Training of operators directed at recoveries

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Improvement of operators' performance is generally directed at increasing the operators' skills to perform step-by-step or step-by-step-like procedures. The means of improvement, however, is typically different when improvement is related to respectively the prevention and the recovering of accidents. Performance related to the prevention of accidents is typically addressed through systematic training sessions, while performance related to recoveries is typically addressed through exercises. In this paper it is suggested that this approach might not be optimal when addressing performance related to recoveries. It is suggested that systematic training sessions, focused around situational assessment, might be a better choice. A case study is used to illustrate two different assessment techniques applied by operators and a potential training approach to be used in relation to these are sketched.

Training focused on the period before an accident occurs

Training of system operators in the broadest sense of the word is usually focused on *preventing* accidents. Pilots are trained to prevent a crash, operators in nuclear power plants to prevent a leak etc. Thus, training is directed at and restricted to the period before an accident occurs. If the performance of a trainee during a session causes an accident, the session will be ended.

The systems which operators work are created by system designers and thus the process flow within the systems is in principle known[1]. This implies that if an operator is able to establish what caused a deviation in the system, s/he can (in principle) correct the deviation based on knowledge about how the processes flow. The main difficulty related to prevention of accidents is thus to establish the cause of a deviation and as a consequence, training will usually be directed at fault-finding (see e.g. Duncan, 1974).

Design of fault-finding training is normally initiated by carrying out a classification of the type of faults which the operators might meet. From this classification, a set of guidelines or procedures to support the operator's performance are developed which then is introduced

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1 Only in principle since as Perrow points out (Perrow, 1984) the possibilities for unforeseen interactions among the system's elements are always present. This aspect will not be taken into further consideration here.

to the trainees during a session. Thus, when a deviation occurs, the operator is to conduct a search for the fault by performing the task as specified in the procedures (heuristics), and the session is designed so that the operator is confronted with samples of the different types of fault which might be encountered.

Training focused on the period after an accident occurs

Performance related to recoveries is usually addressed by means of exercises using one or two complex scenarios. Generally these sessions are focused on performance of the emergency procedures. This can be seen e.g., on board ships where emergency exercises are regularly conducted. Often only limited attention is given to improve the operators' performance during recoveries. In some cases the reason for this might be that the operators actually do not play any role in recoveries, due to the design of the system they operate, the organisation of the work etc. In other cases the reason might be that it is difficult to establish how performance during recoveries could be trained systematically. Usually the emergency procedures are fairly general, step-by-step like procedures created to encompass every situation that might confront the operator. Since it is difficult to specify in advance the exact situations this might involve, training designers can take the point of view that conducting exercises in relation to any recovery-scenario will suffice, as the trainees in each case will have to perform (at least parts) of the emergency procedures[2]. One reason for the difficulties related to design of recovery-training could be that focusing primarily on the emergency procedures, and thereby step-by-step like procedures as in training directed at fault finding, might not be optimal in relation to recoveries. A case study of train control operators' performance during recoveries gave some support for this hypothesis.

Case study

To uncover train control operators' tasks during recoveries and the difficulties associated with performance of these, a Hierarchical Task Analysis (Annett & Duncan, 1967) was carried out based on information from existing documentation, from discussing task performance with experts and from observations during the normal situation (Miberg, 1997). The overall situation of the operators during recoveries can be sketched in four statements. Train control

2 This was the conclusion reached by training designers in the Danish State Railways (DSB) when creating a program for training city train control operators in recoveries (Miberg & Jepsen, 1995).

operators are familiar with the context (the control room) in which task performance occurs. The operators do not expect an accident to occur and are, in this way, unprepared when it happens. The operators are experts in performance during the normal situation -- most of them have never been trained in emergency procedures and their knowledge thereof is accordingly primarily declarative. Finally, the operators have to perform two different types of tasks: Emergency Management (EM) Tasks (tasks related to the situation on the spot of the accident), and Traffic Management (TM) Tasks[3] (tasks related to managing the traffic in the useable parts of the tracks).

Difficulties related to focusing on the emergency procedures

When considering the performance of train control operators it is important to note that the emergency procedures only support a part of the operators' tasks: the EM-tasks[4].

Due to the limited experience in recovery handling, the high stakes (e.g., loss of lives), the time pressure associated with performance and the fact that operators find them self unexpectedly to be in a recovery, negative stress reactions (see Weisæth, 1985) can be expected to influence performance by reducing the operators ability for efficient decision making. For this reason DSB has decided to support the operators' performance by introducing five job aids cards. The job aid cards are each directed at a specific type of: 1. Fire in electric trains, 2. Shunting accidents, 3. Accidents in crossings, 4. Accident where a person is run over, 5. Illegal passing of signals. Each card entails a description of the tasks to be performed in the different situations and of tasks that it *might* be relevant to perform. Training focused on the emergency procedures could thus be seen as merely a case of learning the operators to performed the tasks stated on the cards.

Meanwhile, in actual recoveries, the operators state unanimously that they do not use the cards. They regard the cards as inadequate and their reasons for doing so can be summarised as follows: The concepts used to characterise accident types are not defined. Thus, it can be difficult for the operator to decide with which type of accident he is confronted -- especially since the information he can access in the early phase of a recovery might be restricted.

3 In this way train control operators' situation resembles emergency managers (Walker et al.,1989) - like e.g., a fire chief. While the fire chief is attending to the concrete accident (EM-tasks) he must also be aware that fires can arise in other parts of his district and - if possible - pay attention to this fact when requiring personnel from the fire station ("TM"-tasks) (see e.g. Klein et al., 1986).

4 The TM-tasks are to be performed in accordance with the general Safety procedures which can be seen as a parallel to the traffic regulations for road transport.

Moreover, an accident can possess characteristics that relate to more than one type of accident, e.g., an accident involving the running over of a person might be due to an illegal passing of a signal. In this case the operator would have to spend time on working out which card to follow. Finally and most importantly, the tasks specified on the cards do not always suffice, e.g., in some cases, it might be necessary to request a shut down of power in the power lines when a person has been run over, even though this task is not specified on the related card. By not using the cards and not benefiting from experiences gained from training sessions, the operators, not surprisingly, show a tendency to fall back on the routines associated with the normal situations, during recoveries. This is not optimal, since the features which the operator must attend to should not always be interpreted in the same way during a recovery as in the normal situation, e.g., in the normal situation it is generally unimportant for the operators to be aware of which type of cargo a goods wagon carries. Accordingly, the operators during recoveries have a tendency to pay less attention to this fact than is warranted, given the implications which might follow from a leak.

In all this indicates that it might not be optimal to focus on the step-by-step (like) emergency procedures when addressing train control operators' task performance during recoveries. When a system which confronts an operator has broken down, the actual consequences resulting from this are difficult to anticipate at a general level. Accordingly, it is difficult to predict step-by-step which tasks it will be adequate for the operator to perform – and in which sequence. Applying step-by-step (like) procedures in such settings may, furthermore, prevent the operator from creating an overall picture of the situation and thus from choosing[5] and optimally prioritising his/her tasks. To support the operator in doing so, it seems as a better solution to focus training more on situational assessment. This suggestion is supported by the phenomenon that training instructors, when training is directed at the emergency procedures, tend to give feedback to the trainees by referring to features in the situation: "Because the situation was so and so, it would have been adequate to do such and such ..."

Situational assessment

To focus on situational assessment, effective strategies for conducting assessments should be distinguished. The analysis of train control operators' task revealed that the operators during a recovery use two different assessment techniques. One to assess the need for performance of EM-tasks another to asses the need for performance of TM-tasks (see figure 1). This indicates

5 Many tasks on the cards are marked as "Perform this task *if it is necessary ...*".

that training should be conducted differently in relation to the two assessment situations.

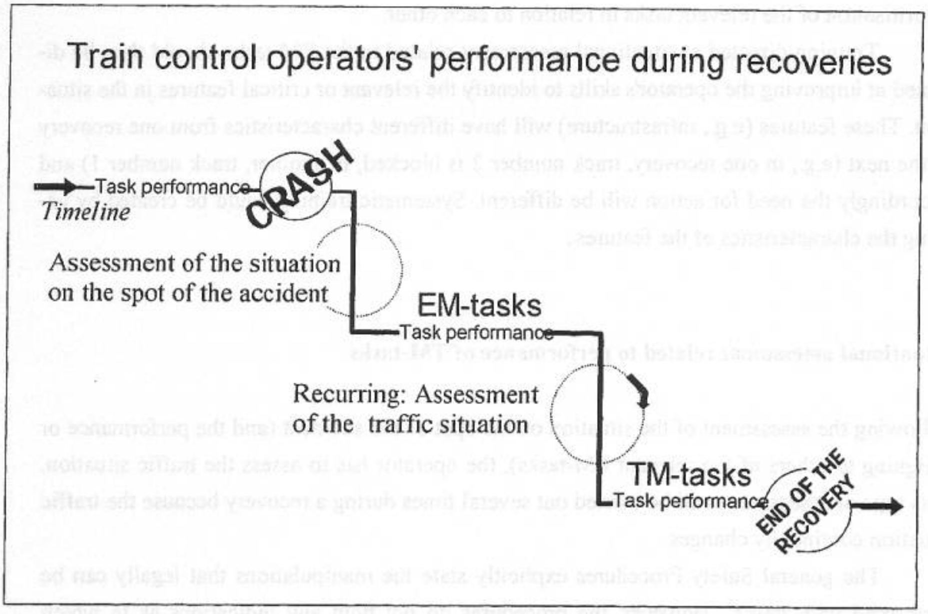

Figure 1

Situational assessment related to performance of EM-tasks

Situational assessment related to performance of the EM-tasks is initiated immediately after the operator recognises that an accident has occurred and is directed at identification of the situation on the spot of the accident. The competent operators seem effectively to perform this task by developing *a profile description of the situation* -- a description which clarifies features of importance for their succeeding task performance. This process can be compared to the act of collecting a jig-saw puzzle. Each piece in the puzzle reflects a certain part of the situation and when all the pieces are put together a distinct profile of the accident emerge. In the operator's puzzle two types of pieces can be distinguished. Pieces that provide the operator with necessary background information (e.g., where and when) and pieces that specify the tasks which the operator should perform (e.g., if persons are injured then the tasks "Require assistance from the Emergency Centre (911). Thus, by using this *puzzle-technique* the operator concurrently establishes which tasks it is necessary to perform and the background information about the accident that is prerequisited when performing the relevant tasks. At the same time it will allows an overview of the situation to be formed that enables prioritisation of the relevant tasks in relation to each other.

Training directed at situational assessment related to the EM-tasks should then be directed at improving the operator's skills to identify the relevant or critical features in the situation. These features (e.g., infrastructure) will have different characteristics from one recovery to the next (e.g., in one recovery, track number 2 is blocked, in another, track number 1) and accordingly the need for action will be different. Systematic training could be created by varying the characteristics of the features.

Situational assessment related to performance of TM-tasks

Following the assessment of the situation on the spot of the accident (and the performance or assigning to others of the relevant EM-tasks), the operator has to assess the traffic situation. This type of assessment will be carried out several times during a recovery because the traffic situation continually changes.

The general Safety Procedures explicitly state the manipulations that legally can be performed with trains[6]. However, the procedures do not hold any indications as to which manipulations it would be adequate to perform in a given situation. To support the operator, a set of guidelines (not rules!) on how to prioritise the trains have been developed but these are far from sufficient to effectively support the operators: The number of guidelines are very limited and can lead to conflicting suggestions. Thus, using the puzzle-technique when assessing a traffic situation is not an optimal solution because neither the individual pieces nor the overall picture would reveal how the traffic adequately could be managed.

Still, the operator needs to acquire an overall picture of the situation, as the manipulation of each train influences the possibilities for the manipulations of every other train on the tracks. The assessment method, which most operators use, can be characterised as the *transparency-technique*. This technique can be metaphorically described as follows. Initially the operator has nine transparencies (one for each of the feature he has to depict) on which an identical chart of the domain is represented. Looking at the distinct features of importance with regard to traffic management (geography, infrastructure etc.) he fills these out one by one. Finally, the operator places all the transparencies on the top of each other and a picture (often a very complex one) of the overall traffic situation will emerge. This picture holds, as

[6] The Safety Procedures can be seen as the traffic regulations for railway traffic.

such, no indications as to the kind of manipulations it would be appropriate to perform, so the operator has to further interpret the data. Thus situational assessment related to performance of TM-tasks involves a larger degree of individual decision making than does an assessment related to the EM-tasks. To interpret the obtained information the operator will generally use a kind of pattern recognition. He will seek to match the actual pattern on the transparencies with patterns encountered previously. If a pattern is recognised, the operator forms a "proposal" (more or less detailed) as to how the traffic can be managed, based on experiences gained from the previous situations. If not, the operator must engage in the difficult and often very time consuming "here-and-now" planning process.

A training design directed at the TM-tasks should obviously include elements to secure that operators' skills to locate features of importance are improved. Beyond this point, however, a training designer can choose two different directions: The TM-tasks can be re-designed to reduce number of decision making components implied, or, the design can be directed at increasing the number of patterns which an operator can recognise, thus reducing the likelihood that the operator has to produce "here-and-now" solutions.

If the designer choose to re-design the task, an apparent solution would be to insure that further guidelines on how to prioritise the traffic are created. This would, in principle, imply that the operator could conduct an assessment using the less demanding puzzle-technique. Meanwhile, to support the operator in this way, the number of guidelines would rapidly exceed what a human operator could be expected to handle effectively while under time pressure. One could say that only a computerised decision support system, which can operate quickly and accurately with a large number of information, would be able to work with such complex specifications. If training is to be focused on increasing the number of patterns which the operator can recognise, the solution implies that "local customs" (common ways to manage the traffic in the local control centre if certain configurations appear on the tracks) should be developed artificially during training. This can be done by systematically varying the characteristics of the features (in so far as they vary, from time to time, in the normal context) which the operator should be able to describe. Such a session would allow the operator to recognise at larger set of situations (patterns) and there associated plans for traffic management. To increase the effectiveness of the operators' decision making/interpretation process, it would be an advantages if the operator, during a session, was allowed to explore a variety of solutions to the same traffic situation (scenario) – as there is not necessarily only *one* optimal solution. This would be possible if a training simulator was used as the training medium.

Concluding remarks

It is possible to develop systematic training directed at task performance during recoveries by using situational assessment as point of origin in a training situation. The ability to adequately describe the situation at hand is generally a prerequisite for the effective performance of the emergency procedures and increased ability in situational assessment by operators can thus be expected to improve performance. A training programme can be created that systematically varies the features of a situation which an operator should be able to pay attention to during recoveries.

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