

## Events and description

No.	Event Abbreviation	Description	Type
1	AN	AUV is not properly monitored during mission	Action
2	BD	Unexpected behaviour not detected	Diagnosis
3	DD	Damage is not detected during preparation for deployment	Diagnosis
4	DM	AUV is dropped during moving from/ to maintenance area	Action
5	DrD	AUV is dropped during deployment	Action
6	DrR	AUV is dropped during retrieval	Action
7	DR	Damages are not detected and repaired	Diagnosis and Action
8	DT	AUV is dropped during manual transport from/ to the vessel	Action
9	FM	AUV is not placed correctly on workbench and falls off during maintenance	Action
10	FS	Existing faults of the AUV are not solved completely before deployment	Diagnosis and Action
11	LC	Local excessive currents and waves are not considered	Diagnosis
12	MC	Maintenance is carried out wrongly	Action
13	NC	Battery is not charged sufficiently	Action
14	RF	Faults are not recognised during planning phase or before deployment	Diagnosis
15	SH	Wrong use of software leads to wrongly implemented parameters	Action
16	TS	Transponders are not set up as planned before	Action
17	WB	AUV is wrongly ballasted	Action
18	WP	Implementation of mission path or map is done wrongly	Diagnosis and Action

## Performance shaping factors

### Available Time

Available time refers to the amount of time that an operator or a crew has to diagnose and act upon an abnormal event. A shortage of time can affect the operator's ability to think clearly and consider alternatives. It may also affect the operator's ability to perform. Multipliers differ somewhat, depending on whether the activity is a diagnosis activity or an action.

#### Diagnosis

*Inadequate time* —  $P(\text{failure}) = 1.0$ . If the operator cannot diagnose the problem in the amount of time available, no matter what s/he does, then failure is certain.

*Barely adequate time* —  $2/3$  the average time required to diagnose the problem is available.

*Nominal time* — on average, there is sufficient time to diagnose the problem.

*Extra time* — time available is between one to two times greater than the nominal time required, and is also greater than 30 minutes.

*Expansive time* — time available is greater than two times the nominal time required and is also greater than a minimum time of 30 minutes; there is an inordinate amount of time (a day or more) to diagnose the problem.

*Insufficient information* — if you do not have sufficient information to choose among the other alternatives, assign this PSF level.

#### Action

*Inadequate time* —  $P(\text{failure}) = 1.0$ . If the operator cannot execute the appropriate action in the amount of time available, no matter what s/he does, then failure is certain.

*Time available is equal to the time required* — there is just enough time to execute the appropriate action.

*Nominal time* — there is some extra time above what is minimally required to execute the appropriate action.

*Time available  $\geq 5 \times$  times required* - there is an extra amount of time to execute the appropriate action (i.e., the approximate ratio of 5:1).

*Time available  $\geq 50 \times$  time required* – There is an expansive amount of time to execute the appropriate action (i.e., the approximate ratio of 50:1).

*Insufficient information* – If you do not have sufficient information to choose among the other alternatives, assign this PSF level.

### Stress/Stressors

Stress (and level of arousal) have been broadly defined and used to describe negative as well as positive motivating forces of human performance. Stress as used in SPAR-H refers to the level of undesirable conditions and circumstances that impede the operator from easily completing a task. Stress can include mental stress, excessive workload, or physical

stress (such as that imposed by difficult environmental factors). It includes aspects of narrowed attentional field or muscular tension, and can include general apprehension or nervousness associated with the importance of an event. Environmental factors often referred to as stressors, such as excessive heat, noise, poor ventilation, or radiation, can induce stress in a person and affect the operator's mental or physical performance. It is important to note that the effect of stress on performance is curvilinear – some small amount of stress can enhance performance, and should be considered nominal, while high and extreme levels of stress will negatively affect human performance.

*Extreme* – a level of disruptive stress in which the performance of most people will deteriorate drastically. This is likely to occur when the onset of the stressor is sudden and the stressing situation persists for long periods. This level is also associated with the feeling of threat to one's physical well-being or to one's self-esteem or professional status, and is considered to be qualitatively different from lesser degrees of high stress (e.g., catastrophic failures can result in extreme stress for operating personnel because of the potential for radioactive release).

*High* – a level of stress higher than the nominal level (e.g., multiple instruments and annunciators alarm unexpectedly and at the same time; loud, continuous noise impacts ability to focus attention on the task; the consequences of the task represent a threat to plant safety).

*Nominal* – the level of stress that is conducive to good performance.

*Insufficient information* – if you do not have sufficient information to choose among the other alternatives, assign this PSF level.

## **Complexity**

Complexity refers to how difficult the task is to perform in the given context. Complexity considers both the task and the environment in which it is to be performed. The more difficult the task is to perform, the greater the chance for human error. Similarly, the more ambiguous the task is, the greater the chance for human error. Complexity also considers the mental effort required, such as performing mental calculations, memory requirements, understanding the underlying model of how the system works, and relying on knowledge instead of training or practice. Complexity can also refer to physical efforts required, such as physical actions that are difficult because of complicated patterns of movements.

It is recognized that a single complexity factor can result in different levels of influence on human-system interaction. For example, mental calculations required of operators may be slight or, given aspects of the event, may prove to be overwhelming. The same is true for combinations of factors. Because of this, assignment of the specific complexity level associated with an HEP is left to the analyst to determine. At the current time, there is no algorithm for inferring levels of influence based on which combination of factors is selected. For analysts who wish to differentiate between rule- and knowledge-based diagnosis, in most cases the former would present less complexity and would often be associated with a positive rating on the procedures PSF. Knowledge-based diagnosis and decision-making will often present the operator with greater complexity and often be associated with more negative ratings on procedures, including incomplete or misleading procedures or lack of procedural guidance. In general, a task with greater complexity requires greater skill and

comprehension to successfully complete. Multiple variables are usually involved in complex tasks. Concurrent diagnosis of multiple events and execution of multiple actions at the same time is more complex than diagnosing and responding to single events.

*Highly complex* — very difficult to perform. There is much ambiguity in what needs to be diagnosed or executed. Many variables are involved, with concurrent diagnoses or actions (i.e., unfamiliar maintenance task requiring high skill).

*Moderately complex* — somewhat difficult to perform. There is some ambiguity in what needs to be diagnosed or executed. Several variables are involved, perhaps with some concurrent diagnoses or actions (i.e., evolution performed periodically with many steps).

*Nominal* — not difficult to perform. There is little ambiguity. Single or few variables are involved.

*Obvious diagnosis* — **diagnosis** becomes greatly simplified. There are times when a problem becomes so obvious that it would be difficult for an operator to misdiagnose it. The most common and usual reason for this is that validating and/or convergent information becomes available to the operator. Such information can include automatic actuation indicators or additional sensory information, such as smells, sounds, or vibrations. When such a compelling cue is received, the complexity of the diagnosis for the operator is reduced. Diagnosis is not complex at this point; it is obvious to trained operators. There is no obvious action PSF level assignment available to the analyst. Easy to perform **actions** are encompassed in the nominal complexity rate.

*Insufficient information* — if you do not have sufficient information to choose among the other alternatives, assign this PSF level.

## **Experience/Training**

This PSF refers to the experience and training of the operator(s) involved in the task. Included in this consideration are years of experience of the individual or crew, and whether or not the operator/crew has been trained on the type of accident, the amount of time passed since training, and the systems involved in the task and scenario. Another consideration is whether or not the scenario is novel or unique (i.e., whether or not the crew or individual has been involved in a similar scenario, in either a training or an operational setting). Specific examples where training might be deficient are guidance for bypassing engineered safety functions, guidance for monitoring reactor conditions during reactivity changes, and guidance for monitoring plant operation during apparently normal, stable conditions for the purpose of promoting the early detection of abnormalities.

*Low* — less than 6 months experience and/or training. This level of experience/training does not provide the level of knowledge and deep understanding required to adequately perform the required tasks; does not provide adequate practice in those tasks; or does not expose individuals to various abnormal conditions.

*Nominal* — more than 6 months experience and/or training. This level of experience/training provides an adequate amount of formal schooling and instruction to ensure that individuals are proficient in day-to-day operations and have been exposed to abnormal conditions.

*High* — extensive experience; a demonstrated master. This level of experience/training provides operators with extensive knowledge and practice in a wide range of potential scenarios. Good training makes operators well prepared for possible situations.

*Insufficient information* — if you do not have sufficient information to choose among the other alternatives, assign this PSF level.

## **Procedures**

This PSF refers to the existence and use of formal operating procedures for the tasks under consideration. Common problems seen in event investigations for procedures include situations where procedures give wrong or inadequate information regarding a particular control sequence. Another common problem is the ambiguity of steps. PSF levels differ somewhat, depending on whether the activity is a diagnosis activity or an action. In situations where multiple transitions between procedures are required to support a task or group of tasks, SPAR-H suggests that the analyst adjust the PSF for complexity accordingly. If the procedures themselves are problematic, i.e., inadequate, then, the HRA analyst should assess the procedures and determine whether they should be assigned an “inadequate” or “poor” rating.

### **Diagnosis**

*Not available* — the procedure needed for a particular task or tasks in the event is not available.

*Incomplete* — information is needed that is not contained in the procedure or procedure sections; sections or task instructions (or other needed information) are absent.

*Available, but poor* — a procedure is available but it is difficult to use because of factors such as formatting problems, ambiguity, or such a lack in consistency that it impedes performance.

*Nominal* — procedures are available and enhance performance.

*Diagnostic/symptom oriented* — diagnostic procedures assist the operator/crew in correctly diagnosing the event.

*Insufficient information* — if you do not have sufficient information to choose among the other alternatives assigns this PSF level.

### **Action**

*Not available* — the procedure needed for a particular task or tasks in the event is not available.

*Incomplete* — information is needed that is not contained in the procedure; sections or task instructions (or other needed information) are absent.

*Available, but poor* — a procedure is available, but it contains wrong, inadequate, ambiguous, or other poor information. An example is a procedure that is so difficult to use, because of factors such as formatting, that it degrades performance.

*Nominal* — procedures are available and enhance performance.

*Insufficient information* — if you do not have sufficient information to choose among the other alternatives, assign this PSF level.

## **Ergonomics/HMI**

Ergonomics refers to the equipment, displays and controls, layout, quality and quantity of information available from instrumentation, and the interaction of the operator/crew with the equipment to carry out tasks. Aspects of human machine interaction (HMI) are included in this category. The adequacy or inadequacy of computer software is also included in this PSF. Examples of poor ergonomics may be found in panel design layout, annunciator designs, and labelling.

However, in SPAR-H, if the job performance deficiency is related to a procedure, then the preferred means of evaluating the situation is to apply this information to the procedures PSF, as opposed to the ergonomics PSF. For example, if the procedure does not match the equipment to be used, then the equipment procedure deficiency should be noted in the procedures, not the ergonomics, PSF.

*Missing/Misleading* — the required instrumentation fails to support diagnosis or post-diagnosis behaviour, or the instrumentation is inaccurate (i.e., misleading). Required information is not available from any source (e.g., instrumentation is so unreliable that operators ignore the instrument, even if it is registering correctly at the time).

*Poor* — the design of the plant negatively impacts task performance (e.g., poor labelling, needed instrumentation cannot be seen from a work station where control inputs are made, or poor computer interfaces).

*Nominal* — the design of the plant supports correct performance, but does not enhance performance or make tasks easier to carry out than typically expected (e.g., operators are provided useful labels; the computer interface is adequate and learnable, although not easy to use).

*Good* — the design of the plant positively impacts task performance, providing needed information and the ability to carry out tasks in such a way that lessens the opportunities for error (e.g., easy to see, use, and understand computer interfaces; instrumentation is readable from workstation location, with measurements provided in the appropriate units of measure).

*Insufficient information* — if you do not have sufficient information to choose among the other alternatives, assign this PSF level.

## **Fitness for Duty**

Fitness for duty refers to whether or not the individual performing the task is physically and mentally fit to perform the task at the time. Things that may affect fitness include fatigue, sickness, drug use (legal or illegal), overconfidence, personal problems, and distractions. Fitness for duty includes factors associated with individuals, but not related to training, experience, or stress.

*Unfit* — the individual is unable to carry out the required tasks, due to illness or other physical or mental incapacitation (e.g., having an incapacitating stroke).

*Degraded fitness* — the individual is able to carry out the tasks, although performance is negatively affected. Mental and physical performance can be affected if an individual is ill, such as having a fever. Individuals can also exhibit degraded performance if they are inappropriately overconfident in their abilities to perform. Other examples of degraded fitness include experiencing fatigue from long duty hours; taking cold medicine that leaves the individual drowsy and non-alert; or being distracted by personal bad news (such as news of a terminal illness diagnosis of a loved one).

*Nominal* — the individual is able to carry out tasks; no known performance degradation is observed.

*Insufficient information* — if you do not have sufficient information to choose among the other alternatives, assign this PSF level.

## **Work Processes**

Work processes refer to aspects of doing work, including inter-organizational, safety culture, work planning, communication, and management support and policies. How work is planned, communicated, and executed can affect individual and crew performance. If planning and communication are poor, then individuals may not fully understand the work requirements. Work processes include consideration of coordination, command, and control. Work processes also include any management, organizational, or supervisory factors that may affect performance.

Examples seen in event investigations are problems due to information not being communicated during shift turnover, as well as communication with maintenance crews and auxiliary operators. Measures could include amount of rework, risk worth of items in utility corrective action program backlog, enforcement actions, turnover, performance efficiencies, etc.

*Poor* — performance is negatively affected by the work processes at the plant (e.g., shift turnover does not include adequate communication about ongoing maintenance activities; poor command and control by supervisor(s); performance expectations are not made clear).

*Nominal* — performance is not significantly affected by work processes at the plant, or work processes do not appear to play an important role (e.g., crew performance is adequate; information is available, but not necessarily proactively communicated).

*Good* — work processes employed at the plant enhance performance and lead to a more successful outcome than would be the case if work processes were not well implemented and supportive (e.g., good communication; well understood and supportive policies; cohesive crew).

*Insufficient information* — if you do not have sufficient information to choose among the other alternatives, assign this PSF level.