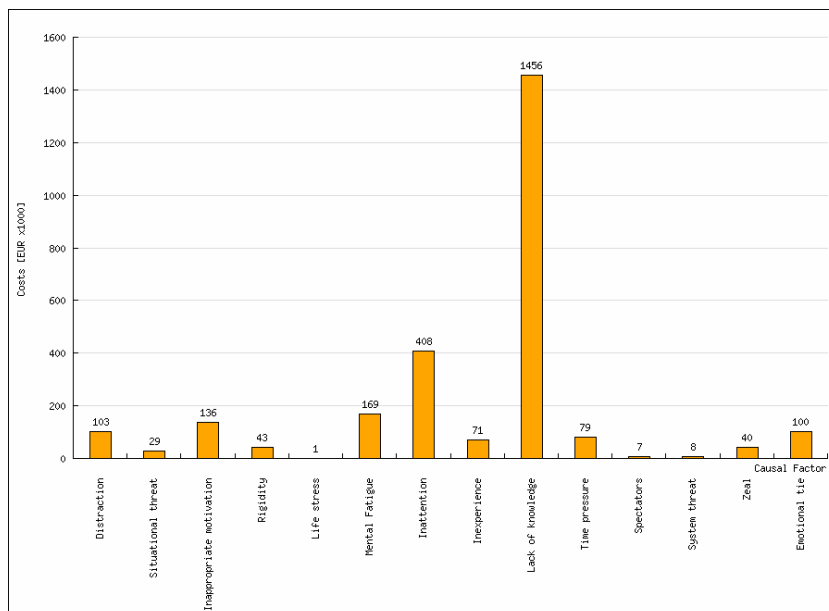


Fig. 9: Cost risk associated to subcategories of behavioural causal factors

These results lead to proposals of two preventive measures:

- enforcement of rules and regulations
- training optimization.

The more detailed analysis not presented here shows which rules and regulations in detail are to be enforced and which kind of knowledge is to be improved. Assuming an

effectivity of the measures finally taken of about 50% a total amount of up to 1 million Euros may be saved in the future. These savings and the improvements may be validated after measure implementation by ARIADNES` quality management tools through comparisons of actual and future accident and incident data.

4 Conclusions

It was shown that human error based accident and incident analysis together with risk management may lead to risk reductions and cost and harm preventive measures. Main advantages of the actual approach are:

- World wide on line accident recording, analysis and risk management
- World wide on line availability of data, reports and archives
- Detailed information on preventive measures and trends
- Detailed system design knowledge about personnel, management and technology
- Increased humanity through savings of lives, injuries and harm
- Economic efficiency with savings of knowledge, systems, time and cost
- Cost effective application without proprietary software
- Easy application adaptation to road, air, ship ...accidents
- Future application extension with proactive information and generic models.

5 References

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