# Task identification for Human Factors Safety Critical Task Analysis

Jamie Henderson, Human Reliability Associates Ltd., 1 School House, Higher Lane, Wigan, WN8 7RP

In the UK, the Health & Safety Executive (HSE) has established a requirement for top-tier Control of Major Accident Hazard (COMAH) sites to demonstrate the management of Human Factors (HF). Part of this requirement, prior to undertaking systematic task reviews, is that sites should "identify those tasks associated with their main site hazards where humans may initiate or fail to mitigate a major incident" (HSE, undated A).

In our experience this has posed problems for many sites: identify too few tasks and risk missing important HF issues, identify too many and become overwhelmed by the potential subsequent analysis effort involved, or identify tasks that are too small, splitting larger tasks, so that the critical aspects are missed.

This paper reviews two different approaches to task identification, discusses their strengths and weaknesses, alongside a more general consideration of practicalities.

Keywords: Human Factors, COMAH, Task Identification, Task Analysis, Critical Task Analysis.

## Approaches to task identification

For the purposes of this paper, two different approaches to task identification have been considered:

1. Starting with a comprehensive list of tasks and using a scoring process to prioritise tasks within the list (*Task list prioritisation*).
2. Starting with a list of outcomes (e.g. MAH scenarios in a COMAH report) and relating tasks to these outcomes (*Outcome-related task identification*).

These different approaches have been chosen to reflect the two main classes of task identification approaches that we have used. In practise, identification techniques exist somewhere on a spectrum between these two extremes, and can include elements of the other approach (e.g. an outcome-related analysis can include a final review of a procedure list to check for completeness).

An established example of Approach 1 is described in HSE Offshore Technology Report – OTO 1999 02 (HSE, 1999) The technique uses a scoring system, where a task is scored according to five factors (including hazardousness, requirement to change configuration and impact of incorrect performance) which are then summed to give an overall task criticality score. Subsequent variations of the technique have included different factors, and some have used different methods for combining the scoring elements (e.g. multiplying the consequence element by the sum of the other factors). There are different ways by which the initial task inventory can be developed. The simplest approach is to refer to existing lists of procedures. A more systematic approach is to break a given plant down into functional sections, and then identify tasks that are performed in each section. The latter approach offers some further opportunities for prioritisation, in that the tasks related to the most critical functional sections can be given higher hazard scores.

To our knowledge, Approach 2 has not been formally described in a paper. However, we have observed, and participated in, several versions of it with our clients, sometimes alongside other engineering analyses (e.g. Bow-Ties, event trees). Again, whilst numerous variations exist, when discussed here, we are referring to a process where outcomes (e.g. MAH scenarios in a safety report) are used as the starting point for the analysis. This then typically takes the form of a structured brainstorming exercise, where a workshop group links the outcomes to a range of task types (e.g. maintenance, operations, emergency response) with the potential to initiate MAH scenarios (e.g. loading of a roadcar, system start-up, maintenance preparation), that are designed to prevent MAH scenarios developing (e.g. manual operation of a Emergency Depressurisation system), and tasks that maintain control measures related to MAH scenarios (e.g. high pressure trips).

Both approaches require facilitation and the input of individuals with a detailed knowledge of site processes. As the focus of this paper is the respective merits of these two approaches, a detailed description of the implementation (e.g. workshop organisation, workshop participants, facilitation) of these two approaches has not been included.

## Requirements for task identification process

To assess the relative merits of a task identification process, its purpose should be clear. The following sections contain some suggested requirements for a task identification process.

### Output requirements

1. Must identify tasks that are critical based on their potential to contribute to a MAH scenario.
   The primary requirement is that the approach must provide an effective method for differentiating between tasks at a site. The analysis effort for each task is potentially a significant investment; therefore identified tasks should be limited to only those with the greatest criticality.
2. Must distinguish MAH critical tasks from tasks that are critical for other reasons (e.g. production and occupational safety).
   A related requirement is that the technique should limit the identification to tasks that are critical from a MAH perspective. Including tasks that are critical for other reasons (e.g. production performance or occupational safety) may significantly enlarge the pool of tasks to be reviewed.

3. Must link tasks to MAH scenarios.
   The HSE guidance (HSE, undated A) stresses that the tasks identified should be related to the MAH scenarios at a site. Any technique that does not do this directly will require additional analysis to make this link.

4. Should provide a comprehensive list of MAH critical tasks.
   Identified tasks should represent a comprehensive overview of those tasks related to the MAHs at a site.

5. Should identify different types of task (e.g. initiation, prevention, mitigation).
   HSE guidance (HSE, undated B) describes three types of task that require attention. Those that have the potential to initiate an event, those required to stop an event sequence (e.g. activation of an ESD), and those that may escalate an incident (e.g. inadequate maintenance of a fire control system). Therefore, any task identification process should cover at least this range of tasks.

**Process requirements**

1. Must be systematic and auditable.
   The identification process must follow a structured approach and provide the opportunity for the review team (or others, at a later date) to revisit the analysis and determine why a particular task was identified.

2. Should be understandable by users.
   The task identification process, whilst likely to be facilitated by an experienced analyst, relies to a large extent for the quality of its outputs on the input of the participants. Therefore, the decision-making process for the assessment of tasks should be understandable to the participants.

3. Should be reliable.
   The process should be repeatable, in that the results should be similar if a different workshop group with similar backgrounds carried out the same analysis.

4. Should be tractable.
   The task identification process should not be so complex or unwieldy that the identification process requires an extended period of time to complete. The goal of the process is to identify tasks for future analysis. We have observed situations where sites have become so absorbed in the identification process that it diverts resource from the analysis programme.

## Assessment of different approaches to task identification

The following table discusses the usefulness of the two approaches when considered alongside the requirements outlined in the previous section. The judgement of the degree to which these approaches meet the requirements if, of course, subjective, however, the judgements and the issues raised in the notes are drawn from first-hand experience in the application of both approaches. The impact of many of these issues can be minimised by careful facilitation.

Example:

| | Requirements | Approaches to task identification (High, Med or Low compatibility with the specified requirements) | |
|---|---|---|---|
| | | **1. Task list identification** | **2. Outcome related identification** |
| Output requirements | 1. Must identify MAH critical tasks. | **Med** - As long as the definition of the hazard component of the scoring system is directly related to the MAH outcomes this is manageable (see 2, below). | **High** - the identification process is linked directly to the MAH issues of concern. |
| | 2. Must distinguish MAH critical tasks from tasks that are critical for other reasons (e.g. production and occupational safety). | **Med** – As the starting point is a full list of tasks, our experience has been that, unless the workshop is carefully stewarded, there is a danger that participants can (perhaps subconsciously) push up the scores for tasks that have production or occupational safety issues. This is particularly true where the hazard component of the scoring system is loosely defined. | **High** – the identification process is linked directly to the MAH issues of concern. This should make it easier for the review team to focus primarily on the MAH critical tasks. |
| | 3. Must link tasks to MAH scenarios | **Low** - No direct line drawn between site hazards and identified tasks (analyst can retrospectively link identified tasks to site MAH scenarios). | **High** – MAH scenarios used as starting point for analysis. |
| | 4. Must provide a comprehensive list of MAH critical tasks. | **High** – As all procedures are included at the start of the analysis a comprehensive task list should result. However, there is a consequent danger that the output can appear overwhelming to a site in terms of the analysis effort required. In addition, an (arbitrary) decision has to be taken regarding how many of the tasks require analysis. | **Low** – As the focus for the analysis are the site safety report MAH scenarios, and as these scenarios are representative rather than comprehensive, it is probable that some critical tasks will be omitted. However, given that ultimately the future task analysis will be limited by resources it does provide a manageable list of tasks for review. |
| | 5. Should identify different types of task (e.g. initiation, prevention, mitigation). | **Med –** Whilst the scoring system can be organised so that different types of task can be included, existing scoring systems (e.g. in HSE OTO 1999 092) work best for initiation-type tasks. | **Med –** The approach is particularly effective for prevention and mitigation type tasks as these can be easily related to control measures for the MAH scenarios of concern. Identification of initiation tasks can require more imagination and is helped by having an experienced facilitator. |
| Process require | 1. Must be systematic and auditable. | **High** (Possibly **Med** for reasons discussed below) - Use of a scoring system means that the analysis can be interrogated at a future point to determine how the analysis was performed. However, unless the individual scores are annotated, it can still | **Med** - Lack of scoring system means that the decisions taken are less auditable. However, as the tasks are linked directly to MAH outcomes there is a clear line to the tasks, which can be examined at a later date. |

| Requirements | | Approaches to task identification (High, Med or Low compatibility with the specified requirements) | |
|---|---|---|---|
| | | 1. Task list identification | 2. Outcome related identification |
| | | be difficult to ascertain the exact thinking of the workshop group when a score was attributed to a task. Even though the scoring is relatively simple, we have observed situations where a group's interpretation of the scoring of factors has drifted over the course of a workshop. Therefore, good facilitation is important. | |
| | 2. Should be understandable by users. | **Med** – The individual scoring process is typically straightforward and understandable. However, as discussed above, there are still group interpretations of the scope of each scoring element and how to assign values within it. The terms of reference need to be carefully explained by the facilitator and monitored for drift as a workshop proceeds. | **High** – The process is simple and easy to understand once examples of the different types of task of interest have been provided to the participants. |
| | 3. Should be reliable. | **Med** – The lengthy nature of analysis process can mean that attention and focus of the workshop group can be lost over the course of the workshop. As mentioned above, there is also a potential issue of different individuals interpreting the elements, and their scoring, differently. | **Med** – Whilst the prevention and mitigation tasks are likely to be easily replicated, the initiation tasks, which can require more imagination to identify, may vary from group to group. |
| | 4. Should be tractable. | **Low** – Nature of the process means that, without careful stewardship, lengthy discussions about the distinctions between different scores on each of the dimensions can result. | **High** (Possibly **Med** if MAH scenario outlines are vague) - Limits the discussion to MAH scenarios only. The length of the analysis is, therefore, determined by the number of scenarios and how tightly they are defined in the safety report. |

## Other common issues

There are a number of issues that apply to the identification of MAH critical tasks regardless of the type of approach used. Some of these are summarised in the following sections.

### Relative criticality of different classes of task

One of the issues with both approaches is that there is a requirement to compare the criticality of tasks that have different types of impact upon a MAH scenario.

For example, using a typical bow-tie type representation, tasks performed on the left-hand-side (i.e. before the consequences are realised) of the bow-tie, will have an impact on the probability of the initiation of the MAH scenario (e.g. failure to close a drain valve after maintenance). However, it is also possible for tasks affecting the right-hand-side (i.e. after the hazard has been released) to fail (e.g. failure to adequately maintain a deluge system). Comparing these two types of tasks for prioritisation in terms of relative criticality can be difficult. One possible argument is that the focus of analysis effort should be on the left-hand-side, where improvements in task performance should reduce the probability of the hazard being released in the first instance. However, in the event that this does happen, it is also important that, for example, gas detectors have been properly reinstated after maintenance, or that operators are able to remotely activate a deluge.

### Ability to determine criticality of task by cursory inspection

An issue for all task identification approaches is that, until a task is examined in detail, it can be difficult to determine the likelihood of it playing a role in a major accident. For example, a task that is considered to be especially critical may be well protected against credible human failures, whereas a less critical task may have a number of task steps where individual actions could result in loss of containment. To some extent, this issue can be avoided by not taking credit for control measures during the task identification process. However, it can be difficult for workshop participants to avoid taking control measures into account when judging the criticality of a task. For example, a dimension of 'error vulnerability' in a scoring system could easily be interpreted by a workshop participant as including the existing interlock system. Moreover, tasks that might appear to be relatively trivial during a task identification exercise (e.g. cleaning out a reactor with water) may have the potential to initiate a significant MAH scenario if the operator inadvertently tries, for example, to clean out a reactor that is still in the cycle and full of a pressurised hazardous substance.

### Preconceptions of the workshop group

In any task identification exercise, workshop participants will make assessments of the probability of tasks being involved in MAH scenarios. As a social process, where individuals draw upon their experiences to make decisions, the outputs will be subject to the same biases as any similar process. For example, a task that an experienced operator has had recent problems a task may find this is at the forefront of their mind when nominating tasks. Or a workshop group with one very experienced dominant voice may be swayed by the input of that individual.

### Maintaining the identification of tasks as the focus of the analysis

Any task identification process that begins to extend into days rather than hours, or where workshop participants have extended discussions about the exact classification or scoring of a task, should be monitored carefully. These are warning signs that the task identification process is in danger of overtaking the identification of potential tasks for detailed review as the main goal.

### Identifying critical tasks without related procedures

Lists of procedures are a useful input to any task identification exercise. However, there can be a danger that the workshop team focuses on these exclusively as a source of information about critical tasks. It is possible that some critical tasks will not have related procedures. Reasons for this might include: a simple oversight; that the task is so simple that it is not felt necessary to have a procedure, and the task is controlled instead solely through competence management (e.g. simple water-drawing activities); or, it may be that the task is not amenable to representation in a standard procedure format (e.g. day-to-day control room tasks). Therefore, the facilitator should ensure that tasks other than those set out in procedures are considered.

### Generic tasks

Many tasks are critical but have numerous, slightly different, practical instantiations on a site. For example, a maintenance preparation task, where an operating team isolates a system in preparation for break of containment, is clearly a MAH critical activity. Failure to perform it to the required standard could result in a loss of containment. However, specific permutations for such a task might be almost limitless (i.e. maintenance preparation might be required on any sub-system on a site). This poses a potential issue for MAH critical task identification, in that there could be significant number of

variations of the same task which would all be reasonable to identify as part of a task identification exercise. To circumvent this, a pragmatic approach is to identify one particular example of such a task (e.g. maintenance preparation of a system with a particularly high inventory of hazardous material) and analyse that during the subsequent task analysis phase. This means that generic issues can be identified and addressed for all similar applications of the task. Unfortunately, it also means that specific local issues that might make a generic task more difficult (e.g. difficult valve access around a particular vessel) might not be addressed. However, unless something like this is done, the number of identified tasks would be unmanageable.

### Comparing maintenance and operations tasks using a scoring system (Approach 1)

Whereas the preceding issues apply to any approach, there are some specific characteristics of maintenance tasks that make their comparison with operations tasks using a scoring system more difficult.

The nature of many maintenance tasks is that they are performed infrequently by design (e.g. on a planned basis, once every quarter or less). This means that if tasks are scored according to frequency of performance, maintenance tasks will often score the lowest possible score on this dimension. Consequently, in general, operations tasks can appear more critical than maintenance tasks according to this measure. In addition, maintenance tasks are often planned to take place during a single shift, and do not need handing over, therefore, if the need to hand-over a task is part of the scoring system, they will appear less critical on this dimension than operations tasks. Where tasks do extend across shifts, their nature might be expected to be different to operations tasks. For example, the delay might be necessary whilst waiting for a part, but, unlike for operations tasks, it may ultimately be completed by the same individual that started the task.

## Conclusion

Given that in the UK the primary driver for this type of analysis is the COMAH regulations, and that the related HSE guidance suggests that the identified tasks should be those associated with main site hazards, there is a strong pragmatic argument for adopting an outcome-related task identification process (Approach 2).

Such an approach has a number of benefits:

- By relating the task to a site's MAH scenarios (as outlined in the safety report), the analysis will be closely aligned with the site risk management strategy. This means that a coherent narrative related to the safety report and the management of HF can be presented by a site.
- This relationship means, for example, that further prioritisation can be undertaken based on the site risk assessment (e.g. if certain scenarios are considered critical more than others, then tasks related to these scenarios can be prioritised for review).
- As the tasks that have been identified are related to MAH scenarios, they are, by definition, MAH critical. This means there is no need, as with approach 1, to determine an arbitrary cut-off point in the task list (e.g. Top 10% of tasks or tasks scoring above a certain number in the scoring system).

This is not to say that task list prioritisation approaches are without value. If, for example, a site is looking for a broader task classification scheme (e.g. to assist in the classification of procedures for training and competence process) then the use of a comprehensive task-list scoring system may be of considerable benefit.

There is a possibility that Approach 2 will generate a lengthy list of tasks. In this case, there may be a need for further prioritisation, if only to determine which tasks should be analysed first. Possible approaches to this could include:

- Analyse those tasks related to the most critical MAH scenarios. Therefore, for example, if MAH Scenario 4 is considered to present the biggest hazard, the tasks related to this scenario could be prioritised for review over tasks related to other scenarios.
- Prioritise tasks according to the phase in an incident that they have influence over. For example, tasks that might initiate an incident, or that involve the maintenance of systems that are designed to prevent an incident (e.g. a high level trip), could be prioritised over tasks related to mitigation systems (e.g. maintenance of emergency call points or deluge systems).
- Use a scoring system such as that described in Approach 1 (which of course, will result in a hybrid of Approach 2 and Approach 1).

Finally, given the issues outlined in the discussion, it is unlikely that the task list will ever be a comprehensive, accurate representation of the relationship between tasks and site MAH risk. Therefore, as long a systematic, auditable process has been followed, the outputs have face validity (e.g. if to another experienced person, not involved in the analysis process, they appear credible), and there is a clear link to site MAH scenarios, then this is probably sufficient. Additional tasks can be added to the list if necessary (e.g. following a near-miss). Task identification is only a tool to enable a site to begin undertaking Human Factors Critical Task Analyses, where the real potential benefits are to be found. Therefore, the task identification process should not become so bloated as to divert resource away from this activity.

## References

Health & Safety Executive (A). Roadmap for the Management of Major Accident Hazards Available at http://www.hse.gov.uk/humanfactors/resources/hf-roadmap.pdf Accessed June 2013.

Health & Safety Executive (B). Inspectors Human Factors Toolkit. Core Topic 3: Identifying Human Failures. Available at: http://www.hse.gov.uk/humanfactors/topics/core3.pdf. Accessed June 2013.

Health & Safety Executive (1999) HSE Offshore Technology Report – OTO 1999 02: Human Factors Assessment of Safety Critical Tasks. Available at: http://www.hse.gov.uk/research/otopdf/1999/oto99092.pdf Accessed June 2013