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Dynamic human reliability analysis A stakeholder survey and an empirical study

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Dynamic human reliability analysis – A stakeholder survey and an empirical study

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Summary

Dynamic human reliability analysis is an approach to human errors, their identification, and estimation of their probabilities that takes into account the changing situation that affects human errors. This report documents two studies on dynamic HRA.

The first study is a survey, the aim of which was to find out how familiar Nordic HRA professionals are with the dynamic HRA concept; what are their opinions and experiences on it; and what further research on it would be interesting or important. Six Finnish and Swedish human reliability analysis experts from five different organizations replied to the query. In general, the respondents' view is that the greatest potential benefit of dynamic HRA is increased realism. On the other hand, they emphasized that deployment of dynamic HRA methods should not lead to increased complexity of models and workload in analysis, because resources available for HRA are limited and the models are already complex. Dynamicity is involved in long time windows and annual maintenance break scenarios, among others. The respondents identified also several interesting future research topics.

The second study is an interview of main control-room operators to shed light on dynamic HRA related phenomena qualitatively, in the form of asking operators' opinions on error possibility in various operational, possibly error-prone situations in the main control room. There was only a small number of interviewees, limiting the conclusions to be made. However, even this small sample provided a lot of information and variation, which can also reflect the true variation, possibly realised also with a larger sample. Whether this is the case, calls for a new study with more interviewees.

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Preface

This report is the deliverable of the task ‘Human reliability analysis’ (T3.2) of the project of ‘New Development and applications of PRA’ (NAPRA) on 2020.

The goal of NAPRA T3.2 is to define realistic or slightly conservative human error probability estimates and to identify the most relevant human failure events in hybrid control rooms. This realism includes dynamic HRA, contrasting the traditional static starting point of HRA.

This report presents the results of a stakeholder survey and an empirical study. The authors thank the respondents of the survey and the operators interviewed in the study.

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1. Introduction

Human Reliability Analysis (HRA) is a structured approach to identify potential human errors (or human failures to accomplish tasks as required by the situation), and to estimate the probability of those errors. The concept of 'dynamic HRA' refers to such an approach to human errors in which the changing situation that affects human errors is taken into account. A practical driver of increased interest in dynamic HRA is the need to consider long time windows, a matter that proved its importance in Fukushima Daiichi nuclear accident, lasting for two to three days from the initiating event (IAEA 2015).

In practice, dynamic HRA refers to situations in which former situation affects the latter one(s). Human performance is of the kind, which is affected by former events, such as an interpretation about a situation affects how it is acted on or being nervous may form a loop so that having become nervous may feed itself, adding nervousness. Also, situations may change unexpectedly, or the situation may change just by time, and human performance after that change can depend on the earlier situation also in an apparently illogical way.

To understand when dynamic HRA is in question, it is important to note that dynamic HRA is not in question unless the inducing matter takes place clearly earlier than the human performance under inspection. This can happen through two different paths. There can a temporal gap or delay between the inducing phenomenon and the human performance in question, or the inducing phenomenon can have a prolonged effect on human performance (an effect requiring long time windows if it needs to be studied). It is also possible that the situation constantly changes and then, the kind of sum or combination of previous events or phenomena can result in making an error. If the possibly affecting matter precedes imminently the human action being focused on, it is a question of “ordinary” HRA. An example of that is making an error in operations when mishearing something or pushing a button, which mediates visually its meaning in an unclear manner (i.e., when the button is of poor quality from the operational perspective).

In NAPRA project, during 2019, a literature study on dynamic HRA, with an emphasis on hybrid control rooms, was carried out (Liinasuo et al. 2019). Based on the results, a detailed plan for a survey among stakeholders and for an empirical study were created. In 2020, the plans have been implemented and the results are presented in this report.

In the stakeholder survey, the conceptions of stakeholders of the meaning of dynamic HRA and its effect on HRA practices were studied. The results illuminate how dynamic HRA, and the effects of context and changing situations on human decision making and human error, are seen at the plants and at STUK. In addition, development needs in this subfield of HRA were clarified.

The empirical study consisted of interviews among main control-room operators. The goal of the interviews was to find out about the effects of the dynamic development of events on the types of errors and their likelihood, based on the conceptions and experiences of the nuclear power plant (NPP) operators.

2. Stakeholder survey

2.1 Purpose of the survey

The purpose of the survey was to clarify how nuclear professionals perceive dynamic HRA and its meaning from the perspective of their work as well as the related potential needs. The responses were to affect what will be studied later in the project.

2.2 Method

The research method was a questionnaire that was targeted to HRA experts (or PRA experts with some experience in HRA) of the Finnish stakeholders. The questionnaire (Appendix A) was sent to the stakeholders by email on August 27, 2020 and the responses were requested by September 13, 2020. Some original respondents sent the questionnaire further to other (also Swedish) organisations. A reminder message was sent on September 18, extending the response time until September 25.

The responses are handled confidentially so that the identity of the respondent for some specific question is not revealed in the reporting of the results of the survey.

In the questionnaire, there was first a brief explanation of the purpose of the study and what dynamic HRA means and, thereafter, the actual questions.

The following research questions or themes were addressed in the survey:

Theme A) Basis for the present conception of dynamic HRA
- how familiar the respondents are with the concept

Theme B) Benefits, challenges and feasibility of dynamic HRA, presently and in the future
- opinions and/or experiences of dynamic HRA

Theme C) Need to study dynamic HRA in SAFIR
- what kind of future research could be interesting or important

2.3 Participants

Five replies were received, three from Finland and two from Sweden. There were six respondents, that is, one of the replies was written by two professionals. One of the respondents represents a regulator, and the rest work at NPP companies. All respondents are PRA professionals. The respondents are from the following organisations:
- one Finnish regulator representative
- two Swedish nuclear power plant (NPP) representatives
- three Finnish NPP representatives

2.4 Results

2.4.1 Familiarity of dynamic HRA

There is large variation in the familiarity of the concept of dynamic HRA. One stated (s)he had never heard about it, three had heard about it but had never needed it professionally, and for two it is part of their work.

One respondent (Swedish practitioner in an NPP), who stated (s)he had never heard about dynamic HRA, added that there are elements of dynamic HRA in the NPP in which that person works (but not under that name). The three respondents (all Finnish practitioners in an NPP), having not needed the concept professionally, could naturally not reply on the question of how dynamic HRA is part of their work.

For those who found dynamic HRA is related to their work, it was familiar as part of PRA and discussed in international forums (one respondent, regulator representative) or used in considering how former situations affect later actions by conducting several analyses on the same action, each for particular sequence(s) (another respondent, Swedish NPP representative). Also dependences to earlier manual actions have been considered in these analyses and in some cases, the same manual action has been modelled at different stages of a scenario, and analysed for each of those to take into account the different conditions.

Additionally, the former respondent stated that HRA as such could be part of risk-informed oversight processes, indicating that it presently is not that, not at least on a regular basis and, furthermore, there was no dynamicity mentioned related to HRA. It is also hard to evaluate whether the reply of the latter respondent reflects dynamic HRA or “regular” HRA in which former situation affect instantaneously the following actions.

None of the respondents replied that dynamic HRA is conducted in their organization but they have not been involved with it.

2.4.2 Challenges and benefits of dynamic HRA

Realised challenges and benefits

Those who had at least some familiarity with dynamic HRA contemplated its benefits and challenges. This received two answers, both concerning the same or similar themes.

One respondent (regulator representative) pondered that those are the same as in ordinary HRA; HRA models and methods are simplifications of human behaviour and, furthermore, statistical methods (which are in the core of PRA and HRA) are, according to him/her, seldom applicable to validate probabilities. As a benefit, the respondent indicated that dynamic HRA has the same benefits as HRA - according to him/her, it is important to incorporate human interactions in PRA. Accordingly, this respondent stated that all dynamic situations require dynamic human responses; for instance, refuelling outages (beginning from shutdown to start-up) include many dynamic situations.

The other respondent’s (Swedish NPP representative) answer was that regarding benefits, it helps in considering differences in scenarios for improved realism. Challenges, in turn, are related to the need of keeping HRA reasonably simple. According to this respondent (direct quotation), “there are often many actions and many scenarios and hence simplifications must be made. Data for quantification is sparse and hence it is not certain that a detailed model results in the most realistic results.” Dynamic HRA can also prove to be too resource demanding.

Contemplated challenges and benefits

The other respondents were also asked to reflect, given that they had no experience on it, the possible benefits and challenges of using dynamic HRA in their company. Their replies are as follows.

In the judgment of the Swedish NPP representative, the main benefit is increased realism, and the main challenge is that dynamic HRA may turn out to be too resource demanding.

The two Finnish NPP representatives remarked that dynamic HRA methods have the potential to produce more credible human error probability estimates, and that dynamic HRA represents the state of the art, which is desirable. On the challenges, the respondents noted that they do not have sufficient data available yet. Another challenge for the respondents is that they are not responsible for PRA, including HRA, and therefore have limited possibilities to influence what methods are used in plant PRA.

One Finnish NPP representative mentioned the benefit that dynamic HRA would be more realistic especially in analysing scenarios involving long time windows. As challenges in using dynamic HRA in the company, the respondent mentioned workload that would be even increased, which is rather demanding as presently, PRA/HRA is already rather extensive. They also have a lack of knowledge about dynamic HRA, possible problems with supporting analyses such as simulation, and integration of dynamic HRA with the existing PRA can be problematic too.

Reasons for not having dynamic HRA

Several reasons were identified why dynamic HRA was not used in the companies, whose representatives therefore could only theoretically contemplate the possible benefits and challenges of dynamic HRA.

One respondent (Swedish NPP representative) thought that at the end, the term dynamic HRA is not used as the basis for the respondent's plant's PRA. This is because the plant's PRA was created in late 1990s-early 2000s, that is, before the emergence of dynamic HRA. However, the methods are updated, and the respondent considered that dynamic HRA is used to a limited extent. However, there was no example of it as at least the respondent was not aware of such examples.

Two respondents (Finnish NPP representatives) pointed to the fact that the (plant construction) project is yet at an early stage, and thus limited information is available. For example, input to HRA such as emergency operating procedures are still missing and it is difficult, hence, to define exact time windows available for personnel or operator actions. However, dynamic HRA was considered to be usable in the situation of long time windows; then, the success or failure of repair actions can have an effect on the consecutive manual actions. Thus, the respondents found a reason for including dynamic HRA to the methodology in the NPP in question.

One respondent (Finnish NPP representative) stated that dynamic HRA has been used to some extent in some scenarios, e.g. for different recoveries for different time windows. A reason for not using dynamic HRA in the respondent's company is lack of familiarity with the concept, though the respondent recognizes scenarios where it would be useful. There has been only little need for it so far. Also, this respondent (cf. the two respondents above) found dynamic HRA relevant in the context of long time windows. In such situations, dynamic HRA could provide more realistic calculations and results that take into account how the situation changes over time. This respondent also mentioned human factors engineering in which it is important to analyse how people behave or react in stressful situations.

2.4.3 Feasibility of dynamic HRA

Respondents contemplated the feasibility of using dynamic HRA in their own organisations.

Regulator representative stated that dynamic HRA is needed in the analysis of complex scenarios.

Swedish NPP representative reflected that the elements of dynamic HRA should increase, but its usage may not be too resource demanding. If used, it should be done in a simplified way, so that it would be possible to handle with the resources available.

Another Swedish NPP representative thought that some dynamic considerations are important, both for PRA and HRA. However, (s)he noted that the already existing PRA and HRA models are already complex and resource demanding. Therefore, it is important that the deployment of dynamic HRA would not increase that complexity and resource-intensiveness.

The two Finnish NPP representatives stressed that provided that the results would be more credible and differ from present results, dynamic HRA would be feasible to use. Otherwise it would not be feasible to make changes to present practices.

The Finnish NPP representative stated that it is hard to say at this point whether deployment of dynamic HRA would be worth the effort. Even if dynamic modelling would make result more realistic, the model could become too complex and/or too heavy to calculate.

2.4.4 Future contemplations

All respondents pondered how dynamic HRA could be used in the respondent's work or company in the future.

Regulator representative remarked that its role will be the same in the future as it is now: for a regulator, it may come about in HRAs to be reviewed, in international (scientific, professional and regulatory) forums, and in risk-informed oversight processes.

Swedish NPP representative predicted that the introduction of independent core cooling will eventually lead to an increased focus on shutdown PSA as the core damage frequency for power operation decreases. In the respondent's plant's shutdown PRAs, HRA has a large impact on the results. Currently used conservative methods cause that the shutdown phase may seem riskier than it really is, and therefore more detailed (and realistic) analysis will be needed. Therefore, in the updates of the shutdown HRAs, which likely will be done in coming years, the respondent considers that the elements of dynamic HRA will likely increase.

Another Swedish NPP representative claimed that static HRA methods are already being applied in a more dynamic way as the level of detail in the PRAs are increasing. The respondent predicted that this trend would continue, but implied that there are some limits to it because the models cannot become too complex and resource demanding to develop and maintain.

The two Finnish NPP representatives considered that dynamic HRA could be used in interim spent fuel storage PRA where time windows are long. The respondents also expressed the view that if reliable studies will demonstrate the better suitability of dynamic HRA, it may be applied to other parts of PRA as well.

Also the Finnish NPP representative found long time windows appropriate for using dynamic HRA in PRA/HRA as dynamic HRA can make calculations more realistic.

2.4.5 Potential of dynamic HRA as a study subject in SAFIR

Regulator representative suggested that in SAFIR, dynamic HRA could be studied in the context of team collaboration in complex scenarios.

Swedish NPP representative found the study object interesting but did not provide any further contemplations.

Another Swedish representative stated that an interesting question would be whether we have (enough) data to support a more dynamic method or would that require even more expert judgement.

The two Finnish NPP representatives considered it would be interesting to study the applicability of dynamic HRA methodology in control rooms and with shorter time windows.

Finnish NPP representative pondered it would be interesting to hear about the approaches and methods that could be used in dynamic HRA; they could also be demonstrated with case examples. Also some kind of estimation of how much more realistic results can be obtained using dynamic PRA/HRA would be interesting.

2.5 Discussion and conclusions

The survey is short and aimed at getting a general overview of dynamic HRA-related issues in the Nordic countries. The number of answers – five in all – is small, and therefore no far-reaching conclusions about the status of practice in dynamic HRA can be drawn. However, the respondents are PRA professionals and most have strong HRA background, and thus, their replies have value not only in probing the status of dynamic HRA, but also in focusing dynamic HRA research efforts.

All the repliers are PRA professionals and HRA is part of their work. Nevertheless, on average they judge their acquaintance with dynamic HRA to be rather superficial. This is a clear indication that dynamic HRA has not made its way to practical analysis at the plants yet. Based on the responses, the approach of dynamic HRA is presently mainly in the level of rather theoretical discussion instead of being represented in the practices in the field. Two respondents recognized elements of dynamic HRA in their plant HRAs, though not necessarily under that name. This supports the hypothesis that HRA practitioners, regulators, or both recognize dynamicity of at least some significance in the tasks that crews perform in NPPs.

None of the respondents replied that dynamic HRA is conducted in their organization but they have not been involved with it. This is quite natural considering that the number of PRA/HRA experts in each organization is quite small, and therefore it is presumable that all PRA experts that deal with HRA are somehow involved with all HRA that takes place in the organization.

A very clear message that emerged is that to be able to introduce a dynamic HRA method, only modest increase in model complexity (existing PRA and HRA models are already quite complex) and resource-intensiveness is feasible, if even that. Therefore, the deployment, use and maintenance of dynamic HRA models need to be simple and not resource-intensive. How to achieve this, was not asked in the questionnaire, but one respondent gives a clue when mentioning that there have been dynamic elements in their HRA. Perhaps the way to bring dynamic HRA into practice is to develop generic dynamic HRA models for common tasks or actions that have elements of dynamicity in them. Those models should have a simple interface - for example, dynamic cognitive or crew simulation models should provide a clear description on the tasks and scenarios they can be used in, and a small set of parameters with which the user can tailor the model to fit the particular task, scenario and plant the user is modelling. Such generic task- or action-level models could then be taken into use in practical plant PRA without too much overhead.

The survey aimed to respond three dynamic HRA related research questions or, in other words, probe three different themes.

Theme A) Basis for the present conception of dynamic HRA; the familiarity of the concept

Even in this small sample of respondents, there was a large variety in the familiarity of the concept of dynamic HRA: One had never heard about it, three had heard about it but had never needed it professionally, and for two it is part of their work. From this, it is not possible to conclude, how familiar the concept is as a whole, but this enables a cautious interpretation that there is variation in the familiarity of this concept. This supports synthesizing of some kind of overview of possible conceptions and experiences over dynamic HRA.

Theme B) Benefits, challenges and feasibility of dynamic HRA, presently and in the future

Respondents found dynamic HRA beneficial because it provides more realistic results regarding human error probability; especially long time windows were often mentioned as an interesting setup for utilising dynamic HRA. Dynamic HRA was found challenging in terms of its assumed methodological complexity as well as the degree of difficulty in using it.

In accordance with these contemplations, respondents considered dynamic HRA potentially feasible for complex or dynamic scenarios but were usually cautious in their considerations of applying it, due to the limited resources combined with the cumbersome methodology of dynamic HRA.

Theme C) Need to study dynamic HRA in SAFIR

All respondents found further research interesting although not all provided examples of interesting topics. Topics that were provided were

- team collaboration in complex scenarios
- would the data presently gathered be sufficient for a dynamic method or is more expert judgement needed
- applicability of the methodology to control rooms and shorter time windows
- approaches and methods that could be used in dynamic HRA.

Based on the survey results, the need to gather more information of the qualities of dynamic HRA phenomena was identified. When knowing more about it, it is easier to assess the needed methodology.

3. Empirical study: Interviews

3.1 Purpose of the study

The purpose of the empirical study was to identify the conceptions, impressions and experiences of operators related to the possibilities of making an error in various types of contexts. The contexts used were all related to dynamic phenomena, basically in pre-accident situations.

3.2 Participants

The possibility to take part on an interview was informed in Loviisa NPP and all volunteers entered. Six operators participated in the interview, including

- two shift supervisors, with work experience as an operator for 10 and 11 years
- two reactor operators, with work experience as an operator for 13 and 18 years
- two turbine operators, with work experience as an operator for 10 and 13 years.

3.3 Method

Interviewing was used as the research method. Interviewees were main control room operators. Dynamic phenomena consist of contextual factors inducing dynamicity in the situation, and cognitive factors related to dynamicity in the human mind. Interviews dealt with phenomena, situations and conceptions that are associated with dynamicity. Some of the questions were forced-choice questions, and others were open.

All interview questions were based on the format in which the interviewee was asked to imagine a certain type of situation and thereafter, to memorise (if the situation is familiar from own or somebody else's) or contemplate (if the interviewee does not have experience of that situation) how that situation affects the possibility to make an error.

The situations to imagine were the following (see Appendix 2 for the actual, detailed interview questions, in Finnish):

- imagine you are in a situation (requiring operation) that you have performed also earlier but it has been unclear to you whether you have performed as well as possible
    - in Results, 'Unclear whether earlier performance had been optimal'
- imagine you have been in a hurry the same day but now the hurry has been over for a while
    - in Results, 'Passed hurry'
- imagine a situation in which you have always performed correctly
    - in Results, 'Previously always correct performance'
- imagine a situation in which you have earlier almost made an error
    - in Results, 'Almost an error'

- think about a work shift and how the proceeding of time during a shift affects performance, due to, for example, the level of being alert
    - in Results, 'Proceeding of work shift'
- imagine a situation in which you have earlier made an error
    - in Results, 'Earlier error' (in two cases, there was no time left in the interview to ask this question)
- does any other situation come to your mind in which something that has happened earlier would affect later performance (asked only if there was time left to ask this question).

Interviewees were also asked to clearly state what error possibility would be in the affected situation by choosing one of the five options:

1) error possibility increases strongly
2) error possibility increases slightly
3) error possibility remains the same
4) error possibility decreases slightly
5) error possibility decreases strongly.

Interviews were transcribed and a qualitative analysis was made, with the intention of finding trends and their deviations in the responses.

3.4 Results

3.4.1 Responses based on the imagined situation

In the following, the results are presented according to the situation that the interviewee was to imagine. The situation is described in more detail in Methods.

Unclear whether earlier performance had been optimal

Most interviewees contemplated this situation based on their own experiences (four interviewees, including one who reported having thought both own experience and something (s)he had seen or heard). Two interviewees had a more general perspective, without any specific situation in mind.

Briefly, almost all interviewees thought that such a situation makes the operator to stop and to not make an error. Regarding the detailed responses, there was a variety of ways to see this situation:

- one stated that if that situation would have occurred, one would have studied that situation so that when running into it later, it is familiar, and the operator is sure to know how to perform
- two considered that when identifying that situation again, one would focus on it so that it would be well performed (by clarifying it by him/herself, by asking colleagues, or by asking shift supervisor)

- two stated it would cause uncertainty and if there is time, one can ask for advice in that situation
- one contemplated that operators tend to think these matters but the interviewee him/herself would not remain thinking as all situations are new by nature; if there was no actual error, the situation is not different from any other normal situation

Accordingly, as a rule, interviewees thought that this situation diminishes the possibilities to make an error in this situation. There was some fine-tuning in these responses too (see Figure 1):

- two considered that the possibility to make an error in this situation remains the same (which, in practice, is really small)
- two stated that the possibility to make an error diminishes slightly
- one found that the possibility to make an error decreases strongly
- one contemplated that training and personality affect, so that if being stubborn, the operator just continues even if the situation is unclear, increasing slightly the possibilities to make an error, but another operator can stop and think and tell superior or somebody else, strongly diminishing the possibility to make an error.

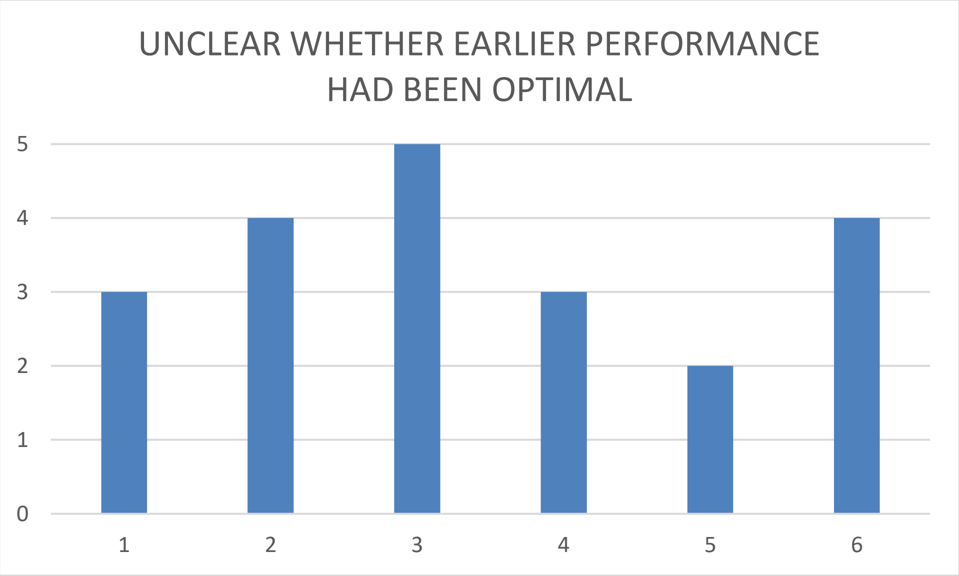

Figure 1. Possibilities to make an error when it is unclear whether earlier performance had been optimal. X axis represents interviewees (n=6) and y axis represents error possibility (1= increases strongly, 2= increases slightly, 3=remains the same, 4=decreases slightly, 5=decreases strongly).

Passed hurry

Most (four) interviewees found this situation familiar and responded based on that. One reported (s)he thought the situation from a general perspective and another thought both his/her and another operator's event. Many interviewees mentioned annual shutdown in this context, probably because that is the situation in which there is often hurry but the situation alters between hurry and more relaxed time.

Mostly, interviewees found this situation prone to making errors. Again, there was still variation in the responses:

- one described that after the hurry, one feels some time a bit strange and concentration is not at its best and in this situation, an error can be made because the operator does not look at details but focuses on process overview; operator can also become careless when tension is lifted and the operator is (too) contented with the situation

- one stated that when relaxing after the hurry, it is possible that some (important) detail is not identified, such as the monitoring of events and alarms may be neglected

- one said that hurry can induce mental load also when the hurry is passed, it takes time before your mind is settled and a kind of large-scale error can be made so that the operator thinks about a previous task when operating or the operator may get mixed with the components

- one stated that it depends on the "pulse"; if operator's mind is not in a hurry, the possibility of making an error is less probable but if the mind is not yet settled, an "ordinary human error" can be made, such as reading erroneously a procedure or performing incorrectly even if the procedure has been read in a correct way

- one contemplated that in a hurry, it is possible that there has not been time to eat when needed and blood sugar is too low, so, eating after the hurry results in the decline of the ability of being alert and an error can be made related to some routine performance; alternatively, short-term hurry can make operator alert and active (reducing the possibility of an error)

- one stated that when not in a hurry any more, it is less probable that an error would be made any more (so an error is more probably when in a hurry)

Thus, when contemplating the situation freely, error possibilities were found, but when asking separately about the possibilities of making an error, responses were more scattered (see Figure 2):

- two stated that the possibility to make an error remains the same (but one respondent added that it may depend a lot on the person in question)

- two found that error possibility increases slightly in this situation

- one contemplated that when still loaded, error possibility may have increased slightly or strongly but in a normalised situation error possibility remains the same

- one concluded that if being tired, error possibility is increased slightly but if the hurry has had the aftereffect of being more alert, error possibility is decreased slightly.

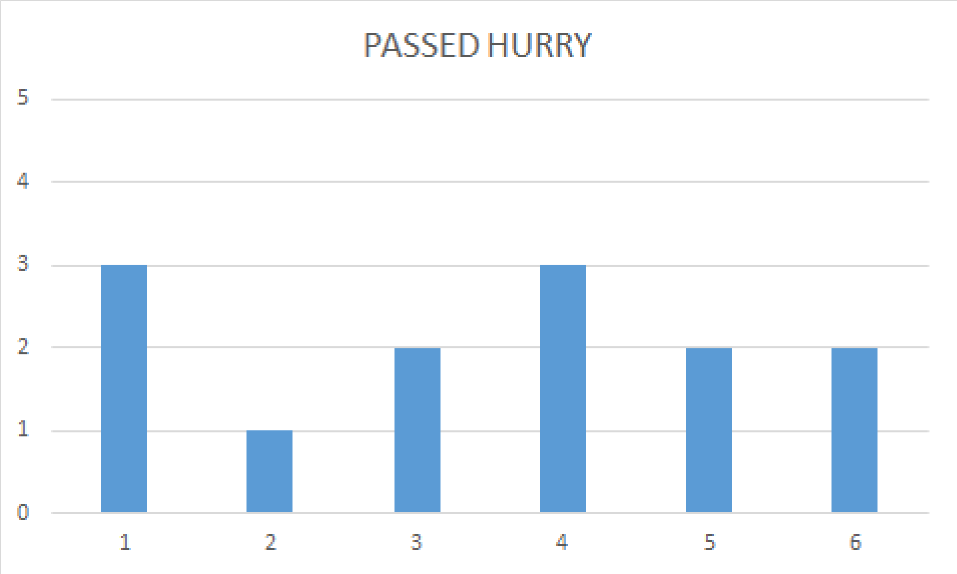

Figure 2. Possibilities to make an error when hurry at work has passed. X axis represents interviewees (n=6) and y axis represents error possibility (1= increases strongly, 2= increases slightly, 3=remains the same, 4=decreases slightly, 5=decreases strongly).

Previously always correct performance

When contemplating this situation, interviewees had usually own experience in mind (three interviewees) but also the one of somebody else (one interviewee); two interviewees told they reflected this from a general point of view.

Opinions of such a situation, regarding errors, were clearly divided.

- half (three) of the interviewees considered that if something is done in a similar way for a long time, routine is built also in a not so safe way, resulting in not being focused when performing the task in question, which, in turn, may result in making an error
- half (three) interviewees thought that when having learned to perform in a correct way, it feeds correct performance also in the future, reducing the possibility to make an error.

Rather accordingly, regarding the assumed possibilities for making an error, the responses were the following (see Figure 3):

- one interviewee stated that error possibility remains the same, even if the original idea of this person was that when having learned to perform correctly diminishes the possibility to make an error
- one interviewee thought that error possibility decreases slightly, and another, decreases strongly
- three interviewees considered that routine increases slightly the possibility of an error.

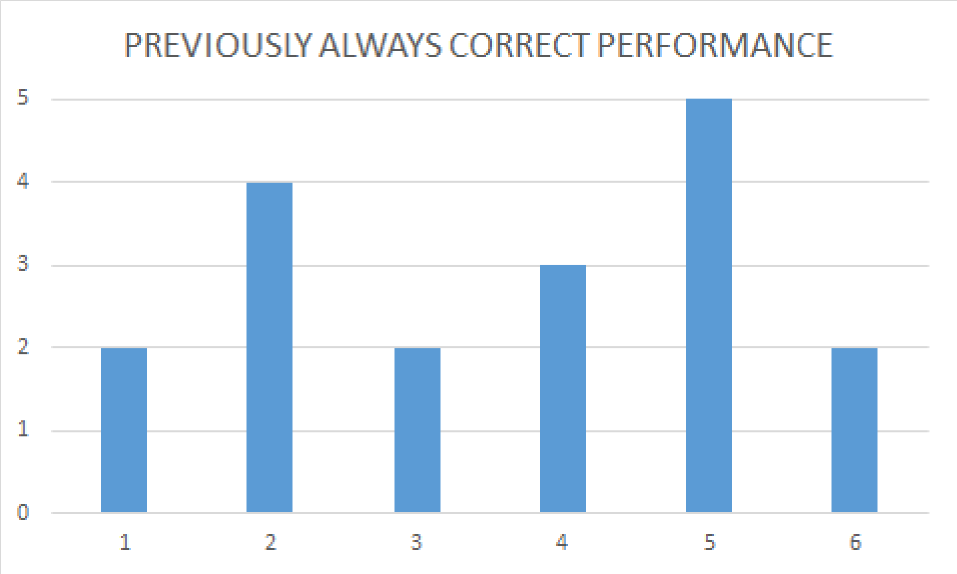

Figure 3. Possibilities to make an error related to a task that has been earlier always performed correctly. X axis represents interviewees (n=6) and y axis represents error possibility (1= increases strongly, 2= increases slightly, 3=remains the same, 4=decreases slightly, 5=decreases strongly).

Almost an error

Most (four) interviewees had an own experience in their mind whereas two interviewees contemplated the situation from a general perspective.

Even if all interviewees expressed the possibility that errors are diminished in this situation, it was still contemplated in various ways:

- five interviewees described how an error leaves such a strong memory trace that the possibility to make an error diminishes after such an experience
- one interviewee contemplated that it is “fifty-fifty” whether to learn from an error or not (so that the response is actually to the situation when the error was really made).

However, scrutiny reveals that there is variation in opinions. Regarding the possibility of an error (see Figure 4),

- half (three) interviewees thought that the error possibility is decreased strongly after having almost made an error
- two interviewees considered that after having made an error, error possibility is first decreased slightly but when more time passes, the possibility of an error has returned to the original level
- one interviewee stated that error possibility is unaltered after having earlier made an error (so that the response is actually to the situation when the error was really made).

Figure 4. Possibilities to make an error related to a task, in which an error was earlier almost done. X axis represents interviewees (n=6) and y axis represents error possibility (1= increases strongly, 2= increases slightly, 3=remains the same, 4=decreases slightly, 5=decreases strongly).

Proceeding of work shift

Most (five) interviewees contemplated the proceeding of the work shift based on own experience. One interviewee took a general perspective.

Interviewees spontaneously pondered day and night shift separately. Also general statements or statements that apply both day and night shift were provided. In the responses the possibility of an error is connected to the level of being alert or tired.

General-level comments:

- when arriving to work, situation awareness is low but right after that it is at its best; eating causes tiredness and at the end of the shift, one tends to be tired too; but if something happens, tiredness vanishes
- in the annual shutdown, error possibility is greater in the beginning of the shift as then, situation awareness is not at its best, then it gets better and then again worse when you get more tired; this applies to both shifts but is stronger in night shift
- when coming to work, situation awareness is not at its best

Day-shift comments:

- I tend to be alert during mornings and have not identified any alteration in it during day shift, although some people say that mornings are bad
- nothing changes during day shift
- for some people (but not for me), level of vitality is lowest during daytime after having eaten

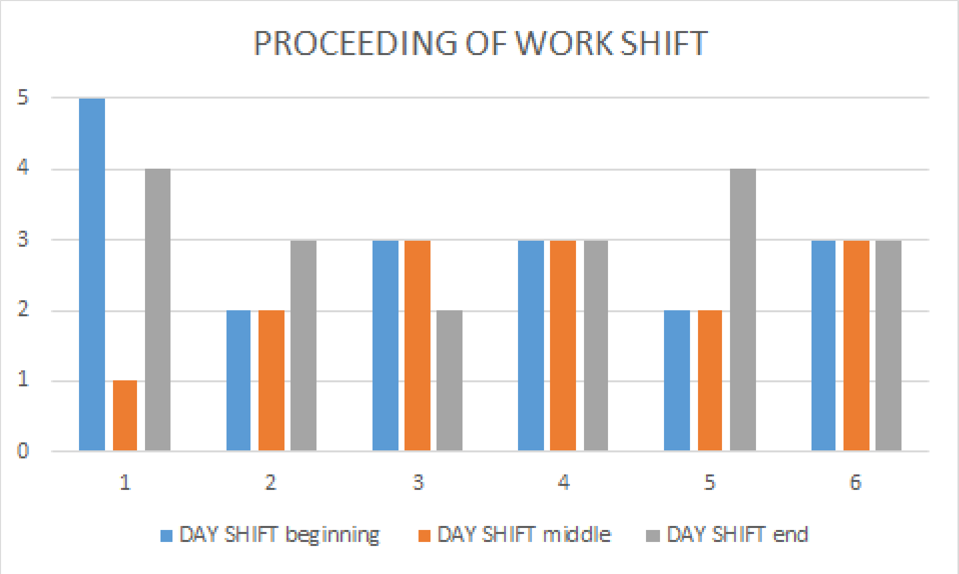

Figure 5. Possibilities to make an error during the proceeding of the day shift. X axis represents interviewees (n=6) and y axis represents error possibility (1= increases strongly, 2= increases slightly, 3=remains the same, 4=decreases slightly, 5=decreases strongly).

Night-shift comments:

- the possibility of an error grows in the latter half of the shift; this should be/is taken into account when planning the tasks for the shift
- at the end of the night shift, around four and five o'clock, I am tired but if something happens, I am instantaneously wide awake
- there is no trouble with the night shift if you have slept properly, but you are not the most alert at the last hours of the night shift.

The evaluation of error possibilities was different for day (see Figure 5) and night shifts (see Figure 6) when the interviewee was asked to specify what happens to error possibility when the shift is proceeding (each bullet point represents the response of one interviewee):

- independently of the shift, possibility for an error is somewhat or strongly diminished in the beginning if the shift, then error proneness somewhat or strongly grows in the middle of the shift and finally, error possibility somewhat diminishes at the end of the shift
- in the very beginning of the shift, error possibility first somewhat grows and then returns to the normal level; error possibility somewhat grows in the middle of the shift and returns again to normal at the end of the shift
- error possibility remains the same in the beginning and in the middle of the shift but increases slightly at the end of the shift
- during the day shift, error possibility remains the same but in the night shift, error possibility is increased at the end of the shift
- during the day shift, error possibility increases slightly in the beginning and in the middle of the shift but decreases slightly at the end of the shift; during night shift, error possibility remains unaltered in the beginning of the shift, decreases slightly in the middle of the shift and increases slightly at the end of the shift (and at the end of the

shift, tiredness affects but the better situation awareness serves as a trade-off so that error possibility is not so big)

- during annual shutdown, independently of the shift, error possibility increases slightly in the beginning of the shift, whereas during normal operations, independently of the shift, error possibility remains unaltered in the beginning of the shift
- during annual shutdown, independently of the shift, the possibility of an error is decreased strongly in the middle of the shift whereas during normal operations, independently of the shift, error possibility is unaltered
- and finally, during annual shutdown, independently on the shift, error possibility is increased slightly at the end of the shift whereas during normal operations, error possibility remains unaltered during day shift but is increased strongly at the end of the night shift.

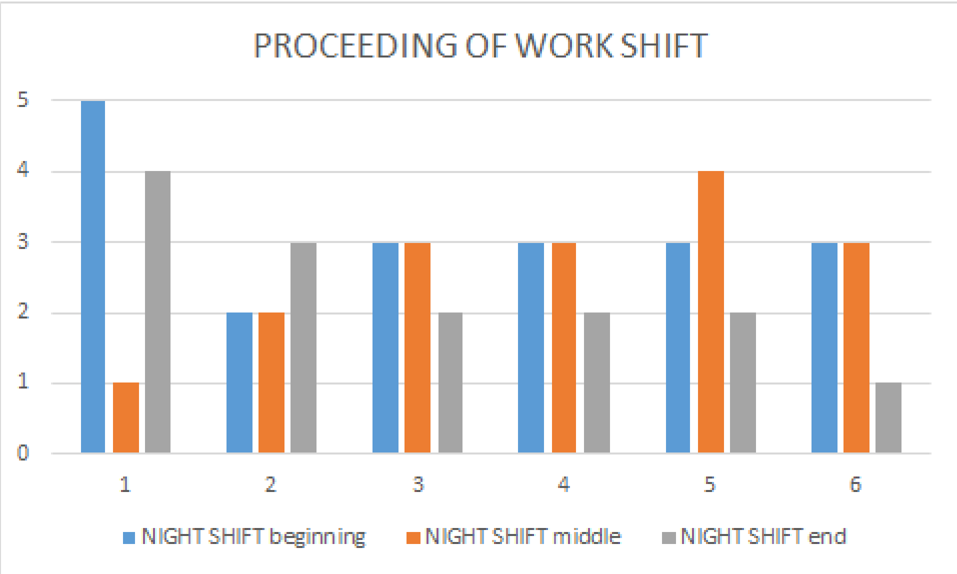

Figure 6. Possibilities to make an error during the proceeding of the night shift. X axis represents interviewees (n=6) and y axis represents error possibility (1= increases strongly, 2= increases slightly, 3=remains the same, 4=decreases slightly, 5=decreases strongly).

Earlier error

Due to lack of time, this question was not asked from all interviewees. However, some interviewees seem to have contemplated the situation when an error was almost but not actually made, as a situation including an error. Two interviewees out of four had their own experience in their minds, one thought a situation of somebody else and one from a general perspective.

Regarding the description of this kind of a situation,

- all four interviewees thought that one tends to remember the error made.

Regarding the error proneness (see Figure 7),

- two interviewees considered that an earlier error strongly decreases the possibility to make an error later
- one interviewee said that the error possibility is slightly decreased

- one contemplated that the error possibility is slightly decreased but if the person is not aware of the error, error possibility remains the same.

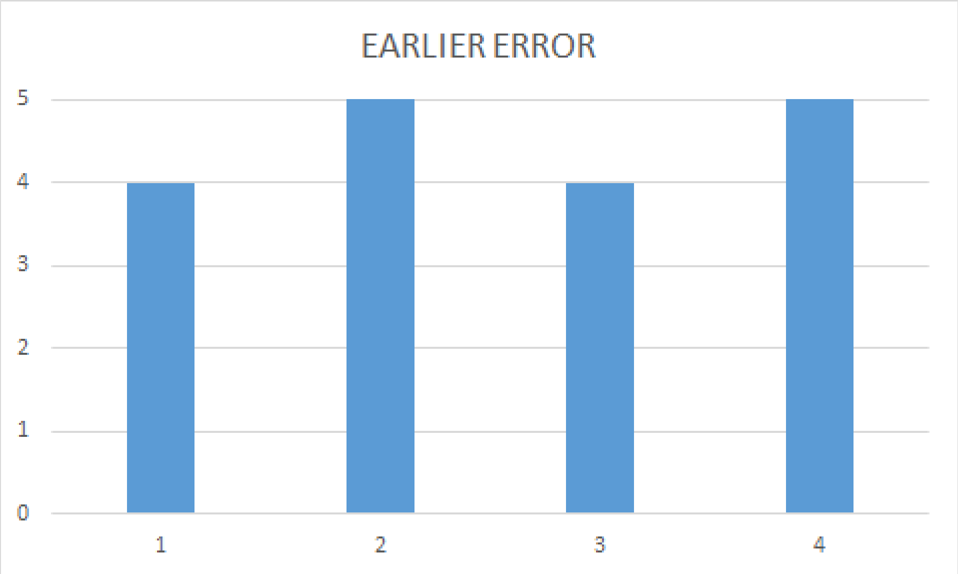

Figure 7. Possibilities to make an error related to a task, in which an error was earlier done. X axis represents interviewees (n=4) and y axis represents error possibility (1= increases strongly, 2= increases slightly, 3=remains the same, 4=decreases slightly, 5=decreases strongly).

3.4.2 Error descriptions

In the interview, interviewees were asked to describe what the typical errors could be in the specific situations. This question was asked, irrespectively of whether the interviewee had identified an error possibility or not. In all cases, interviewees tried to describe some error, nobody stated that it is hard to describe an error just after having stated that the error possibility is diminished. In the following, error descriptions are provided for each imagined situation.

Unclear whether earlier performance had been optimal

The following errors were described (each bullet point stands for the response of one interviewee):

- lack of skills or knowledge
- operational error
- the same error is not repeated (so the interviewee was thinking about the situation when an error had occurred earlier, not the situation that had remained unclear); in the simulator I wish to make an error so that it stays better in my mind
- perhaps operational error, so that a false valve is opened for instance
- an error in a situation to which there is not a procedure (so it was not a response for the question of a typical error in this situation)
- perhaps there is not time to focus on the situation; it is an error in itself if operator is not talking with anybody about an unclear situation.

Passed hurry

The following errors were described (each bullet point stands for the response of one interviewee):

- hard to imagine, perhaps something related to carelessness
- when the pulse is high, you can make a human error, such as you read the procedure incorrectly (and then make an error) or you read correctly but still perform incorrectly
- you don't focus on small details but only perceive the overview of the process (luckily there are two other guys in the control room as well); and you can also become careless when the stress is over and you feel contented
- when performing a new task, everything can get mixed up and you can work on a wrong component
- when the level of being alert is lowered, some routine task may get forgotten and only after the hurry you identify also the small deviations in the process
- typically, after the annual shutdown you relax even too much, you are not focused, and the following of alerts may be left undone.

Previously always correct performance

The following errors were described (each bullet point represents the response of one interviewee):

- carelessness, when you press accidentally a wrong button, when you are highly experienced
- you trust on your memory
- errors related to perception; I don't believe that there would be operational errors so that you would press a wrong button; if you make an operational error it means that you neglect the procedure
- human error, you perform with a routine and accidentally push a wrong pump or valve
- push a wrong button or you don't monitor the performance of the other (performance should not depend on one person only)
- when in your thoughts, you push the button next to the correct one.

Almost an error

The following errors were described (each bullet point stands for the response of one interviewee):

- carelessness when you have a strong routine
- you are on your way to operate an incorrect device
- in a hurry, you can operate the valve next to the correct one
- operating pump in the panel with similar mark
- pushing a wrong button

- when implementing a device, something was about to happen and now you remember that at least you should not do similarly.

Proceeding of work shift

The following errors were described (each bullet point stands for the response of one interviewee):

- error due to deficient skills or an error due to carelessness
- if you need to do something in a hurry and with insufficient familiarisation, one may operate accidentally wrong component
- insufficient perception of plant's parameters (before an alarm is released)
- operating error, human error; human error means that one accidentally chooses a wrong component
- possibility for a human error, one may forget something, error in communication so that you talk about some valve when you mean another valve

Earlier error

- operational error, so that you push a wrong button
- operational error, human error, or any error
- timetable-based error, when being in a hurry you don't stop and think; you skip one point or don't perform according to the procedure

3.5 Discussion and conclusions

Regarding error possibilities, interviewees' conceptions were mainly in accordance with each other although some variation existed as well. In the following, responses are briefly described, based on the situation to imagine in question.

When operator is unsure whether earlier performance had been optimal, it was usually considered that unclear matters are clarified. When the same situation is faced later again, error possibility was usually considered to be diminished. Additionally, one interviewee contemplated that a stubborn person may just continue operating, neglecting uncertainty and thus increasing error possibility whereas an operator who stops and discusses with colleagues diminishes his/her error possibility.

When operator has experienced hurry some time ago, error possibility was usually considered to be elevated. Hurry-originated stress does not vanish immediately, but it takes time before operator is fully prompt and exact again. Again, on interviewee considered that if being tired after hurry, error possibility is elevated whereas if the hurry has made the operator more alert, error possibility is diminished.

Dealing with a situation, which has always been operated correctly, divided operators' opinions. Most interviewees (three) considered that there is a danger in routines and constant success may lull to complacency, resulting in an error. One interviewee did not find that the situation affect error possibilities at all and two thought that good routines strengthen themselves, resulting in diminished possibility of making an error.

When an error was almost done in the past, half of the interviewees (three) believed this to decrease error possibility and the other half considered this would not affect error proneness at all. However, this task was hard to some interviewees – in the response, an actual error was sometimes spoken about instead of an error, which was prevented before the actual operation. There was also some fine-tuning in the responses. What is described above, represents the situation in the long run. Two interviewees thought that soon after the situation, error possibility is decreased, and it returns (raises) to normal when some time has passed.

Regarding error possibility variation during a day or night shift, interviewees had rather detailed conceptions on how the level of vitality varied during the shift, affecting error possibility.

During the day shift, half of interviewees (three) thought that error possibility is unaltered in the beginning of the shift while two considered that because situation awareness is not at its best in the very beginning of the shift, error possibility is then increased. One interviewee found error possibility low in the morning.

About in the middle of the day shift, and some interviewees contemplated especially the effect of lunch, half of interviewees found error possibility increased, and three thought it is unaltered.

There was a lot of variation in opinions regarding error possibility at the end of the day shift. Three respondents found error possibility unaltered, two interviewees considered error possibility decreased, perhaps due to good situation awareness, and one thought that error possibility is increased, perhaps because of fatigue.

The responses for the night shift were somewhat similar with the ones of the day shift. In the beginning of the night shift, one interviewee thought error possibility is strongly decreased and one considered it increased, but most interviewees (four) thought it is unaltered. In the middle of the night shift, three interviewees found error possibility unaltered, two thought it is increased and one found it decreased.

At the end of the night shift, most interviewees (four) considered that error possibility is increased – from four to five o’clock, people tend to be sleepy and that was told to be the reason for that. Two interviewees found, however, error possibility decreased at the end of the night shift. It may also be that these interviewees had the very end of the shift in their minds, taking place later than the tired period a couple of hours before the end of the shift.

Finally, all interviewees agreed that if an error was made earlier, the possibility to do it again is decreased in the future.

All in all, error related contemplations were valid among the interviewees and provided insight on error proneness in various operational situations. It was good to realise that all interviewees agreed on learning from errors: if one is done earlier, the same error will not be repeated.

The evaluation of error possibility (whether it remains the same or increases or decreases remarkably or to some extent) was hard to make. It is shown in the responses, as interviewee may have described how error possibility was, say, decreased, but when choosing one option among all possibilities, the interviewee may have chosen it to increase. The reason to this may have been in scarce experience of this type of questions. It became evident that at least to some interviewees, this was the first interview. It is also possible that the interviewee had a slightly different situation in his/her mind when describing the situation and when choosing the correct alternative of error possibilities. Say, error proneness after hurry can be considered to take place rather soon after the hurry or several hours after the hurry, and that distinction can be vital when considering alteration in error possibilities.

The format of interview was rather demanding and would have been demanding to anyone. Interviewee was to understand a specific type of situation, imagine it and keep it in mind for evaluating what kind of consequences that passed situation would bring in the future. Interviewees performed this task well. The hardest situations to imagine were the ones in which operator was left unsure whether performance had been optimal and when an error was almost but not done. These situations were mixed with the situation in which error was done, and interviewer had to often clarify that these situations are not about an actual error.

Error examples or typical errors were somewhat hard to create. This is not astonishing, in the nuclear domain probably only “human error” or “operational error” are referred to whenever an operator has made an error and the errors as such take seldom place. These are also the most often used terms when interviewees were asked to describe a typical error in some situation. Some examples of those were provided, though, such as unintentionally pushing a wrong button or neglecting some possibly important information.

Errors, which happen considerably later than its triggering situation or when the error is rather contextual, not a cause, are also more demanding to conceive. Sometimes interviewees provided the “traditional” human errors as an example, that is, the proceeding of events so that the cause and effect (error) follow immediately each other. An example of this is an error due to mishearing something and, immediately after that, acting incorrectly, according to what one had heard.

In the interviews which had some spare time, an additional question was asked. Then, interviewees had the possibility to invent a new dynamic situation. In such instances, two interviewees described how errors made during simulator training or reported issues at the plant decrease error possibility, providing actually an example of the situation already dealt with in the interview (‘earlier error’). One interviewee described mishearing as an example which was not a dynamic error. This reflects how difficult it is to assume a new concept (error that is triggered after a delay) and the difficulty of the concept itself.

The study has only a small amount of interviewees, limiting the conclusions to be made. However, even this small sample provided a lot of information and variation, which can also reflect the true variation, possibly realised also with a larger sample. Alternatively, the results are biased in some way and some critical features are missing. What the true case is, calls for a new study with more interviewees.

4. Concluding remarks

Dynamic HRA appears to be an interesting topic among PRA/HRA professionals but it raises doubts about its complexity and the additional resources it may require.

Interesting topics, identified in the survey, were the following:

- team collaboration in complex scenarios
- would the data presently gathered be sufficient for a dynamic method or is more expert judgement needed
- applicability of the methodology to control rooms and shorter time windows
- approaches and methods that could be used in dynamic HRA.

Main control-room operators were interviewed to shed light on dynamic HRA related phenomena qualitatively, especially the related human error possibilities - probabilities were not calculated - and to the possible research questions elicited in the survey responses.

Regarding the phenomena to study, the interviews provided some answers. Team collaboration in complex scenarios is such a complex matter that it is hard to discuss in a general-level interview. However, the example situations, created by researchers (present authors), were situated in the main control room and one of them took place within a shorter time window (‘passed hurry’). Other situations take supposedly place during a longer period of time, even if, for example, an error, or almost an error, could have been made at any moment in the past. In practise, though, most situations probably represent long time windows. The effect of the phase of the shift may also be considered as a performance shaping factor, not a cause for an error to make.

The variety of the responses and the vast operational experience they are based on talk for the complexity of cognitive processes behind the emergence or absence of human errors. One clearly described situation elicits many possibilities for an error to emerge or not. Thus, if cognitive processes would be modelled, one should take into account the variety of possible deviations, based on individual differences and the nuances in the situation, which may define whether an error path or errorless path is taken in the main control room operations.

References

IAEA (2015). The Fukushima Daiichi Accident Report by the Director General. Director General, 1–222. https://doi.org/10.1037/a0018137

Liinasuo, M., Karanta, I., Kling, T. (2019). Dynamic human reliability analysis (HRA) - a literature review. SAFIR 3/2019, VTT-R-00193-20.

Appendix 1: Questionnaire

Dynamic HRA: State-of-the-practice questionnaire

Human Reliability Analysis (HRA) is a structured approach to identify potential human errors (or human failures to accomplish tasks as required by the situation), and to estimate the probability of those errors. The concept of 'dynamic HRA' refers to such an approach to human errors in which the changing situation that affects human errors is taken into account. A practical driver of increased interest in dynamic HRA is the need to consider long time windows, a matter that proved its importance in Fukushima Daiichi nuclear accident, lasting for two to three days from the initiating event (IAEA, 2015).

In practice, dynamic HRA refers to situations in which former situation affects the latter one(s). Human performance is of the kind which is affected by former events, such as an interpretation about a situation affects how it is acted on, or being nervous may form a loop so that having become nervous may feed itself, adding nervousness. Also situations may change unexpectedly, or the situation may change just by time, and human performance after that change can depend on the earlier situation also in an apparently illogical way.

This questionnaire belongs to a HRA related task in the SAFIR2022 project NAPRA. In the previous phase of this task, literature review of dynamic HRA was written (Liinasuo et al. 2019). The aim of this questionnaire is to clarify how nuclear professionals perceive dynamic HRA and its meaning from the perspective of their work as well as the related potential needs. The responses affect what will be studied in this task.

The responses will be handled confidentially so that the identity of the respondent for some specific question will not be revealed in the reporting of the results of this survey. Please answer the following questions by writing your response in this document. If there are unclear expressions or something else to comment, please contact any of the authors of this questionnaire (contact information at the end of this page).

In the case the questions are answered by several people, please provide the name of all the people involved as background information. You can answer in Finnish or in English.

We kindly ask you to provide your response by **September 13**, 2020. Please send the filled-in questionnaire to one of the following e-mail addresses.
Thank you!

Ilkka Karanta (ilkka.karanta@vtt.fi)
Terhi Kling (terhi.kling@vtt.fi)
Marja Liinasuo (marja.liinasuo@vtt.fi)

1. Background information of the respondent(s)

   Name(s):
   Company:
   Profession(s):
   Involvement with HRA:

2. How familiar the concept of dynamic HRA is to you? *Bold the option closest to your opinion.*

a. This questionnaire is the first time I have heard about it
b. I have heard the concept earlier but haven't needed it professionally

c. I know it because it belongs to the work in our organisation (but not my work)
d. I know it because it distantly touches my work
e. I know it because I use it as part of my work

3. *If you selected the option "d" or "e" in question 2, answer this question:*
How is dynamic HRA part of your work (how you have used it, in what tasks, etc.)?

4. *If you selected the option "c" in question 2, answer this question:*
How is dynamic HRA part of the work in your organisation?

5. *If you selected the option "d" or "e" in question 2, answer this question:*
What have the challenges been in using dynamic HRA?

6. *If you selected the option "d" or "e" in question 2, answer this question:*
What have the benefits of dynamic HRA been?

7. *If you selected the option "a" or "b" in question 2, answer this question:*
What do you think are the reasons why dynamic HRA is not used in your work/company?

8. Can you give examples of situations in nuclear operations where issues of dynamicity related to human behaviour would have played a part? If yes, could you please describe them?

9. How could dynamic HRA be used in your work/company in the future?

10. What do you think are the challenges in using dynamic HRA in your company (or would be the challenges, if dynamic HRA is not presently used)?

11. What do you think are the benefits in using dynamic HRA in your company (or would be the benefits, if dynamic HRA is not presently used)?

12. As a whole, what do you think about the feasibility of using dynamic HRA in your company? Why would it be worth using/not worth using?

13. What would be interesting or important to study in SAFIR programme related to dynamic HRA?

14. Any other comments

Appendix 2: Interview questions (in Finnish)

Operaattorihaastattelu syksyllä 2020
”dynaamiset ilmiöt operoinnissa”

Taustakysymykset

Mikä on roolisi?
Kuinka kauan olet työskennellyt valvomo-operaattorina?

Varsinaiset kysymykset

1. Kuvittele mielessäsi tilanne, jossa sinulle on jäänyt epäselväksi, oletko toiminut mahdollisimman oikein ja se on jäänyt mietityttämään
    a. Miten tällainen tilanne saattaisi vaikuttaa jatkossa myöhempään onnistumiseen/virheiden tekemiseen?
    b. Minkälainen esimerkkitilanne tuli mieleesi; onko kysymyksessä kokemus (oma tai kuultu) vai mietiskely siitä, mitä voisi tapahtua?
    c. Minkälaiset virheet voisivat olla tyypillisimpiä tässä tilanteessa?
    d. Miten tilanne vaikuttaa mielestäsi virheen tekemiseen; virheen mahdollisuus lienee erittäin pieni, mutta mitä virheen mahdollisuudelle tapahtuu?
        i. kasvaa paljon
        ii. kasvaa vähän
        iii. pysyy ennallaan
        iv. pienenee vähän
        v. pienenee paljon

2. Kuvittele mielessäsi tilanne, jossa jokin aika sitten (samana päivänä) on ollut jonkin aikaa kiire operointitehtävissä, ja kiiretilannetta ei enää ole
    a. Miten tällainen tilanne saattaisi vaikuttaa myöhempään onnistumiseen/virheiden tekemiseen?
    b. Minkälainen esimerkkitilanne tuli mieleesi; onko kysymyksessä kokemus (oma tai kuultu) vai mietiskely siitä, mitä voisi tapahtua?
    c. Minkälaiset virheet voisivat olla tyypillisimpiä tässä tilanteessa?
    d. Miten tilanne vaikuttaa mielestäsi virheen tekemiseen; virheen mahdollisuus lienee erittäin pieni, mutta mitä virheen mahdollisuudelle tapahtuu?
        i. kasvaa paljon
        ii. kasvaa vähän
        iii. pysyy ennallaan
        iv. pienenee vähän
        v. pienenee paljon

3. Ajattele tilannetta, jossa on toimittu aina oikein
    a. Miten tällainen tilanne saattaisi vaikuttaa myöhempään onnistumiseen/virheiden tekemiseen?
    b. Minkälainen esimerkkitilanne tuli mieleesi; onko kysymyksessä kokemus (oma tai kuultu) vai mietiskely siitä, mitä voisi tapahtua?
    c. Minkälaiset virheet voisivat olla tyypillisimpiä tässä tilanteessa?
    d. Miten tilanne vaikuttaa mielestäsi virheen tekemiseen; virheen mahdollisuus lienee erittäin pieni, mutta mitä virheen mahdollisuudelle tapahtuu?
        i. kasvaa paljon
        ii. kasvaa vähän
        iii. pysyy ennallaan

iv. pienenee vähän
v. pienenee paljon

4. Ajattele tilannetta, jossa operaattori on (sinä olet) joskus tehnyt virheen
    a. Miten tällainen tilanne saattaisi vaikuttaa myöhempään onnistumiseen/virheiden tekemiseen?
    b. Minkälainen esimerkkitilanne tuli mieleesi; onko kysymyksessä kokemus (oma tai kuultu) vai mietiskely siitä, mitä voisi tapahtua?
    c. Minkälaiset virheet voisivat olla tyypillisimpiä tässä tilanteessa?
    d. Miten tilanne vaikuttaa mielestäsi virheen tekemiseen; virheen mahdollisuus lienee erittäin pieni, mutta mitä virheen mahdollisuudelle tapahtuu?
        i. kasvaa paljon
        ii. kasvaa vähän
        iii. pysyy ennallaan
        iv. pienenee vähän
        v. pienenee paljon

5. Ajattele tilannetta, jossa operaattori on ollut (sinä olet ollut) tekemäisillään virheen
    a. Miten tällainen tilanne saattaisi vaikuttaa myöhempään onnistumiseen/virheiden tekemiseen?
    b. Minkälainen esimerkkitilanne tuli mieleesi; onko kysymyksessä kokemus (oma tai kuultu) vai mietiskely siitä, mitä voisi tapahtua?
    c. Minkälaiset virheet voisivat olla tyypillisimpiä tässä tilanteessa?
    d. Miten tilanne vaikuttaa mielestäsi virheen tekemiseen; virheen mahdollisuus lienee erittäin pieni, mutta mitä virheen mahdollisuudelle tapahtuu?
        i. kasvaa paljon
        ii. kasvaa vähän
        iii. pysyy ennallaan
        iv. pienenee vähän
        v. pienenee paljon

6. Ajattele kokonaista työvuoroa. Miten vuoron eteneminen vaikuttaa operointiin (virkeys, tilanteen hahmottaminen yms.)?
    a. Miten mahdollisuus onnistumiseen/virheiden tekemiseen vaihtelee vuoron etenemisen myötä?
    b. Minkälaiset virheet voisivat olla tyypillisimpiä vuoron eri vaiheissa (alussa, keskellä, lopussa)?
    c. Miten tilanne vaikuttaa mielestäsi virheen tekemiseen; virheen mahdollisuus lienee erittäin pieni, mutta mitä virheen mahdollisuudelle tapahtuu?

    alussa
        i. kasvaa paljon
        ii. kasvaa vähän
        iii. pysyy ennallaan
        iv. pienenee vähän
        v. pienenee paljon

    keskellä
        i. kasvaa paljon
        ii. kasvaa vähän
        iii. pysyy ennallaan
        iv. pienenee vähän

v. pienenee paljon

lopussa

i. kasvaa paljon
ii. kasvaa vähän
iii. pysyy ennallaan
iv. pienenee vähän
v. pienenee paljon

7. Tuleeko mieleen muuta tilannetta, jossa aikaisemmin tapahtuneella olisi vaikutusta myöhempään operointiin?
   a. Minkälainen tilanne tämä on ja miten siihen voisi liittyä onnistuminen tai virhe?
   b. Minkälainen esimerkkitilanne tuli mieleesi; onko kysymyksessä kokemus (oma tai kuultu) vai mietiskely siitä, mitä voisi tapahtua miten tilanne vaikuttaa mielestäsi virheen tekemiseen?
   c. Miten tilanne vaikuttaa mielestäsi virheen tekemiseen; virheen mahdollisuus lienee erittäin pieni, mutta mitä virheen mahdollisuudelle tapahtuu?
      i. kasvaa paljon
      ii. kasvaa vähän
      iii. pysyy ennallaan
      iv. pienenee vähän
      v. pienenee paljon