Petro-HRA

Analysis of human actions as barriers in major accidents in the petroleum industry

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Contents

Overview of the Petro-HRA Method

- Background
- The Petro-HRA Project
- Development of the Petro-HRA Method
- The Petro-HRA Method including case examples
  - Qualitative
  - Quantitative

Background

- HRA in the nuclear industry
  - Long history of HRA, going back to early 1960s
  - HRA used as input to PRA/PSA
- QRA in the petroleum industry
  - Differences in how human & organization factors are represented in QRA
  - Maybe due to lack of suitable (i.e. non-nuclear) HRA methods?

Glossary

- HRA – Human Reliability Analysis
- QRA – Quantitative Risk Assessment
- PRA – Probabilistic Risk Assessment
- PSA – Probabilistic Safety Assessment
- HFE – Human Failure Event
- HEP – Human Error Probability
- PSF – Performance Shaping Factor

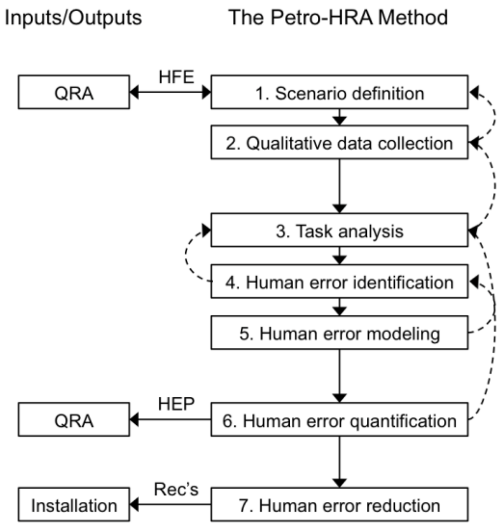
The Petro-HRA Project

- Established in 2012
- Main goal was to evaluate and adapt a nuclear HRA method to a petroleum context
  - SPAR-H chosen based on previous study which concluded that it was the most promising for evaluating petroleum events

Development of the Petro-HRA Method

- Much of the focus was on:
  - Evaluating and adapting SPAR-H nominal values and PSF descriptions & levels, to make them more suitable for petroleum activities & tasks
  - Documenting the qualitative analysis process, including task and error analysis, to make Petro-HRA a "complete" method
- Many HRA methods do not describe how to do qualitative analysis
  - Causes uncertainty amongst less experienced analysts
  - Increases variability between analysts in their approach and results
- Petro-HRA includes the qualitative part, "Complete" method

The Petro-HRA Method



- 7 steps in the method
- Non-linear – iteration between & within steps
- May include inputs from the QRA in the form of a HFE, HEP and/or scenario information
- Outputs an updated HEP to the QRA
- Outputs recommendations for improvement measures to the installation itself

7

The Petro-HRA Method

Qualitative Petro-HRA

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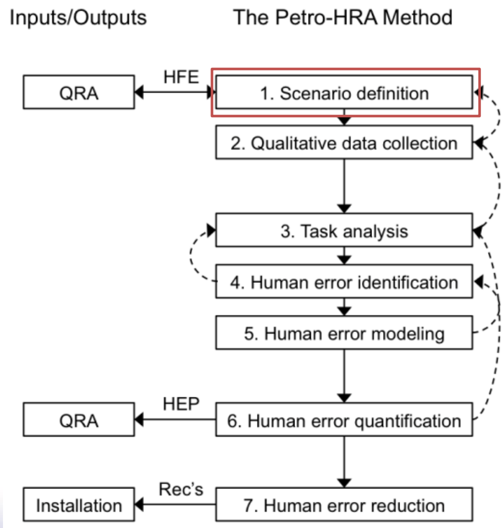
8

Step 1: Scenario Definition

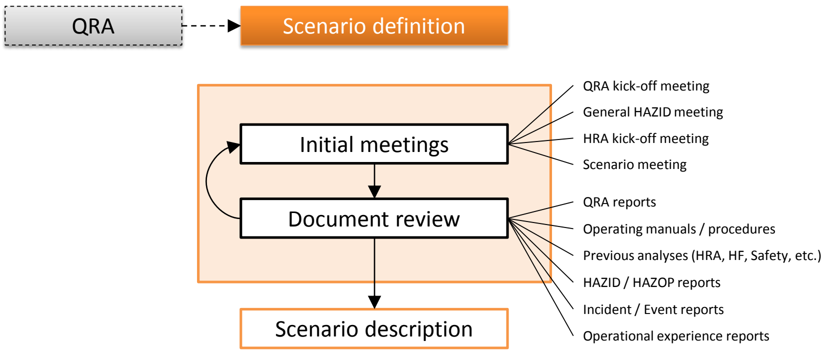


Step 1: Scenario Definition

- **Aim:** To define the scenario that is to be analysed and set the scope for the HRA

??? *In your experience, what is the best source of information for developing the scenario description? Why?*

Define the Scenario



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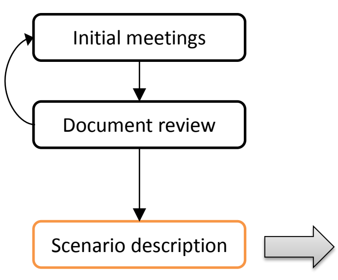
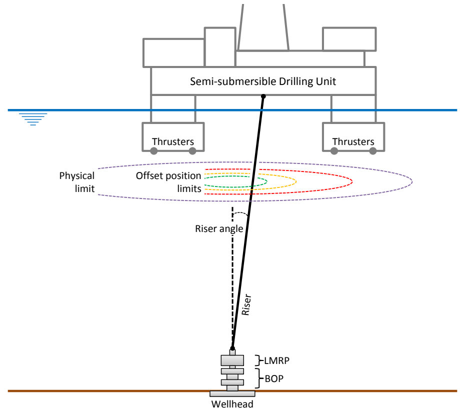
Develop the Scenario Description



TOPIC	DESCRIPTION	COMMENTS	ACTIONS
Location and external environment			
Location of event			
External environmental conditions			
System and task context			
Operational mode			
Safety system / barriers			
Personnel roles and responsibilities			
Event sequence and duration			
Initiating event			
Intermediate events			
End of event sequence			
Timescale			
Duration of event			

Scenario example – DP drive off



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Scenario analysis table

Topic	Description	Comments
Initiating event	An undefined DP failure initiates the drive-off. All thrusters pointing aft – giving forward thrust. Thrusters are at zero revolution giving zero forward thrust at the starting point. Error in the DP control initiates the thrusters to accelerate up to full forward thrust: 6 thrusters running in calm water.	It is not important to define the actual cause (i.e. failure mode) of the drive-off. This is because the response pattern and required actions will more or less be the same. For more than 6 thrusters, calculations show that the scenario duration reported below is too long and the automatic EDS will activate before the DPO activates the manual EDS.
Intermediate events	Operator: • Detect drive-off • Diagnose the situation • Decide the next steps • Activate emergency thruster stop (bringing the rig into a drift-off) • Activate the Red Alert and EDS	It is assumed that DPO activates the emergency stop of the thrusters. This is done to save time and reduce possible damages to the well-head. The rig will still be drifting off position, but at a lower speed. From the DP manual "*In a Drive-Off event, stop thrusters, Initiate Red Alert and enable EDS immediately.*" DPO2 may notify the driller.
End of event sequence (successful)	Successful manual shutdown of the thrusters followed by manual activation of the EDS results in a timely and safe disconnection of the LMRP from the BOP.	There is no direct feedback in the system for successful disconnection. However CCTV images from the ROV and Moon Pool camera may show if the LMRP is disconnected and whether there is tension on the riser (i.e. slip joint is moving).
End of event sequence	For this scenario the Automatic EDS is enabled with a safety margin to prevent damage to the well and rig. As	

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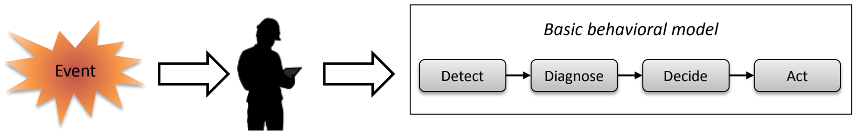
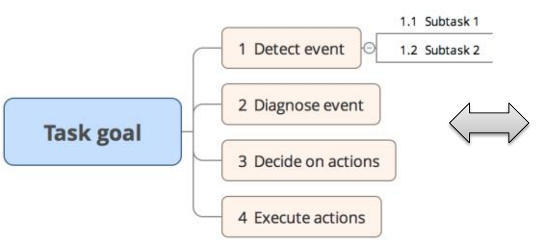
Initial Task Identification





TOPIC	DESCRIPTION	COMMENTS	ACTIONS
Location and external environment			
Location of event			
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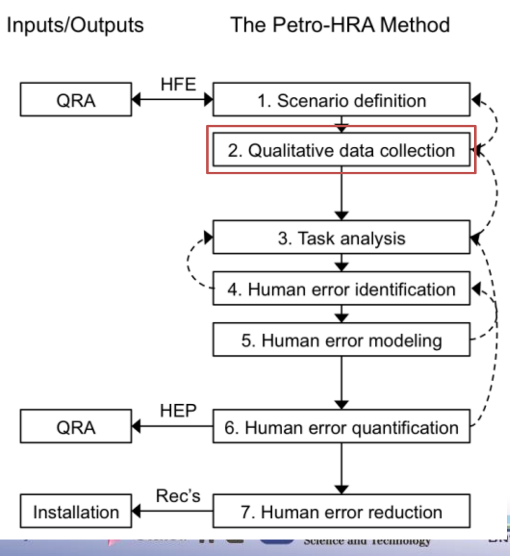
System and task context			
Operational mode			
Safety system / barriers			
Personnel roles and responsibilities			
Event sequence and duration			
Initiating event			
Intermediate events			
End of event sequence			
Timescale			
Duration of event			

15

Step 2: Qualitative Data Collection



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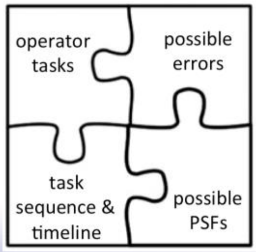
16

Step 2: Qualitative Data Collection

- **Aim:** to better understand the operator tasks, possible errors, and performance shaping factors, *i.e. build a more detailed picture*



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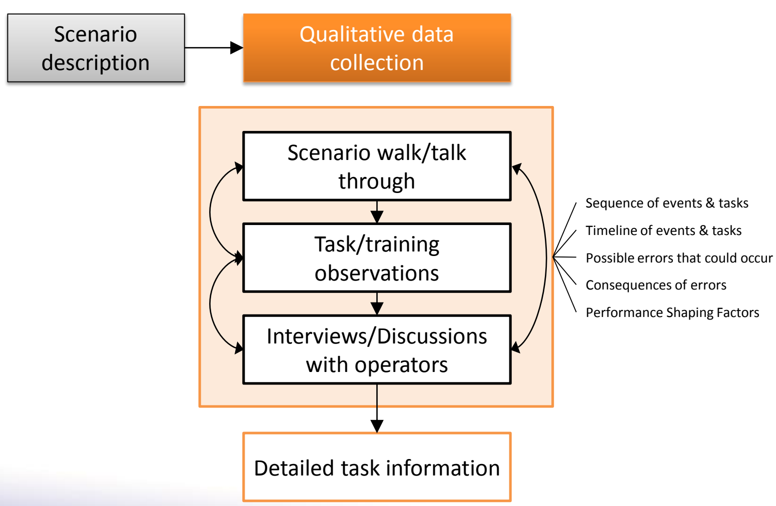
In your experience, what is the best forum for collecting qualitative data?

Collect Qualitative Data



Collect Qualitative Data

Scenario talk-through / walk-through

- This should be one of the first activities in the data collection
- Gain a detailed understanding of how the operator would respond in the scenario
- Understand local contexts and constraints that could affect operator response

Observations of Task Performance / Training

- Understand how the operators work and interact with each other and the I&C systems around them
- Observe normal working conditions to collect general qualitative data
- Observe training exercise to collect scenario-specific qualitative data

Interviews / Discussions with Operators

- Most commonly used data collection technique
- Should always interview more than one operators to ensure a more balanced view
- Also consider interviewing shift managers, trainers, site QRA analyst/end user, HSE advisor, etc.

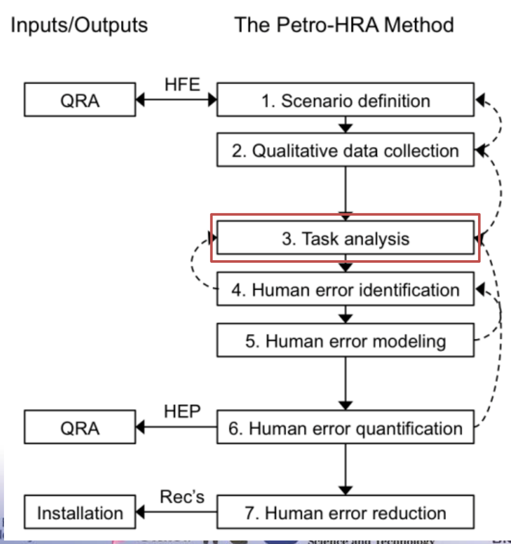
Talk About Human Error

- A common challenge for HRA analysts
  - This can be a sensitive subject, especially if there is a history of similar events at the installation
  - There may be high expectations of success in the scenario, and an unwillingness to admit things could go wrong
  - There may be a mindset of "that would never happen here"
- The analyst should:
  - Try to make the operator feel comfortable
  - Avoid directly asking what errors the *operator* could make
  - Instead ask "what could go wrong to prevent you from completing this task successfully?" or "what could happen if a less experienced operator was in this situation?"
  - Read event reports before interviews to be more familiar with error types, relevant terminology, etc.

Identify Deviation Scenarios

- Deviations to the main scenario might also exist, and should be considered for analysis
  - *A scenario that deviates from the nominal conditions normally assumed for the QRA sequence of interest, which might cause problems or lead to misunderstandings for the operating crews (adapted from Forester et al., 2007)*
  - *Deviations from what is generally expected, if sufficiently difference, can cause serious mismatches between the actual situation and the operators expectations, their performance aids, their usual approach to implementing procedures, and so forth (from Forester et al., 2007)*

Step 3: Task Analysis

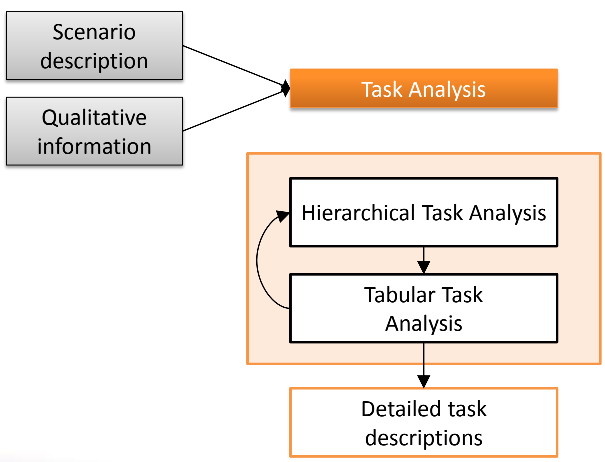


Step 3: Task Analysis

- **Aim:** to understand the activities that are being analysed and to translate these details into the level of detail suitable for the HRA and the QRA.

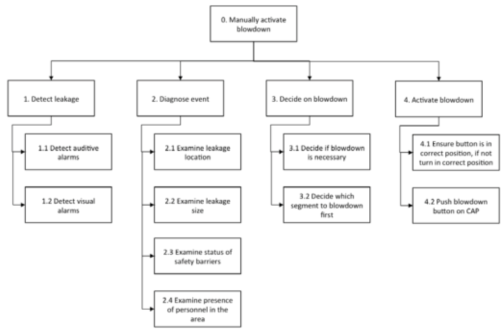
??? *In your experience, what are the main uses of the task analysis in an HRA?*

Develop the Task Analysis

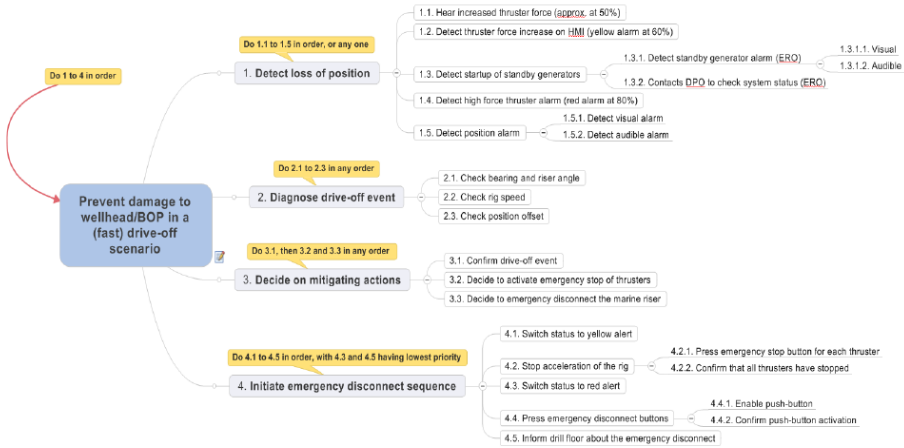


Hierarchical Task Analysis

- Main challenge is to determine the appropriate level of decomposition
  - Level of decomposition should be matched to the purpose of the analysis & to enable error identification & PSF evaluation
  - Not all task steps need to be decomposed to the same level – focus on those critical to the overall analysis



HTA example



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Tabular Task Analysis

	A	B	C	D	E	F
1	Step No.	Description	Cue / Feedback	Procedure	HMI	Person Responsible
2	0	Manually activate blowdown				
3	1	Detect leakage				
4	1.1	Detect audio alarms				
5	1.2	Detect visual alarms				
6	2	Diagnose event				
7	2.1	Examine leakage location				
8	2.2	Examine leakage size				
9						

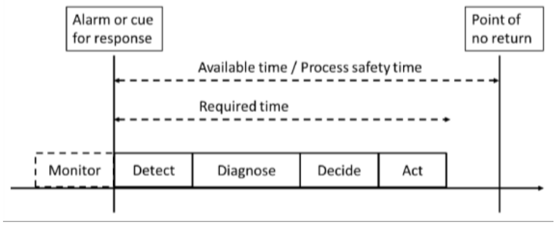
- Extends the HTA to include more detailed information about the tasks
- The exact content of the TTA may vary from HRA to HRA, depending on the scope and needs of the analysis; e.g.
  - A critical task may be diagnosis of the event from the alarm screen, and so the TTA may be more focused on how operators use the HMI, rather than e.g. tasks outside the control room; or
  - A critical task may be the location and manipulation of a particular valve by a field operator, and so the TTA may be more focused on the work environment, access to the valve location, etc.
- Remember to include any assumptions or uncertainties about the task steps in the TTA

TTA example

Table 10.1 TTA for the task "Diagnose drive-off event"

Step No	Task	Cue	Feedback	HMI	Responsible	Assumptions	Notes
2	DIAGNOSE DRIVE-OFF EVENT						
PLAN 2	*DO 2.1 to 2.3 in any order, then DO 2.4*						
2.1	Check riser angle	One or several loss of position indicators detected as part of task step 1.0 – most likely increase in thruster sound. In addition, previous task steps in 2.0 will be cues for subsequent diagnosis steps.	Noticeable increase in riser angle displayed in degrees.	DPOS	DPO 1	The DPO on duty monitors parameters continuously through the watch and will quickly notice deviation in trends and values.	Automatic EDS initiates when the riser angle exceeds 2°. To be successful (safe) the disconnection must occur before the riser angle exceeds 8°.
2.2	Check rig speed	Same as for task step 2.1.	Noticeable increase in speed on HMI displayed in knots.	K-Pos – DPOS.	DPO 1	Same as for task step 2.1.	
2.3	Check position offset	Same as for task step 2.1.	Noticeable position offset on HMI displayed in meters and with a rig position diagram.	K-Pos – DPOS.	DPO 1	Same as for task step 2.1.	It could take up to 5 seconds from the thrusters starting up before he will see any change in rig position on the HMI. The DPO would therefore have to check the position offset a few times to be sure that a drive-off is occurring.

Conduct a Timeline Analysis



- Time is often a critical factor in petroleum events; operators often have only minutes, or even seconds, to respond and intervene to control and mitigate the consequences of an event.
- Operators and other SMEs can give good insights into the time required to complete tasks, which tasks can be performed in parallel, where time pressure might exist, etc.

Timeline analysis example

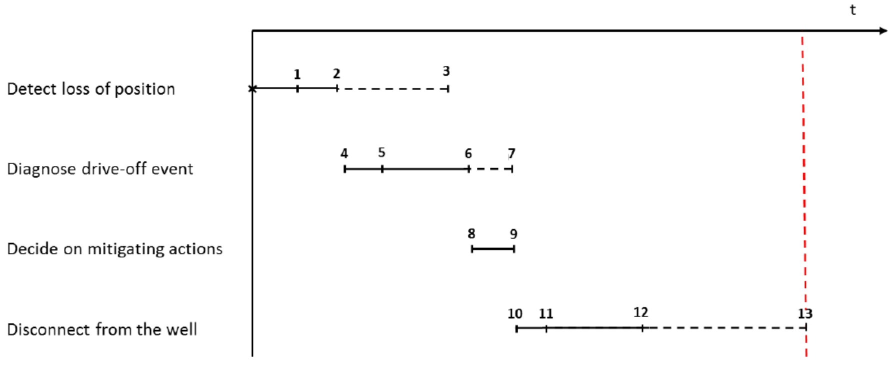


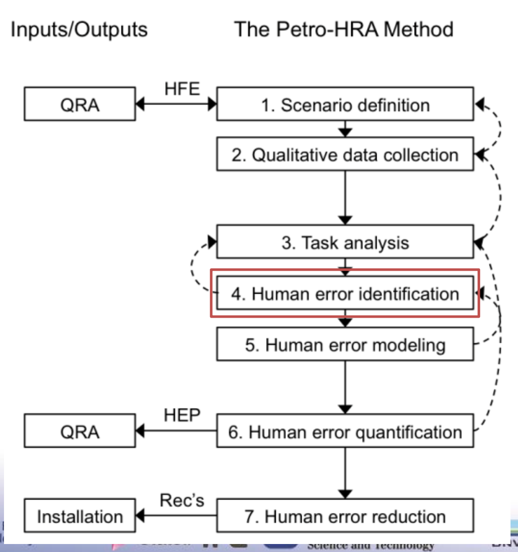
Figure 10.3 Timeline analysis diagram for a drive-off scenario.

Timeline analysis table example

Table 10.1 Timeline analysis table for the task "Diagnose drive-off event"

Task step	Step times and duration	Comments
Diagnose drive-off event	4. XX seconds after noticing increased thruster rev and sound, at Time=XX seconds, the DPO starts diagnosing the event by checking riser angle, rig speed, and position offset. 5. Realizing that the rig is in a degraded situation, the DPO switches to yellow status at Time=XX seconds. At this time it would also be natural to call on the second DPO for support. 6. XX to YY seconds is required to confirm drive-off by iteratively examine trends of various parameters, making the diagnosis last until approximately Time=XX to YY seconds. 7. The last XX seconds of performing the diagnosis, the DPO(s) start deciding on how to act.	Comments: • In the workshop it was argued that XX seconds for diagnosis is a conservative estimate. Recommendation: • The priority of switching to yellow status during this scenario should be evaluated in terms of criticality (consequence of omitting this step) against the added complexity of the task by having yet another action to recall. This could be compared against only having to switch to red status before shutting down thrusters and activating EDS.

Step 4: Human Error Identification



Step 4: Human Error Identification

- **Aim:** to identify and describe potential errors that could occur in the scenario as well as the consequences and possibilities for recovery of these errors, and to identify and describe the performance shaping factors that could impact on error probability.

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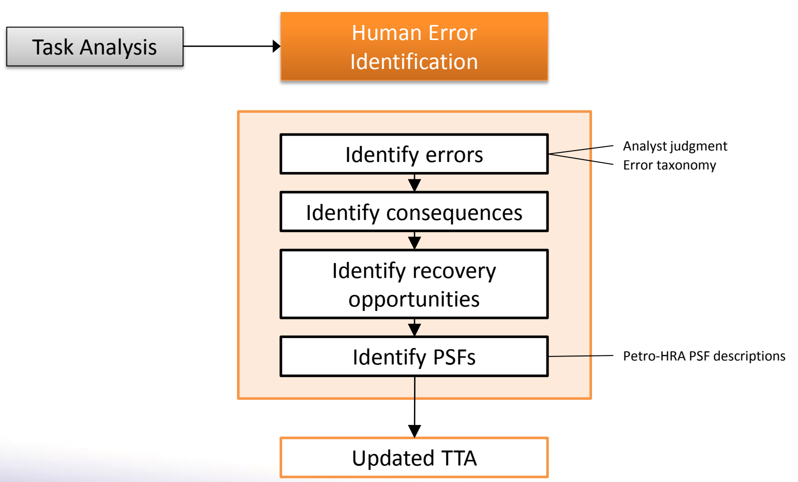
In your experience, what difficulties might the analyst encounter when trying to identify and describe potential errors?

Identify and Describe Errors



Identify Human Errors

- Two main ways to identify errors:
  1. Identify the “obvious” errors. E.g. if the task step is “detect visual alarms” then the obvious error is that the operator does not detect the visual alarms
  2. Use the extended list of SHERPA guidewords to prompt error identification

Action Errors	**Checking Errors**
A1-Operation too long/short	C1-Check omitted
A2-Operation mistimed	C2-Check incomplete
A3-Operation in wrong direction	C3-Right check on wrong object
A4-Operation too little/much	C4-Wrong check on right object
A5-Misalign	C5-Check mistimed
A6-Right operation on wrong object	C6-Wrong check on wrong object
A7-Wrong operation on right object	**Retrieval Errors**
A8-Operation omitted	R1-Information not obtained
A9-Operation incomplete	R2-Wrong information obtained
A10-Wrong operation on wrong object	R3-Information retrieval incomplete
Information Communication Errors	**Selection Errors**
I1-Information not communicated	S1-Selection omitted
I2-Wrong information communicated	S2-Wrong selection made
I3-Information communication incomplete	**Decision Errors**
	D1-Correct decision based on wrong/ missing information
	D2-Incorrect decision based on right information
	D3-Incorrect decision based on wrong/ missing information
	D4-Failure to make a decision (impasse)

35

Identify Error Consequences

- Error consequences should be specific, to allow for later screening and modeling
  – What is the immediate consequence of the error?
  – What is the long-term consequence?
  – Does the consequence have an effect on subsequent task steps?
  – Does the consequence have an effect on how the event escalates?

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36

Identify Recovery Opportunities

- The analyst should consider whether and how the operator could recover from the error, and what effect this has on the scenario:
  - Could the operator immediately identify that they have done something wrong, e.g. through a subsequent task step or system intervention?
  - Could the operator identify and recover from the error later in the task, e.g. as a result of a peer check?
  - Could the operator fail to recover from the error as there is no subsequent cue for the operator to check, and no interlocks to prevent further incorrect actions?

HEI example

Table 10.3 Human error identification for the task "Diagnose drive-off event"

Step No	Description	Potential error	Likely consequences	Recovery opportunity	Further analysis	PSFs
2	DIAGNOSE DRIVE-OFF EVENT				Y	
PLAN 2	DO 2.1 to 2.3 in any order, then DO 2.4					
2.1	Check riser angle	DPO omits to check riser angle	DPO has an incomplete awareness of drive-off situation and must rely only on information about rig speed and position offset. This may cause delay or omission of thruster stop and EDS activation.	Additional checks in Steps 2.2 and 2.3	N	
		DPO misreads / misdiagnoses riser angle degrees (being less than actual)	DPO may experience less urgency something which in turn may delay subsequent required actions, i.e. thruster stop and EDS activation.	Additional checks in Steps 2.2 and 2.3	Y	
		DPO checks riser angle too late/ or spends too much time checking	DPO has less time available to check other loss of position indicators. DPO has an incomplete awareness of drive-off situation and must rely on checking rig speed and position offset alone. This may cause delay or omission of thruster stop and EDS activation.	No recovery	Y	

Update the TTA

- The TTA should be extended to include information about errors, consequences and recovery alongside the relevant task steps.

	A	B	C	D	E	F	G	H	I
1	Step No.	Description	Cue / Feedback	Procedure	HMI	Person Responsible	Potential Error	Consequence	Recovery Opportunities
2	0	Manually activate blowdown							
3	1	Detect leakage							
4	1.1	Detect audio alarms							
5	1.2	Detect visual alarms							
6	2	Diagnose event							
7	2.1	Examine leakage location							
8	2.2	Examine leakage size							
9									

Identify Performance Shaping Factors

- The Petro-HRA method quantifies errors by considering the effects of PSFs
- Therefore the analyst must also consider what PSFs exist that may contribute to the identified errors by considering "*what if…?*", e.g.
  - *Is time a factor for the error potential in this task?*
  - *Could the quality of procedures affect the potential errors in this task?*

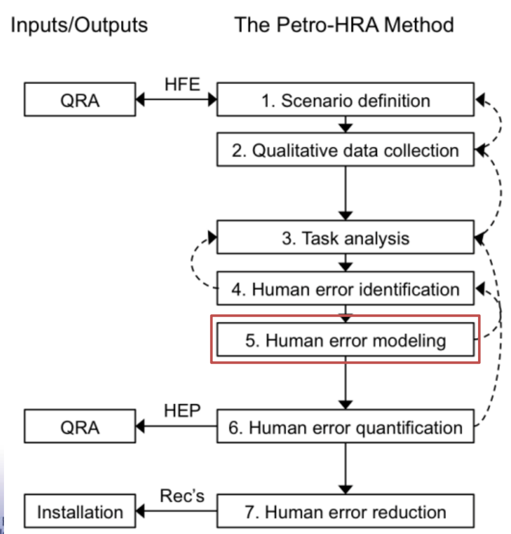
- The Petro-HRA method includes nine PSFs:
  1. Time
  2. Threat Stress
  3. Task Complexity
  4. Experience / Training
  5. Procedures
  6. Human-Machine Interface
  7. Adequacy of Organization
  8. Teamwork
  9. Physical Working Environment

Update the TTA

- The TTA should be extended again to include information about the identified PSFs alongside the relevant task steps.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Step No.	Description	Cue / Feedback	Procedure	HMI	Person Responsible	Potential Error	Consequence	Recovery Opportunities	Performance Shaping Factors	Assumptions	Notes / Comments
2	0	Manually activate blowdown										
3	1	Detect leakage										
4	1.1	Detect audio alarms										
5	1.2	Detect visual alarms										
6	2	Diagnose event										
7	2.1	Examine leakage location										
8	2.2	Examine leakage size										
9												

Step 5: Human Error Modeling



Step 5: Human Error Modeling

- **Aim:** to clarify and demonstrate the links between the identified human errors, task steps, PSFs and the overall HFE.

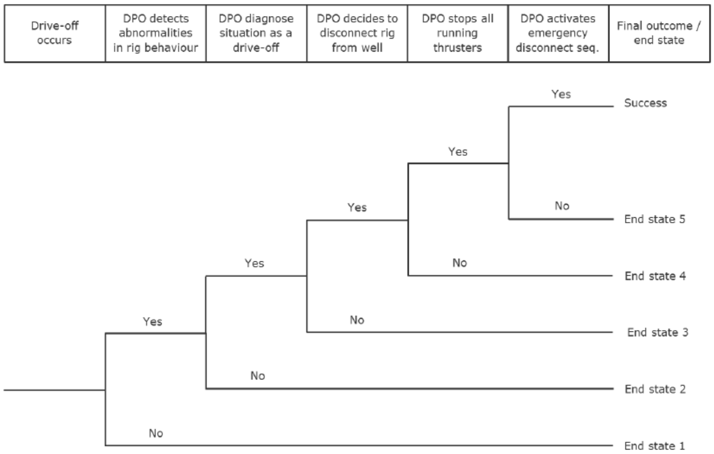
??? *What is your preferred method for human error modeling? Why?*

Human Error Modelling

- Two main approaches used in HRA:
  - Event Tree Analysis
  - Fault Tree Analysis

- Event trees most commonly used in QRA, and therefore it is the recommended approach for Petro-HRA
  - Event trees provide a good high-level description of the post-initiating event scenario
  - It may be easier to integrate the results into the QRA event tree if a similar format is used

Develop an Event Tree



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45

Event tree table

Table 10.5 Operator action event tree table for a drive-off scenario

ID	Event	Failure Event	Potential errors (from HEI)	HEP	Final outcome/End state
0	Drive-off occurs.	Initiating event: A drive-off occurs due to DP failure.	N/A	N/A	N/A
1	DPO detects DP abnormalities. Ref. Task 1.0	Failure to detect DP abnormalities. The drive-off is not detected or detected too late by the DPO, making him or her unaware of the drive-off being initiated.	DPO does not hear sound of thrusters increasing (or too late). DPO does not detect increase in thruster force on HMI. DPO does not hear sound of thrusters increasing. DPO does not detect increase in thrusters force on HMI.	0.x	The Automatic EDS is activated according to the offset position limit defined in the WSOC. Due to the speed of the rig the riser angle may be too steep for the disconnection to be successful. Damage or breakage of equipment, with potential environmental impact (e.g. spill of mud).
2	DPO diagnose situation as drive-off. Ref. Task 2.0	Failure to diagnose drive-off. The DPO does not realize that the abnormalities indicate a drive-off (as described in the scenario description). For example, he or she fails to recognize the type of event or its severity.	DPO does not diagnose that this is a drive-off event. See additional associated human errors marked (Y) in the HEI, Table 11.3.	0.x	See ID 1 (above).
3	DPO decides to disconnect rig from well.	Failure to decide on correct mitigating actions.	DPO does not realise that thrusters should be stopped first before initiating EDS.	0.x	See ID 1 (above).

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Event tree table cont.

ID	Event	Failure Event	Potential errors (from HEI)	HEP	Final outcome/End state
	Ref. Task 3.0	The DPO decides not to stop thrusters and/ or disconnect, fails to make a decision in time, decides to attempt a different recovery (e.g. regain position), or reaches not decision, e.g. 'freezes' due to stress.	Decision to stop thrusters takes too long. DPO decides not to initiate EDS. Decision to initiate EDS takes too long.		
4	DPO stops all running thrusters. Ref. Task 4.2 Ref. Task 4.4	Failure to stop all running thrusters. The DPO fails to stop all running thrusters at all, too late, or partially.	DPO takes too long to press the buttons for all active thrusters. DPO stops the wrong thrusters (i.e. The wrong 6 out of 8). DPO does not confirm that all active thrusters have stopped.	0.x	See ID 1 (above). For partial or delayed stop of the thrusters, damage can be less than if the thrusters are not stopped at all.
5	DPO activates emergency disconnect seq.	Failure to activate emergency disconnect sequence (EDS). The DPO fails to active EDS at all or in time before the Automatic EDS is activated.	DPO does not press EDS buttons. DPO takes too long to press EDS buttons.	0.x	Assuming that the Automatic EDS is enabled and that the DPO stops the thrusters in a timely manner, there will are not impacts associated with this event.

PetroHRA Quantification

How to, when to, where to, who should and why quantify

Martin Rasmussen

HFC

27.04.16 Oslo

My role in PetroHRA

- The Ph.D. Candidate (submitted jan 16)
- From a psychology background
- Mainly focused on quantification

- 1 PhD (hopefully accepted soon)
- 4 journal papers
- 10 conference papers

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Approach to creating the quantification in PetroHRA

- Based on SPAR-H
- Interviews with HRA analysts to pinpoint problems
- Thematic analysis to determine content in PSFs and reduce overlap
- Evaluated both research and other HRA methods in the selection of values and multipliers

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When to quantify

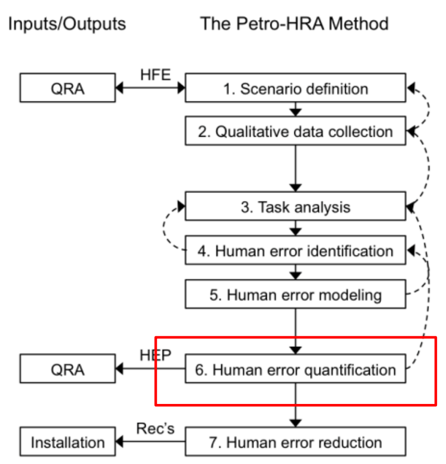
Where to quantify

How to quantify

Why quantify

Who should quantify

When to quantify



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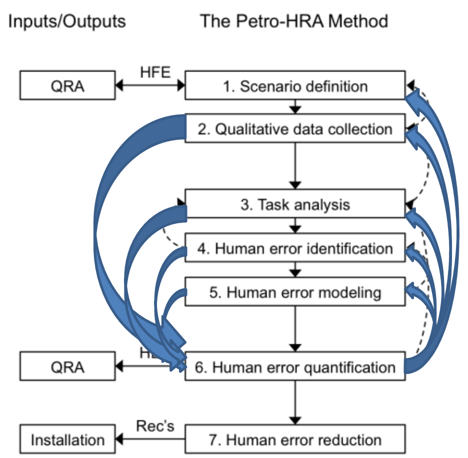
When to quantify



When to quantify

Where to quantify

How to quantify

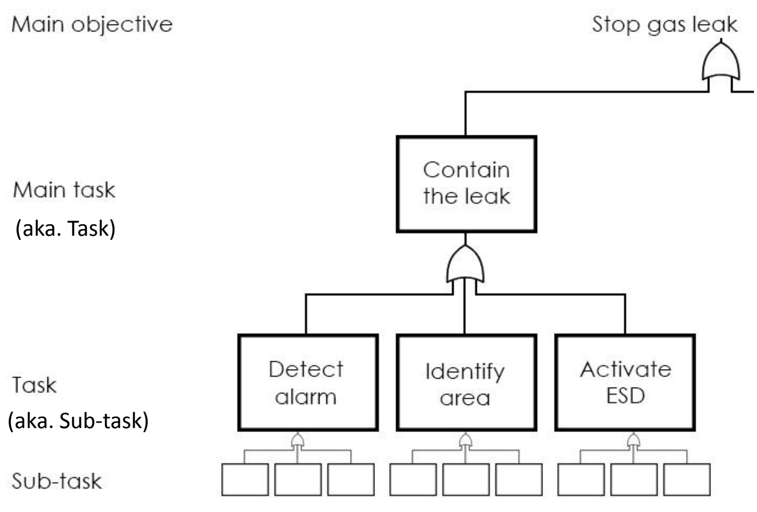
Why quantify

Who should quantify

Where to quantify

- Same issues as in task analysis
  - What is the appropriate level of decomposition to quantify at?
    - If you quantify at a level too high you might loose important information
    - If you quantify at a level too low you might loose the big picture
    - Some PSFs are easier to include at a low level, others are easier at a high level.

Rasmussen, M., & Laumann, K. (submitted). The impact of decomposition level in human reliability analysis quantification. In *Proceedings of ESREL2016*. Glasgow, Scotland.



Rasmussen, M., & Laumann, K. (submitted). The impact of decomposition level in human reliability analysis quantification. In *Proceedings of ESREL2016*. Glasgow, Scotland.

Where do we quantify

- Findings from ESREL-paper: Does the granularity of the quantification matter?
  - It does, but no level is necessarily perfect for every occasion. There are pros and cons with any level
  - Major problems are likely to be found and dominate the analysis either way
  - SPAR-H leaves the choice to the analyst, is that the best approach? Or should a level be specified?

When to quantify

Where to quantify

How to quantify

Why quantify

Who should quantify

How to quantify

Nominal HEP x PSFs with PSF Levels = HEP

PSFs	PSF Levels
Time	Extremely High Negative
Threat Stress	Very High Negative
Task Complexity	High Negative
Experience/Training	Moderate Negative
Procedures	Low Negative
HMI	No Effect
Adequacy of Organization	Low Positive
Teamwork	Moderate Postive
Physical Working Environment	

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59

PetroHRA Quantification

Nominal HEP x PSFs with PSF Levels = HEP

PSFs	PSF Levels
Time	Extremely High Negative
Threat Stress	Very High Negative
Task Complexity	High Negative
Experience/Training	Moderate Negative
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HMI	No Effect
Adequacy of Organization	Low Positive
Teamwork	Moderate Postive
Physical Working Environment	

Differences from SPAR-H

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60

The Performance Shaping Factors	Effect of the Performance Shaping Factors	How it Affects Performance
Human Machine Interface	Stress	Reliability
Task Complexity	Time Pressure	Efficiency
Limited Time	Workload	
Experience		
Training		
Procedures		
Ergonomics		
Teamwork		

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Time

Threat Stress

Task Complexity

Experience/Training

Procedures

HMI

Adequacy of Organization

Teamwork

Physical Working Environment

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Example PSF: HMI

Definition: The Human-Machine Interface (HMI) PSF refers to the quality of equipment, controls, hardware, software, monitor layout, and the physical workstation layout where the operator/crew receives information and carries out tasks.

Examples: Difficulties in obtaining relevant information or carrying out tasks through the safety and automation system, layout organization or colors that are not stereotypical, and communication difficulties due to communication technology (walkie-talkies, phones, messaging systems). In systems that use inter-page navigation it should be evaluated if it is likely that this will cause masking of relevant information or difficulties in carrying out a task due to several page shifts.

50	Very high negative effect on performance	The HMI causes major problems in either obtaining relevant information or carrying out the task. For example, the HMI is not designed for the task leading to a difficult work-around, some of the relevant information required for a reliable decision is not made available or, the inter-page navigation creates severe difficulties in obtaining the relevant information or carrying out the task.

HMI

- Changed to only focus on HMI
  - Physical work environment included in a separate PSF.
- Large differences between the HMI in most US NPPs and O&G-industry
- The evaluation of whether the HMI impacts the performance of the operators is similar
- Probably even more important in a computerized/digital control room

Time

- In other methods included as:“Available time”, “Time Pressure”
- Time needs to be included
- Should it be as a PSF?

Time

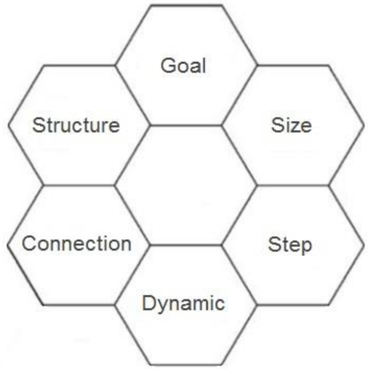
- **Available time:** the time from the presentation of a cue for action to the time of adverse consequences if no action is taken.
- **Required time:** the time it takes for operators to successfully perform and complete a task.
- Input from the the timeline analysis

Threat Stress

- Threat to:
  - Own life
  - Others lives
  - Self-esteem
  - Professional status

Task Complexity

- Replaces «Complexity»
- Focuses on the objective, not the subjective complexity
- We have attempted to reduce overlap



Rasmussen, M., Standal, M. I., & Laumann, K. (2015). Task complexity as a performance shaping factor: A review and recommendations in Standardized Plant Analysis Risk-Human Reliability Analysis (SPAR-H) adaption. *Safety Science*, *76*, 228–238. http://doi.org/10.1016/j.ssci.2015.03.005

Experience/Training

- Focus on quality
  – Different from SPAR-H focus on time employed

Laumann, K., & Rasmussen, M. (2016). Experience and training as performance shaping factors in Human Reliability Analysis (HRA). In *Proceedings of ESREL2016*. Glasgow, Scotland.

Procedures

- Large industry differences in the extent of procedure use
- Important to remember that the evaluation is of the effect they have

Adequacy of Organization

- One of the two factors that replaces «Work Processes» from SPAR-H
- The PSF Adequacy of Organization consists of two related factors that have been found to predict safety outcomes in studies of safety culture:

1) Attitudes to safety and work conduct,
2) Management support.

Teamwork

- The other of the two factors that replaces «Work Processes» from SPAR-H
- Teamwork can have a very significant effect on performance
- Is very team/crew dependent, but factors that contribute to good or poor teamwork can be found.

Physical working environment

- Aka. «Ergonomics»
  - Changed name due to potential confusion
- Was included in the «HMI/Ergonomics» PSF in SPAR-H
- Included to ensure that non-HMI problems (such as those faced in ex-control room tasks are covered)

Petro-HRA PSF summary worksheet			
Plant/installation		Date	
HFE ID/code			
HFE description			
HFE scenario			
Analysts			
Subject Matter Experts			
Other info / comments			
PSFs	PSF levels	Multiplier	Substantiation. Specific reasons for selection of PSF level
Available time	Extremely high negative	HEP=1	
	Very high negative	50	
	Moderate negative	10	
	Nominal	1	
	Moderate positive	0.1	
	Not applicable	1	
Threat stress	High negative	25	
	Low negative	5	
	Very low negative	2	
	Nominal	1	
	Not applicable	1	
Task complexity	Very high negative	50	
	Moderate negative	10	
	Very low negative	2	

When to quantify

Where to quantify

How to quantify

Why quantify

Who should quantify

The remaining questions

- Why do we quantify? And what is the expected outcome?
  – Is it only to get an HEP?
  – Is it to red flag the most important issues?

- Who should quantify?

Boring, R. L., & **Rasmussen, M**. (in review). GOMS-HRA: A method for treating subtasks in dynamic human reliability analysis. In *Proceedings of ESREL2016.* Glasgow, Scotland.

Bye, A., Laumann, K., Taylor, C., **Rasmussen, M.,** Øie, S., van de Merwe, K., … Gould, K. (2014). Petro-HRA New Method for Human Reliability Analysis in the Petroleum Industry. In *Proceedings of PSAM13*.

Laumann, K., & **Rasmussen, M.** (in review). Experience and training as performance shaping factors in Human Reliability Analysis (HRA). In *Proceedings of ESREL2016.* Glasgow, Scotland.

Laumann, K., & **Rasmussen, M.** (2016). Suggested improvements to the definitions of Standardized Plant Analysis of Risk-Human Reliability Analysis (SPAR-H) performance shaping factors, their levels and multipliers and the nominal tasks. *Reliability Engineering & System Safety*, *145*, 287–300.

Laumann, K., & **Rasmussen, M**. (2014). Suggestions for improvements to the definitions of SPAR-H performance shaping factors, to the definitions of the levels, and suggestions for changes in the multipliers. In *Proceedings of the Probabilistic Safety Assessment and Management (PSAM12).* Honolulu, HI.

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Rasmussen, M. (n.d.). ***The Development of Performance Shaping Factors for the PetroHRA Method: A Human Reliability Method for the Petroleum Industry*. NTNU.**

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Rasmussen, M., & Laumann, K. (n.d.). Human-Machine Interface as a Performance Shaping Factor in the PetroHRA method. *(In Review)*.

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Rasmussen, M., Standal, M. I., & Laumann, K. (2015). Task complexity as a performance shaping factor: A review and recommendations in Standardized Plant Analysis Risk-Human Reliability Analysis (SPAR-H) adaption. *Safety Science*, *76*, 228–238. http://doi.org/10.1016/j.ssci.2015.03.005

Van De Merwe, K., Hogenboom, S., **Rasmussen, M**., Laumann, K., & Gould, K. (2014). Human Reliability Analysis for the Petroleum Industry: Lessons Learned from Applying SPAR-H. *SPE Economics & Management*, 159–164.

Error reduction

- Impact assessment
- Error reduction analysis

Impact assessment

- Integration of HEP into overall risk model
- Consideration of impact assessment criteria;
  - Risk acceptance criteria
  - Size of HEP value(s), >0.1
  - Degree of HEP uncertainty
  - Severe QRA end states
- Assessment of HEP contribution

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Error reduction analysis

- Select events for risk reduction
- Re-visit performance shaping factors
- Develop ERMs targeting specific human errors
- Develop ERSs targeting overall task performance
- Recalculate HEPs based on updated PSF justifications

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Select events for risk reduction

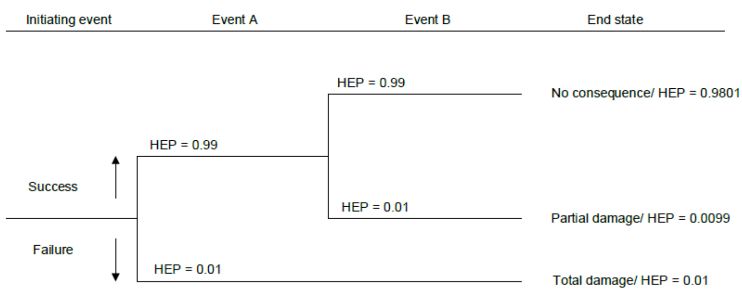

Figure 7.2 Event tree with example quantifications

For event trees, events are selected based on three combined considerations:

1) the HEP for each single event
2) the HEP for end states associated with each event sequence pathway
3) the severity of end states for each event sequence pathway the events are part of

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Re-visit performance shaping factors

- Purpose is to demonstrate risk reduction
  - Establish traceability between the PSF evaluations, calculated HEPs and suggested ERMs and/or ERSs
- Re-check which PSFs are performance drivers
- Error reduction measures (ERM) and strategies (ERS) can target other PSFs than the negative ones

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Develop ERM & ERS

- Error mechanism prevention
- Error pathway blocking
- Error recovery enhancement
- Error consequence reduction

ERM

- Overall task re-design
- Overall PSF improvement

ERS

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Update HRA/QRA model

HRA

- Document justifications (Petro-HRA sheet)
- Re-calculate HEPs for each event and model

QRA

- Integrate HFE HEP in QRA model
- Re-calculate QRA to check for effects

Document HRA

- All analysis outputs; ensure traceability
  - Scenario description
  - PSF assessment
  - Task and timeline analysis
  - Human error identification
  - Human error model, incl. summary table
  - Human error quantification, incl Petro-HRA sheets
  - Impact assessment and error reduction analysis

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