Review: System Reliability Analysis Based on Software Properties

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Abstract

System Reliability Service (SRS) establishing the reliability of the historical development is discussed against the background of a computation covering multi-disciplinary groups organized under one management. Analysis, project evaluation, research and development, and a background spanning almost twenty years ago, to vast data bank of different ways reliability. Data nuclear plant safety assessment of the bank's core operations and systems as well as applications as general SRS techniques were being discussed. These techniques, developed. The system is designed for. Then, not only safety but also to determine the reliability of availability was extended to cover aspects.

Administrator, and man-machine interface other system components, this paper to study the reliability of the development process extend these methods. To study the feasibility of the approach, the paper orientation of a system reliability analysis and reliability growth model is evaluated using the results of an experiment in which the analyzes. Graphic man-machine interface is related to the evaluation and operators, and the software control system can be extended to. Experimental results and trend analysis, reliability growth models within cognitive science approach to qualitative performance assessment can be complementary to show that

Index Terms - *System reliability, software engineering, software reliability, Reliability Engineers, Reliability Services.*

I. INTRODUCTION

Increasingly, computers prompt answers, or create a large amount of revenue based on complex problems, solutions or decisions or actions that require support in carrying humans. The system software and human resources showed a tight integration. In some applications, this type of system failure, human life, environmental effects, and / or in terms of economic loss can cause serious damage. Typical examples cur rent nuclear or chemical process, air traffic control, and transportation systems will be controlled [1].

Operator error arising from the actual automation to reduce risk was anticipated, it does not remove it from the system. Automation increases the responsibilities of designers, and supervisory control and decision-making for a high level suggests operators. Emergency response to the supervisory tasks and new people moving, underestimated in the past, brings risks to the fact that there has been increasing recognition. I still highly flawed human decisions and actions have the potential serious consequences. And other equipment when it is designed [1].

Equipment reliability analysis equipment and technical support is the basis of the system. Fault tree analysis (fault tree analysis FTA), after years of development, the FTA through this method, system reliability analysis equipment has become an effective devices, a method for system reliability analysis , the system detected threats, and can be useful data to evaluate and improve system reliability, more weapons and equipment to improve reliability can be provided.

Currently, the separate system, software, and hardware components that address are estimated using methods. Most hardware and software partner integration efforts limited to design, and human-computer interface are some aspects. Research usually only a hardware, software and human components addresses.

This paper-based human resources software system reliability and the trend is to study an experimental effort. This operator training, and during the stages of human ma- chine interface is designed. Reliability trend anal- ysis techniques and using reliability growth model is evaluated.

II. INTRODUCTION TO FTA

FTA's key initiatives include: fault tree construction, fault tree analysis of qualitative and quantitative description of the calculation.

A. Fault Tree Construction

Fault tree construction is the key to FTA; its maturity will directly affect the accuracy of qualitative and quantitative results.

Fault tree symbols and the symbols used are mainly divided into events in two types of logic gate symbol.

- Collects and analyzes relevant technical information relating to the equipment system fully systems knowledge is on the basis of identifying several of factors effecting on equipment systems; Identification may include a variety of system state models, the relations between these models, the unit status, and transitions between these statuses.
- According the information which will result in system failure, all fault events are listed, and

based on faulty analysis for tasks and associated criteria to determine the top event.

- Setting the identified top event on the upper, the factors that cause all the top events in the second row, depending on the actual relations of system and appropriate logical connection between top events and the direct cause of the event. Repeated the above analysis, until the end of the minimum row causes.

B. Mathematical Description of the Fault Tree

Assuming all equipment components and systems research are only two normal or faulted states, unit failures are independent with each other. According to the analysis of key tasks, clear analysis of the system and other systems (including human and environment) interface, then make certain assumptions, a major logical relationships equivalent of the simplified system is built based on the real system figure.

C. Qualitative Analysis of a Fault Tree

Qualitative analysis of a fault tree aims to find out the cause of the incident and combination of causes, and identify all potential failures in the system factor, to provided plan for fault diagnosis and maintenance.

- Cut set is a collection of some events at the end of the fault tree, when these events occur at the same time, which will inevitably lead to the top events. The minimum cut sets is a minimum set of events occurring at the end of the collection, when the collection of all events occurs, events must occur, its complementary set will not occur. The task is to find out the all minimal cut sets of the incident.
- Minimal cut set method is based on the fault tree structure, analysis from top to bottom, find the minimal cut sets of events at the end of the event. From the logical relationship between the upper and lower levels, increase the number of cut-order only (but the number of events at the end of), does not increase the cut number; or increase the cut number, do not increase the number of cut-order.

D. Quantitative Calculation

In quantitative calculations, we do not consider the intersection between the minimal cut sets.

III. COGNITIVE VIEW OF HUMAN PERFORMANCE AND RELIABILITY

Cognitive psychology is a discipline studying how humans acquire information, represent it internally, and use it to guide their behavior. This discipline emphasizes the role of intentions, goals, and meanings, as a central aspect of human behavior. An influential classification of the different types of informa- tion processing involved in control of systems such as chem- ical-process plant or nuclear-power generation was developed by Rasmussen and is described in. Rasmussen identi- fied three levels of information-processing at growing levels of conscious control, on which the human behavior is based. He defined these levels as “skill-, rule-, and knowledge-based be- havior,” describing how switching occurs between the different level of information processing in process control, and how an operator learn from experience.

The skill-based level involves an automated sensory-motor behavior in responding to external signals, with the operator per- forming the required control-task without conscious attention. Riding-a-bicycle is a good example of this type of behavior: the task is very complex but is performed automatically with the human responding with no conscious attention to signals giving information about speed, slope, and direction. The ability to use this type of behavior in some control tasks is reached and main- tained by learning from experience and errors and using higher levels of information processing for checking progress in the goal-directed activity.

The rule-based level requires a more conscious involvement. Actions are controlled by stored rules or procedures (heuristics); selection of appropriate rules is controlled by inferences about the current state and events. For example, an operator gathers information from various sources and uses them as input to di- agnostic rules of the type:

If, as a result of applying the action rule, the problem is solved, the operator will switch to the skill-based level. If the problem is not resolved, further information can be gathered, to try to iden- tify a pattern of symptoms corresponding to a known cause. If the cause of the problem cannot be established, then the oper- ator must use the highest level of information processing. Again, training, experimentation, and errors are necessary to develop and adjust efficient rules, and to identify the conditions under which the rules should be applied.

The knowledge-based level is used to solve problems that cannot be identified and solved using available rules. “In this situation, the goal is explicitly formulated, based on an anal- ysis of the environment and the overall aims, and a plan is con- structed. The plan can be formulated: 1) by selection, where dif- ferent plans are considered and their effect is tested against the goal; 2) by physical trial and error, or 3) by a conceptual under- standing of the functional properties of the environment, and prediction of the effects of the plan being considered” [11].

According to this view, Reason defined [26] four ways by which human cognition shows its processing limits leading to human errors:

- **Slip** occurring when there is a mismatch between intention and action: the intention is satisfactory, but the actions are not carried out as planned. A slip is mainly due to some kind of attentive failure in the low-level of action control, and usually occurs in routine situations characterized by automatic and over-practiced behavior.

- **Lapse** consisting of memory failures, and concerning ei- ther the intention of the action under execution, or its cor- rect execution, or the information necessary to perform the action that cannot be retrieved from memory (e.g., tip of tongue).
- **Rule-based error** usually consists of the wrong activa- tion of well-known rules or procedures, either in identi- fying the situation where the rule should be applied or in adopting the plan of action.

• **Knowledge-based error** occurs when a selected plan, or even the intended goal, is not adequate to solve the problem. Knowledge-based errors are attributed to lack of completeness of the mental models used, and/or a fault in causal thinking. People are not able to recognize properly the relation between different aspects of the problem or to achieve an adequate diagnosis of the problem.

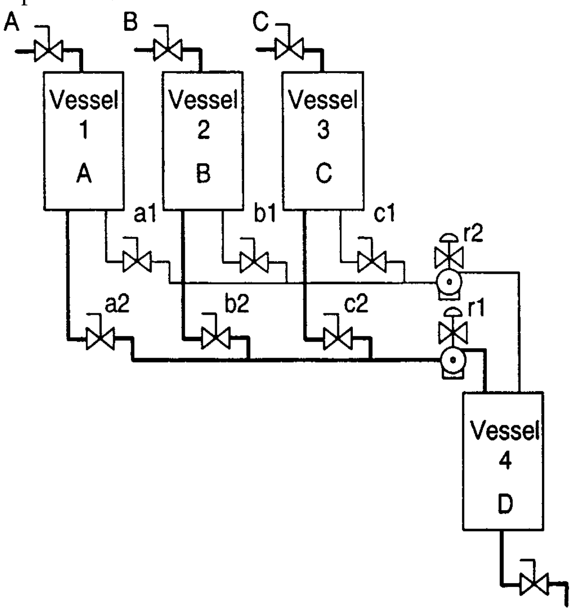

Figure: Simulated process to be controlled.

IV. EXPERIMENT RESULTS AND DISCUSSION

A. Results

the average of the interfailure times for the operators of the groups A, B. Data of the single op- erator are not reported here for reasons of clarity and simplicity. Table II shows the standard deviation and the analysis of vari- ance, with the effect on - significance for hypotheses 1 and 2.

The arithmetical mean of the interfailure times for the 2 operator-groups, with the mean calculated for each single failure as

$$\tau(i) = \frac{1}{i} \cdot \sum_{k=1} \theta_k$$

θ_k are the interfailure times.

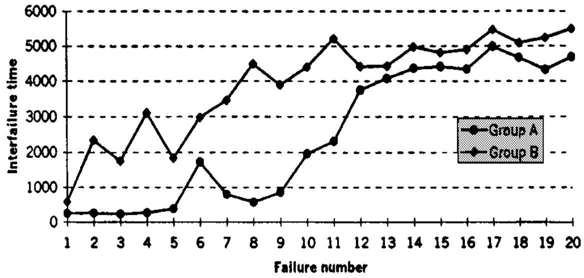

Figure: Average of the interfailure times for groups A and B.

	Hypothesis 1	Hypothesis 2
Std.Dev. group A	2137	N/A
Std.Dev. group B	3018	N/A
Degree of freedom	19	19
Fisher dist.	17.60	1.88
s-Significance	$p < 0.001$	$p < 0.05$

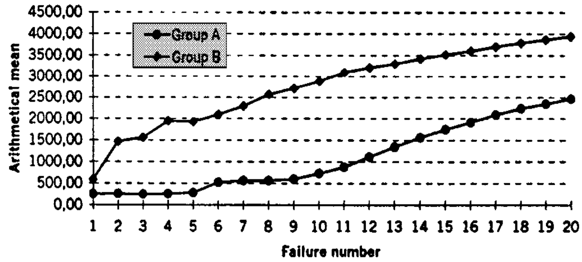

Figure: Arithmetic mean of the interfailure times for operators of groups A and

B.

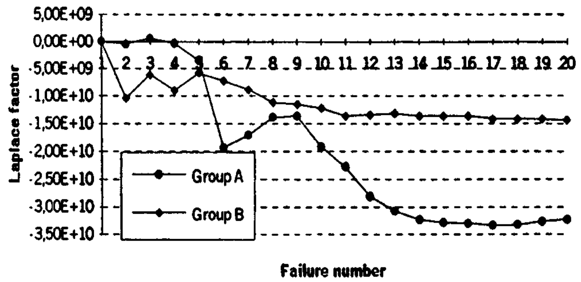

Figure: Laplace test results for the two groups of operators

The increasing series of $\tau(i)$ indicates a clear reliability growth for the operators, confirming the intuition given by the analysis of the raw data.

Fig. shows the results of the Laplace test for the operators of groups A and B. The value of the Laplace factor is derived as in [9]. The Laplace test shows that the growing trend for the operators of group A is not constant until failure 8. For this group the Laplace factor is stable from failures 1 to 4, indicating local reliability fluctuations. For failures 6–8, the Laplace factor is increasing, indicating a local reliability decrease, despite an overall reliability-growth. After failure 9, the Laplace factor in- dicates a clear growing trend in reliability.

Three reliability-growth models were applied to raw data of groups A and B. The best models for predictions from specific data must be selected by analyzing the accuracy of past pre- dictions on the same data. CASRE provides several analysis techniques (goodness of fit, PL, bias, noise, and trend) for the models available. Table III shows the result of this analysis for the models used.

The L&V model was selected for the data of group A. This model has a low "goodness of fit" (it does not fit the data at the 95% -significance level), but it has the lower "noise" and best PL. In addition its bias is very stable (optimistic) during the whole period of observation.

B. Discussion

The first two work-hypotheses are confirmed by the analysis of variance in Table II. The first work-hypothesis is a quite ob- vious result that can be easily confirmed by observation. The second work-hypothesis supports the idea that different inter- faces could be evaluated on the basis of the operator reliability- growth. But this result has a meaning only if one considers the average performance of different operators.

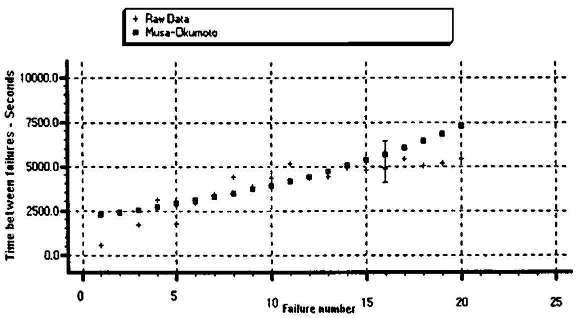

Figure: Example of the predictive ability of the M–O model applied to data of group B

There was a high level of fluctuation in the reliability of single operators and a high variance between different operators. This is also shown by the significance level 0.05 for the second work-hypothesis.

The validity of the other two work-hypotheses is less evident and is based more on interpretation of the experimental data. Even the analysis of the raw data can show intuitively the superi- ority of the new interface, used by group B. This analysis shows that with the new interface, operators have part of the knowl- edge required to control the system, immediately available and represented externally by the interface display. This reduces the effort required to begin working correctly with the plant. After a certain period (after failure 12 in our data), operators working with the old interface reach the same level of knowledge, cre- ating an internal representation of the same information. At this point the difference between the two interfaces decreases. The remaining difference could be because: in particular stress con- ditions the new interface still has the advantage of reducing the mental workload of the operator. This claim is confirmed and strengthened by the analysis of the trend tests. The arithmetic mean clearly shows the learning process of the operators, elimi- nating the local fluctuation. This advantage is more visible with the data concerning the single operators (not reported here for lack-of-space) because local fluctuations are more evident than when dealing with average values. Another phenomenon that can be appreciated from trend test is the "saturation" effect of the training process. After a certain period (approximately 14 failures) the increasing trend is less evident, perhaps because of a reduced ability of the operators to increase their skill just from simulation.

C. Limitations

Quantification is extremely difficult when dealing with human behavior, and inappropriate generalizations of prelim- inary results can be completely misleading. Thus, consider carefully the limitation of this study when trying to draw general conclusions.

A limited number of failures were considered during the experiment, while trend tests and software reliability-growth models would require a much larger set of data. But, from a practical view-point, this limitation could strengthen the experi- mental results. Trend tests are likely to show their effectiveness, in supporting the analysis of the reliability trend, much better with larger samples of data, while the direct analysis of the raw data can be less intuitive and immediate. Analogously, software-reliability growth models are likely to fit better when dealing with larger data sets.

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