Integrating HEART+ in Probabilistic Risk Assessment

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Introduction

Quantified Human Reliability Assessment tools like HEART+ provide assessors with a probability of human error per task, often called a Human Error Probability (HEP). Questions often arise as to how to integrate HEPs into Probabilistic Risk Assessments such as fault trees and Layers of Protection Analysis (LOPA). This guidance discusses how to make sure you are integrating HEPs generated by the HEART+ method appropriately although it will also apply to tools derived from HEART such as RARA, and to other quantified Human Reliability methods.

Risk Modelling

The first step is to ensure that the risk model reflects human activity at the right level to incorporate HEART+ HEPs. HEART+ works using Generic Task Types (GTTs) which are high level description of tasks. HEART+ can only be appropriately applied to tasks at a similar level e.g. driving a train or a tanker, diagnosing a plant upset or medical condition, starting up plant following procedures.

The risk model used by probabilistic risk assessors may identify errors at a more granular level than HEART+ can support, e.g. failure on one step in a complex procedure, then failure on another step in the same procedure. This results in overestimates of human reliability.

- Incorrect route alignment

- Valve MV101 left open
- Valve MV102 left open
- Valve MV103 left shut

- Driving too fast in speed restriction zone

- Passes sign 1 too fast
- Passes sign 2 too fast
- Passes sign 3 too fast

In the correct examples, the HEP is only counted once. In the incorrect examples, the HEP would be multiplied 3 times giving a much lower likelihood of error than is realistic.

Risk Assessors and Human Factors Assessors need to work together to agree the risk model to arrive at a realistic conclusion.

Don’t forget to factor in the likelihood of equipment failure in human tasks as well. An operator may fail to respond to an alarm OR the alarm may not go off.

Dependency

Probabilistic risk assessments should consider dependency where more than one human error may be a factor. Just as with technical equipment, humans can suffer common cause failure. An operator who does not understand the current status of the system can make more than one error in controlling it. A supervisor can make the same error as an operator for the same reasons.

People **Plant** **Procedure** **Time**	If people, plant, procedure and time are all the same, there is total dependency - probability of failure on the second task is 1. If they are all different, there is no dependency and the full HEP for the second task can be claimed. Otherwise, a modifying equation should be applied to the second task HEP - as set out in the HEART+ manual

HEPs in LOPA

HEART+ is best suited to estimating the likelihood of initiating events which result from human error. When conducting tasks in normal circumstances, humans are more reliable than the standard 0.1 or 0.01 claimed for human performance in LOPAs. There is therefore a benefit to estimating human failure in such cases. However, use of quantification is tricky when it comes to independent layers of protection and mitigation.

				Independent Protection Layers				IML	CM
#	Initiating event	Initiating cause	Cause likelihood	Process design	BPCS	Alarm	SIS	Mitigation	Conseq modifier
	Valve left open	Operator error	HEP x n_i						

The reason for this is that it is difficult to demonstrate an equivalent human reliability to a SIL-rated system. If you claim more than 0.1 for operator response to an alarm, you are saying that the human operator is equivalent to a SIL 1 System or more. At best, a HEART+ analysis is likely to give an HEP of no less than 0.01 for this. How will you proof test your operators? On the whole it is best to leave IPLs at 0.1.

Mitigation tasks, which are carried out after the event has occurred are likely to be GTT type A - unfamiliar tasks carried out under time pressure. The starting HEP on these tasks is 0.41, so there is no benefit to applying HEART+ to these tasks.

Consequence modifiers, such as likelihood of people being on plant, are sometimes used in LOPA. HEART+ wouldn't be used for this - but we recommend caution. The first step in many alarm response procedures is 'go and investigate'. Assume there will be someone there.

When using HEPs for initiating events, remember that HEPs represent the probability of failure on each task. LOPA uses frequency (per year). You should multiply the HEP by the number of times it is likely to be conducted in a year before applying it.

Using real data

We sometimes get asked if it is better to use real data or HEART+. The answer is - as with all questions in Human Factors - it depends! It is usually a good idea to look at any HEPs you generate and see if they reflect the lived experience of people who carry out the task. This is checking the 'face validity' of your result - does it seem right on the face of it.

Sometime you can use real data to compare to the calculation - how many times has this task failed in the past number of years of operating? However, care must be taken that you are comparing like for like. For example, if you are calculating the probability of overfilling a tank, the number of overfills represents the number of **unrecovered errors**. That is the number of times people failed and so did all the systems, including supervision, you have in place. It is not the same as the number of errors people made on the tank filling task. A more reliable guide might be the number of times the high level alarm went off, or the number of times the high high level tripped, depending on the task you are evaluating.

If you have good reliable data for a task, use it in preference to any quantified HRA method. This is because QHRA is always a model that approximates to reality.

Key Takeaways

- Risk Assessors and Human Factors Assessors need to agree the risk model before applying HEART+
- Don’t apply HEART+ at too granular a level, it will result in an underestimate of probability of human error.
- Consider dependency if there are two or more human tasks in a single fault tree
- Use HEART+ to evaluate the likelihood of initiating events only.
- When using real data to evaluate a HEART+ result, be careful to compare like for like.
- Use real data in preference to QHRA if you have good reliable data to work with.

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