Check Mate: A framework for optimising human-based checking

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Across the high-hazard industries there is a reliance on effective human performance, particularly within complex sociotechnical systems. These systems will include a range of safeguards, both engineered and procedural, to defend against human or engineering failure. Such safeguards may be formally claimed as part of a safety case or safety justification, or serve as a defence-in-depth measure. A common procedural control that tends to recur throughout complex systems is human-based checking (HBC), usually in the form of two-person checks or independent checks. Confidence in these types of checks exists despite a lack of evidence supporting their efficacy. Nonetheless, HBC usually forms an integral role in supporting claimed overall system reliability.

Whilst explicit claims can be made on the performance of specific checking tasks, there is an implicit requirement for a HBC regime to meet Human Factors relevant good practice, and deliver its intended function throughout the system. This function is to facilitate timely identification and rectification of human failures, in addition to avoiding routine challenge of engineered safety measures.

Historically, the implicit requirement on HBC has not been subject to rigorous review, perhaps due to perceptions that HBC activities are prone to failure themselves, or mis-placed confidence exists in the perceived simplicity of HBC activities, and therefore, does not warrant detailed review.

The concept that checking tasks are simple may influence management perceptions of the causes of failure, leading to a misplaced focus on competence or culture. In practice, it may be poor task design and/or ineffective implementation of management system arrangements that exacerbates instances of human failure. Failure to explore the impact of such arrangements on human performance, tailored with inadequate investigation mechanisms, may inadvertently reinforce perceptions that checking tasks are simple, when in fact, they are characteristically complex.

Greenstreet Berman has supported a Periodic Safety Review for a UK Nuclear Licensee, which included review and substantiation of safety-critical HBC activities and the supporting HBC regime. Operational Experience data indicated that a large proportion of human failure was associated with HBC activities. Therefore, work was undertaken to better understand how workers conceptualise HBC, potential weaknesses with checking activities, and whether there were alternate approaches that would render more robust checking arrangements.

As part of this work, a HBC framework has been developed to facilitate a systems approach to the optimisation of HBC activities and arrangements. The framework prompts consideration of the conceptual principles of HBC, in order to define reasonable and realistic HBC performance requirements. This then facilitates development of appropriate implementation strategies, which will enhance levels of human reliability. The framework aims not only to support the assessment of HBC arrangements by HF practitioners, but also to support system designers, engineers, and managers in understanding how to optimise human performance in relation to HBC activities and hence to achieve a balanced design that places reasonable and realistic claims on human performance.

The purpose of this paper is to present an HBC framework that provides a systems approach to the implementation of HBC activities and serves as a valuable tool for the assessment of the suitability of HBC, and, importantly, supports effective integration of HBC into complex systems. It also supports communications regarding the significance of HBC in the delivery of safe and reliable operations.

Keywords: Human-based checking; two-person checks, independent verification, Human Factors

Introduction

This paper presents a framework for optimising Human-Based Checking (HBC). The framework has been developed to support a systems approach to the use of HBC activities in the management of human performance, in complex sociotechnical systems. The discussion presented in this paper is intended to increase understanding of the role HBC plays in the management of risk and the components that comprise optimised HBC; the implication being that changes in safety can only come about through changes that not only address people, but also the multiple system components with which people interact.

Whilst engineered and technological systems may achieve a much greater level of accuracy and reliability than human processes, fully integrated and automated systems are not likely to exist without some requirement for human interaction. For example, human operators may have to confirm and validate the correct performance of a system. As such, HBC is likely to remain a necessary safety function for organisations in the years to come. Indeed, the current debate concerning autonomous vehicles and whether a driver should be present encapsulates the challenge.

Background

Across the high-hazard industries there is a reliance on effective human performance, particularly within complex sociotechnical systems. These systems tend to include a range of safeguards, both engineered and procedural, to defend against human or engineering failure. Such safeguards may be formally claimed as part of a safety case or safety justification, or serve as a defence-in-depth measure. A common procedural control that tends to recur throughout complex systems is human-based checking (HBC), usually in the form of two-person checks or independent checks – the sign-off in a procedure, the confirmation from a colleague, the formal checklists in the operating theatre or the aircraft cockpit. Confidence in these types of checks exists despite a lack of evidence supporting their efficacy. Nonetheless, HBC usually forms an integral role in supporting overall system reliability.

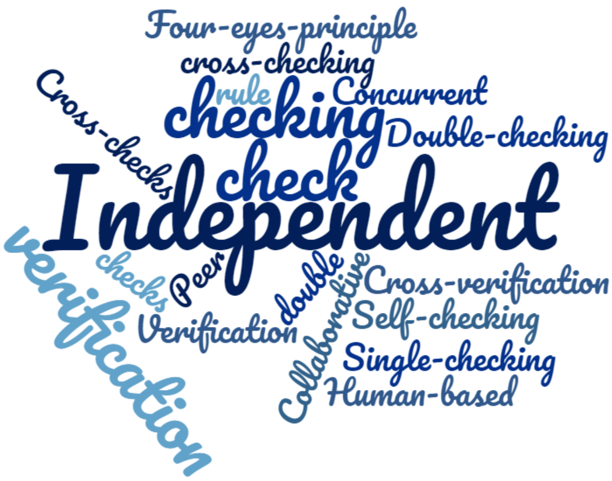


Figure 1: HBC terminology

The role of HBC

HBC has long been utilised in high-hazard industries, and usually forms the last line of defence against adverse events. Whilst HBC may be employed as a risk-reduction strategy, there remains dispute as to how best to integrate HBC.

Workers at the sharp-end are often responsible for checking, and although automation can be employed to conduct checks that are free from human error, this is not always a feasible option, nor is it absent of engineering failures. Instances therefore remain where people are required to deliver the identified checking requirement. Performance of HBC activities becomes notoriously challenging when the nature of the checking activity or task is ill-defined and is undertaken within a complex sociotechnical system. Whilst a human-based check may be required, the placement and type of check needs to deliver its intended function, especially given that the task of HBC is fallible itself. By its nature, human performance is inherently vulnerable to routine slips, lapses and mistakes. Different circumstances will be best suited to different types of check, although generally the premise behind the implementation of checks is that 'two heads are better than one' (even though there are examples where this is not the case due to dependency, and overall performance is better when only one person is involved). However, not all types of checks are equally effective in the identification of errors, and success is influenced by the context in which individuals are operating and the complexity of the work being undertaken.

Table 1 presents a number of common terms employed within high-hazard industries used to denote HBC activities (sourced from publicly available documentation). Definitions and a brief description of its role in HBC are provided. Whilst there is a paucity of literature regarding HBC, the literature that does exist highlights a lack of agreement regarding the definitions and conceptualisation of the different types of HBC, especially across industries where it is employed. Furthermore, the literature does not go very far in discussing the efficacy of the different HBC activities. Where attempts to discuss this have been made, there is little agreement regarding its effectiveness in managing human failure, perhaps due to the differing contexts and tasks within which it has been examined.

Table 1: HBC definitions and concepts implemented across high-hazard industries

Terminology	**Definition and role**
Independent Verification (IV) (Variations include independent double-check)	There are many definitions of IV available within the different contexts in which they are applied (primarily the nuclear industry and health care): • The act of verifying the condition of a component, system or document, independent from the original act that placed it in that condition, to find errors by the performer. • IV confirms the condition of equipment or accuracy of documents, or calculations. It is a process by which one individual, separated by time and distance from the action changing the component's state confirms the condition of the component or document. (Human Performance Improvement Handbook, 2009)
Double-checking (Variations include routine double-check, independent double-check)	This phrase is primarily utilised in health care, although no universally accepted definition exists within literature. The concept is seen to cover: • Reviewing one's own work; • Reviewing one's own, or a colleague's, work together with another colleague;

Terminology	Definition and role
	• Independently reviewing a colleague's work. (Armitage, 2008) • A procedure that requires two qualified health professionals independently checking the medication before administration to patients. • A two-person process where the first practitioner does not communicate what they expect the second practitioner to see. (Hewitt, Chreim, & Forster, 2015)
Concurrent Verification (CV)	This phrase stems primarily from the nuclear energy sector, with little application found in other sectors: • CV focuses on the verification of the correct device, the expected operation, and the abilities of the person making the verification. It is used to prevent an error by a worker when changing the condition or status of a component. CV is intended to address every aspect of the task <u>before</u> any change is made. (mul) • CV is a series of actions by two individuals working together at the same time and same place to separately confirm the condition of a component before, during, and after an action when the consequences of an incorrect condition would subsequently lead to undesired harm. (Human Performance Improvement Handbook, 2009)
Self-checking	Self-checking is a form of HBC applied within nuclear and energy contexts: • Self-checking is a human performance tool designed to enhance an individual's attention to detail, i.e. to think about an intended action, understand the expected outcome before acting, and verify the intended results after the action. • Self-checking helps prevent errors when 'touching' plant equipment to change its status, or even when revising documentation. The technique boosts attention at important points in an activity before an important action is performed. If attention is not focused, error is likely. (Human Performance Improvement Handbook, 2009)
Peer-checking (Variations include two-person check)	Peer-checking is a series of actions by two individuals working together at the same time and place, before and during a specific action, to prevent an error by the performer. The purpose of peer-checking is to *prevent* an error by the performer. Error prevention is the principal function of the PC technique. PC augments self-checking by the performer - it does not replace it. PC involves two people (performer and peer) self-checking in parallel, agreeing together that the action is the correct action to perform on the correct component. Similar to CV but less formal, this technique takes advantage of a fresh set of eyes not trapped by the performer's task-focused mind-set. The peer, an individual familiar with the activity, may see hazards the performer does not see. (Human Performance Improvement Handbook, 2009)

Table 1 illustrates that there are numerous definitions and terminology available to denote HBC activities, with some concepts (i.e. double checking) being inconsistently conceptualised. The range of concepts associated with HBC increases the likelihood for confusion and mis-application, especially if the role of the check is not explicit and the level of human reliability required not defined. It should also be noted that there is some confusion over the distinction between checks intended to prevent an error (e.g. confirmation that the action is about to be undertaken on the correct component), and checks intended to reveal an error (e.g. identification that an incorrect value has been entered into a system). For the latter to be effective, it is important that the system provides opportunity to correct a revealed error before it has an impact on system performance. In other words, the effectiveness of HBC is partly dependent on the overall design of the system and its error-tolerance.

Whilst a number of the concepts have emerged from the nuclear and energy sectors, and appear to be implemented as part of a suite of Human Performance tools, no evidence has been found that discusses the effectiveness of these concepts and their efficacy in achieving required levels of overall system reliability.

More recently, the role of HBC has gained importance, particularly in the health and medical profession. There is consensus that medication administration and dispensing errors pose a significant threat to patient safety, and *double-checking* is a recommended method of reducing such errors, although it can be considered a relatively 'weak intervention' and is regarded as the 'last barrier' in error prevention (Kellet & Gottwald, 2015). Research has shown that there continues to be inconsistent views, among health professionals, of what a double-check constitutes and a number of associated limitations with this type of check have been identified (Hewitt, Chreim, & Forster, 2015). For example, the double-check can be perceived, by some, as a costly and time-consuming procedure, i.e. by having to find an additional person to check and sign paperwork in a busy and high workload environment.

Other literature and systematic reviews (Alsulami, Conroy, & Choonara, 2012) highlighted that there is insufficient evidence to either support or refute the practice of double-checking the administration of medicines and that clinical trials are needed to establish whether double-checking medicines are effective in reducing medication errors. This is due to the scarcity and quality of studies, the variability in what constitutes double-checking and inconsistencies with the application of this intervention strategy (Carson, n.d.).

Factors leading to sub-optimal HBC

Research has identified a number of factors that may lead to sub-optimal HBC activities. Often a check is inserted into a process as a 'knee-jerk' reaction to a previous failure or adverse event without thoughtful planning and assessment to eliminate possible failure modes of the check itself, or negative impacts on other tasks that might be introduced by having the additional check. Common factors cited in literature that contribute to sub-optimal HBC include:

- Lack of clear definition of how the check is to be performed by the individual(s) involved;
- Lack of detailed (human factors) assessment regarding the suitability and appropriateness of the proposed check;
- Failure to design a truly independent check when the requirement for one has been appropriately identified;
- Second person checks that facilitate confirmation bias, deference to authority or reduction in responsibility. For example, the task may be designed such that it allows specific information to be passed from the first person to the second person prior to the second check being conducted, leading to the second person having a false expectation and hence missing the error;
- Ineffective training for staff that are expected to perform the check;
- Interruptions during the check;
- Rushing the check due to a perceived time pressure, resulting in superficial checks being undertaken;
- Lack of investigation and analysis of errors that occur during HBC activities and not using such data to drive root cause analysis and interventions upstream to minimise as many of these performance influencing factors as possible
- Inappropriate culture that downgrades the role and importance of the HBC (e.g. incorrect expectations concerning the performance of the task being checked).

The factors presented above can be grouped into three core themes as shown in Figure 2.

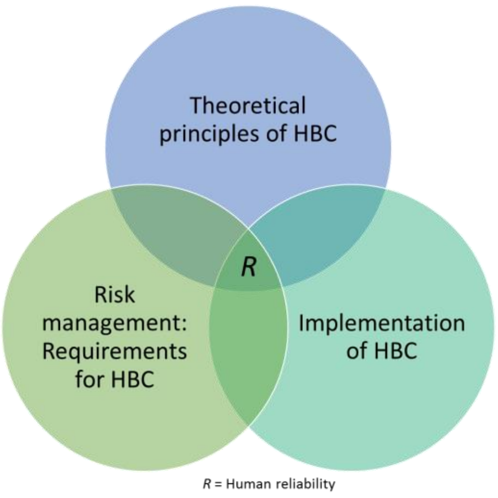


Figure 2: Factors that lead to sub-optimal HBC

- *Theoretical principles of HBC* - Lack of clarity regarding the definition of the specific human-based check leading to inconsistent views and perceptions of its role and safety function;
- *Risk management: Requirements for HBC* – Lack of evidence-based safety assessment that defines the requirement for HBC and placement within activities and tasks;

- *Implementation of HBC* – Inadequate implementation, for example, through poorly defined roles and responsibilities, lack of training, task support features that do not support delivery of the check as intended, perceived time pressures and high workload leading to superficial checks.

The three components are inter-related and the effectiveness of these will influence the level of human reliability that can be achieved for HBC activities. It is these three components, and how they interact, that underpins the HBC framework and the goal of optimising HBC activities to deliver the required levels of human reliability. By understanding the factors that lead to sub-optimal HBC activities, then safety professionals can set out to design and implement HBC activities in such a manner that efficacy is enhanced.

The framework

Greenstreet Berman Ltd (GSB) has supported a Periodic Safety Review for a UK Nuclear Licensee, which included review and substantiation of safety-critical HBC activities and the supporting HBC regime. Operational Experience data indicated that a large proportion of HBC activities were subject to routine human failure. Therefore, work was undertaken to better understand how workers conceptualise HBC, identify potential weaknesses with checking activities, and explore possible alternate views to render more robust checking arrangements. It should be emphasised that this work was not undertaken in isolation. Whilst it is important that HBC should be optimised, it is equally important that proper attention is devoted to the activities that are subject to checks, in order to minimise the likelihood of the human failures that would be revealed by HBC. Furthermore, the design of those activities needs to consider how the necessary HBC is facilitated.

An HBC framework has been developed by GSB to facilitate a systems approach to the optimisation of HBC activities and arrangements, particularly in the context of complex systems. This framework, applied in response to the Licensee's issues, prompts consideration of the conceptual principles of HBC, in order to define reasonable and realistic HBC performance requirements. In turn, this facilitates development of appropriate implementation strategies, which should deliver the requisite level of human reliability. The framework aims not only to support assessment and review by HF practitioners, but also to support system designers, engineers, and managers in understanding how to optimise human performance in relation to HBC activities. The framework serves as a valuable tool to present an approach for the assessment of the suitability of particular approaches to HBC, and importantly support effective integration of HBC into complex systems across high-hazard sectors and organisations.

GSB's application of the framework in a real-world situation identified a number of similar findings to those observed in other sectors, described earlier in the paper. For example, two-person checks had become a superficial, routine task, eroding its perceived importance amongst system operators. A subsequent impact of this effect was that operators' wider perceptions towards safety critical checks was also degraded, particularly those that constituted IV. Some key findings in a Nuclear context align with those identified in literature across other industries, for example:

- Widespread differences in understanding of key terms and their definitions, including specific task requirements;
- Inconsistency and ambiguity in the implementation of HBC tasks through procedures, and training/assessment documentation;
- Checks become habitual, with reduced levels of attention and little genuine appraisal of the performer's actions, or information subject to review;
- A reduction of responsibility or over reliance on two-person checks in which staff believe someone else will spot any errors;
- Deference to authority in which the person checking the work of someone who outranks them may not raise concerns;
- Perceived time pressures which may adversely impact human performance, and have the potential to drive non-compliance through the overlooking of minor differences, or the omission of checking tasks.

The framework, presented in Figure 3, comprises the core components considered necessary to optimise the integration of HBC into complex systems. Four components have been derived, namely:

1. Theoretical concepts and principles of HBC;
2. Risk management: Requirements for HBC;
3. Implementation of HBC;
4. Reliability of HBC.

Each component represents a number of activities that, when performed together, support optimised design and implementation of HBC. The structure of these components is intended to provide individuals involved with task or system design, with a mechanism to adopt a system-centric and evidence-based approach, informed by contemporary theory and research, such that requisite and optimal reliability may be achieved from the human aspects of a system.

The framework operationalises those themes introduced earlier in Figure 2 into a process that may be applied across high-hazard industries. In essence, the framework is focused on well-defined and well-understood terminology, being appropriately integrated into safety management assessment and arrangements (from task design through procedures, training and assessment) and realised in actual human performance mirroring intended performance. As a result, the design of HBC should optimise its contribution to overall system reliability, and on-plant performance should deliver this.

Theoretical concepts and principles of HBC

The foundation of robust HBC activities includes deliberate and unambiguous terminology, which is clearly defined and widely understood across the organisation. This should reflect contemporary research in the area, for example how is peer-checking or IV best designed and achieved. This will vary between industries along with the requirements of HBC from sectors, or even specific systems.

The capturing of definitions provides an anchor from which all subsequent HBC tasks can be developed. The application and integration of HBC will likely be diverse and undertaken by a range of stakeholders. As such, consistent definitions and information such as the bounds of the HBC measure, or where it may appropriately be used, ensure that each instance of an HBC measure being implemented, reflects the same understanding.

In complex systems, personnel, teams, and local business areas are likely to interface with each other in a number of ways. The common understanding regarding HBC (or indeed any aspect of the Safety Management System [SMS]) supports consistent performance, reduces the potential for failure and ultimately enhances reliability.

Risk management: Requirements for HBC

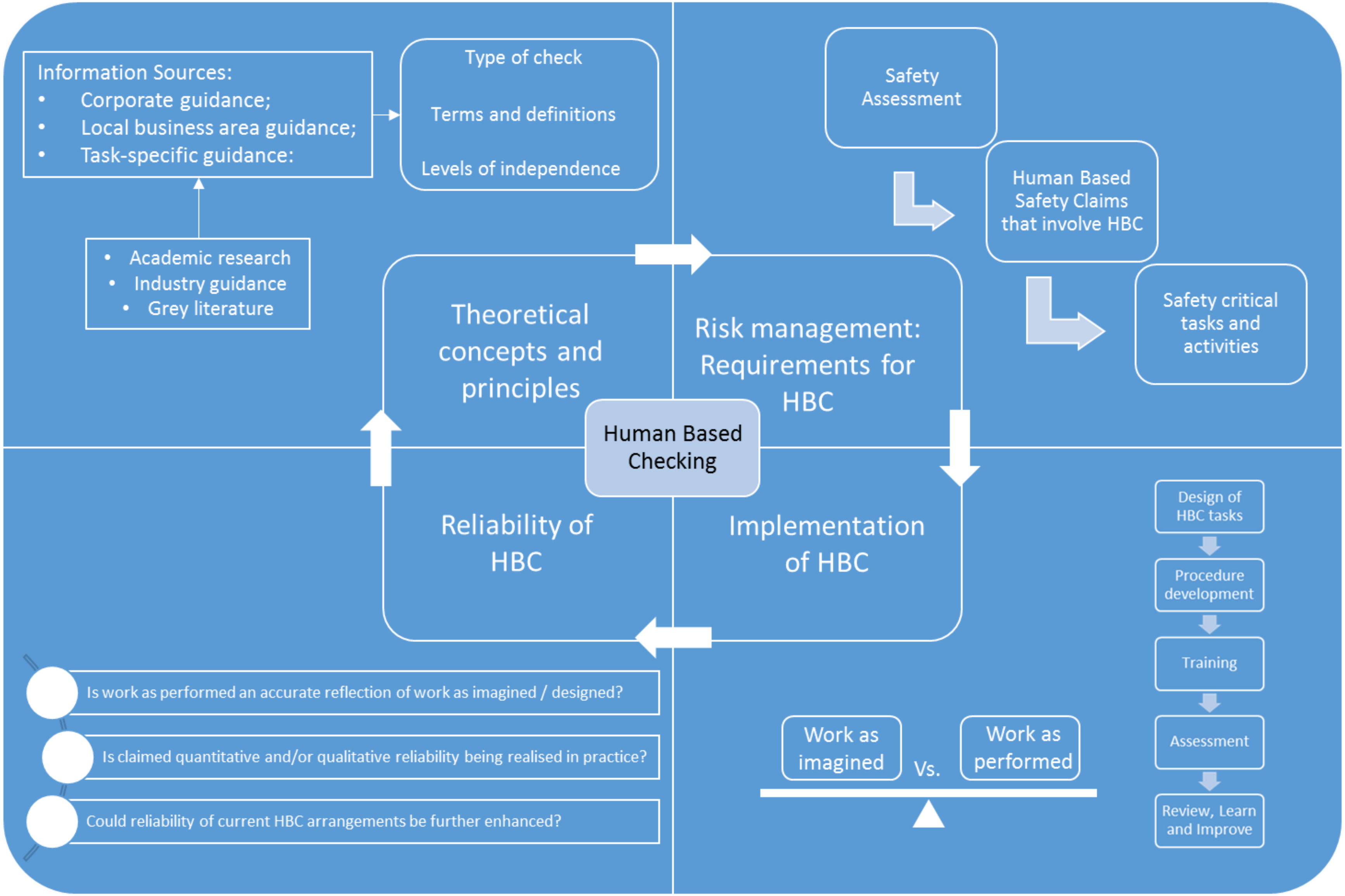
Across high-hazard organisations, the method for documenting and justifying the adequacy of safety arrangements will vary. A constant, however, is that there is likely to be a form of argument that assures safe operations, for example through a Safety Case, or Major Accident Prevention Policy.

The role of HBC in the context of risk management is likely to be captured (albeit at differing levels of detail) as part of this argument, which in essence forms the bridge between research and theory, and real-time operations, in the form of evidence-based practice. This information should state parameters, requirements and conditions, within which systems and tasks are designed. A requirement for HBC can emerge where additional reliability is required beyond what can be claimed from the task itself. This usually coincides with engineered defences against failure (whether human failure or engineered system failure) being unable to be justified or provide the necessary reliability.

The selection of an appropriate form of HBC is of great importance, and is best achieved through the review of relevant theoretical and conceptual principles of checking tasks. It is equally important that HBC is incorporated in a consistent manner, which can be achieved by the use of clear terms and definitions, developed as part of the previous component. In turn, this reduces the likelihood of overuse and misapplication of checking tasks; the negative implications of which are evidenced throughout literature, particularly in healthcare.

It is possible that those responsible for designing and integrating HBC in a safety argument are different from those individuals whom are responsible for its detailed implementation (for example, procedure authors). It is, therefore, important that where HBC forms part of, or supports, safety requirements, the terminology is clear and unambiguous so that subsequent task design can deliver against the underlying intent of HBC.

Figure 3: HBC framework



Implementation of HBC

This component is most easily understood in the context of the relationship between ‘work as intended’ and ‘work as performed’. This principle has been extensively applied to safety assessment and management across many high-hazard sectors, and is normally associated with High Reliability Organisation (HRO) principles. For reference:

- Work as Intended (WAI) – this refers to the operational work as intended by safety documentation, and as expected by the organisation’s leadership and management. This is what is believed to happen, or claimed happen. WAI forms the basis for task design, training and control and includes both the mental model of WAI by managers, and the documented WAI through rules, procedures and the safety assessment requirements;
- Work as Performed (WAP) – this refers to the operational work as it occurs on plant. This work is cognisant of WAI but is impacted by local performance shaping factors, resulting, sometimes, in modifications to the manner in which the work is done in the given circumstances.

A widely acknowledged characteristic of HROs is that WAP is a fair and accurate reflection of WAI. It is the presence of a difference between the two that makes the system vulnerable to failure. In the context of HBC, using this relationship as an indicator of actual system reliability supports an essential feedback mechanism as part of ongoing monitoring and review activities.

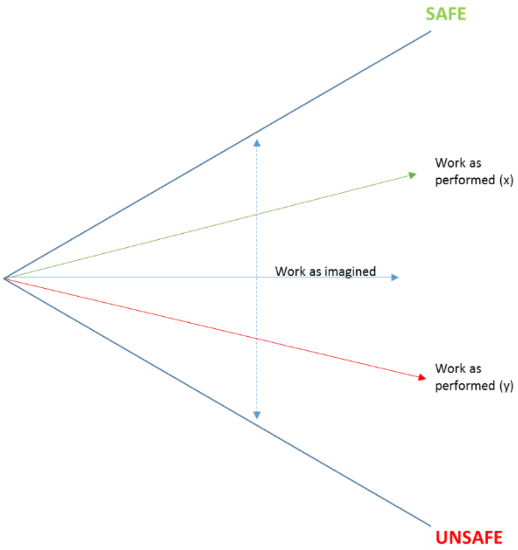


Figure 3: WAI versus WAP

Consider Figure 3 where WAI is a constant, given that it is a theoretical intention. There are two clear ways in which WAP may deviate from WAI in relation to HBC activities, which take the system to either a more, or less, safe state.

For example, two pairs of operators (groups x and y) are performing a series of checks to confirm it is safe to move hazardous material to a new location. Both operators undertake these checks in a different manner to the intended method. Group x opt to increase the level of independence in the task by performing checks in full, separately, at different times, thus improving task reliability. Group y, however, opt for one operator to perform the check, whilst the other watches them do so, satisfied that the check has been undertaken by actively confirming specific information. In the latter, reliability has been reduced.

In both cases, a gap exists between the check as intended, and as performed on plant. This suggests that the checking activity can be enhanced, however, the nature of the deviation from WAI must be understood in order to determine appropriate improvement. This is particularly important as too often, organisations implement measures attempting to direct WAP back to WAI, without considering potential for a redesign of WAI itself (Dekker, 2006).

The functional activities contained within this component include capturing and presenting HBC activities as they are intended to be performed, supported by appropriate and well-designed arrangements including task and procedure design, task support features, and training and competence management activities.

Reliability of HBC

This component draws together the outputs of the preceding three components, and focuses on whether the HBC activity itself is likely to deliver the necessary level of reliability, in addition to that of the task subject to checking. When considering the HBC task, the argument for reliability can take multiple forms, e.g. qualitative and/or quantitative. The type of reliability considered should be proportionate to the nature and scale of the risk. In keeping with the principle of ALARP, the reflexive nature of this component serves to challenge whether the preceding components of the framework have been optimised and effectively implemented, and should support identifying opportunities to further optimise current arrangements.

It is equally important to consider the wider system, such that the contribution of HBC to overall reliability can be better understood. The design of HBC tasks will shape system and human performance elsewhere, and conversely, the perceived reliability of the system can influence the reliability of HBC. The modelling of this interaction, as part of the framework, facilitates optimal reliability to be realised at all levels.

Making the framework work.

The framework can be used to identify where failures may exist within existing risk management arrangements, related to HBC, or can be used within new safety assessments to effectively identify and integrate HBC. There are a number of underpinning activities and success factors, within each component of the framework, that support a systems approach to optimising HBC within any organisation. The components of the framework are inter-related, whereby shortfalls in one component may influence the success of another component, therefore consideration of each component is necessary to maximise the opportunity to optimise HBC activities and subsequent human and system reliability. The framework can be utilised, perhaps, in a more sequential manner when considering HBC activities in the design and development of a new system or plant. In the context of existing systems and plants that already utilise and integrate HBC activities, all four components should be explored to identify potential opportunities for improvement.

Theoretical and conceptual principles

Central to this component is the requirement to have agreed, and clearly defined, concepts related to HBC activities within the organisation, function, department etc. These definitions should be informed by evidence (where available), and documented within a policy document (or similar) to support consistent communication and understanding of the importance and role of HBC within the organisation's risk management strategy. In essence, where HBC activities exist, have they been appropriately defined, operationalised and communicated to ensure there is a consistent understanding of their purpose.

Risk management: Requirements for HBC

The role of HBC should be considered and made explicit within any risk management strategy, supported by robust and systematic safety assessments that determine a legitimate requirement for HBC. This can include:

- Identification and assessment of activities that rely on human interaction, specifically HBC, ensuring that the possibility of greater controls (i.e. engineered) have been ruled out;
- Human Factors assessment of current HBC activities and supporting arrangements in place to understand what failures may be occurring, and where in the framework;
- Determine the errors with high consequence or high probability using techniques such as failure modes and effects analysis, hazard and operability studies, supported by human factors assessments such as task, error and consequence analysis that will identify potential human and system failures, their causal mechanisms and their likelihood.

Implementation of HBC

Central to successful implementation of HBC activities are a number of success factors:

- Where independence is required, the check is separated by time and distance and using different information sources, to mitigate the risk of influencing the checker with information originating from the first person about the work, inputs, outputs, calculations, and or any judgement applied;
- Where checks are carried out together, ensure roles and responsibilities are explicitly defined and understood;
- It is important that the checker understands the failure mode and consequences that the check is intended to defend against. Furthermore, it is important that the terminology and definition of the check is clear, so that the checker understands what is required. For example, are they checking that the task has been completed, that it has been completed correctly, or that it has completed at the right time?
- Checklists are utilised and designed to support successful and reliable performance of the check (i.e. alignment between WAI versus WAP), e.g. checklists that include details of what information to check (quantities, values, calculations) and from what sources. Keep the list short by omitting items with lower risk and lower probability;
- Procedures are in place that document the checks required, and any specific action to be taken related to implementation of the check;
- Procedures align with, and support, training and assessment of those who will be performing HBC activities;
- A physical environment free from distraction, particularly where checks support high-risk activities or task steps;
- Periodic review and assessment of the efficacy of the check;
- Provide training in human error dependency and/or education on raising the profile of HBC as a critical activity;
- Errors identified during HBC activities should be analysed and used for learning and system improvement.

Reliability of HBC

How reliability is modelled and assessed varies greatly across high-hazard industries. As such, this component supports optimisation of HBC activities through understanding whether claimed quantitative levels of human reliability are being achieved, and their contribution to overall system reliability. If claimed reliability is not being achieved for HBC activities, then it becomes necessary to understand why. The reliability of HBC activities should be modelled through Human Reliability Assessment, and its contribution to overall system reliability assessed.

Furthermore, it is essential to consider the implications of any difference between WAI and WAP of HBC tasks, in the context of human reliability, to support identification of appropriate resolution and enhancements that would support enhanced human performance and system reliability.

Value to industry

Despite advances in technology, and increased system automation, modern systems continue to utilise and rely on HBC activities as part of an overall safety argument. It then follows that where there continues to be a requirement for HBC, there is also a requirement for its implementation to support the goal of optimal system performance and reliability. Historical experience and performance suggests that current arrangements may not be optimised to support the delivery of this requirement. The HBC framework provides a mechanism to support safety professionals with a structured approach to the design and integration of HBC. Furthermore, it recognises that HBC is likely to remain a part of the overall approach to achieving the required system reliability, as part of a balanced design. Rather than seeking to remove HBC through ever more complex engineering (which itself might introduce other error modes and performance penalties), the use of the framework to optimise HBC can lead to an overall improvement in system reliability.

The HBC framework serves as a valuable tool to present an approach for the assessment of the suitability of HBC, and importantly, support effective integration of HBC into complex systems. The framework is flexible and scalable, such that it may support a range of activities, across high-hazard sectors. For example, it can be used to sense-check current processes for integration of HBC activities. Conversely, the framework can be used to guide the detailed design of HBC activities, in addition to assessment and monitoring and review activities that form part of the wider risk management strategy. Such flexibility allows the framework to support the derivation and justification of quantitative reliability claims (such as the derivation of Human Error Probabilities), or qualitative discussion as to the indicative level of reliability to be expected in given tasks, including ALARP justifications.

To determine how best the HBC framework can be utilised in your organisation, and where there may be potential opportunities for further optimisation of HBC, a number of key questions are provided.

Ask yourself:

- Why does your organisation utilise human-based checking?
- Can you easily describe how HBC is conceptualised in your organisation?
- Think about a term that is used within your organisation related to HBC activities (e.g. peer-checking, independent checking). How confident are you that five, randomly selected, workers would share a common understanding of this term, particularly how it should be delivered in practice and any associated failure modes and consequences?
- How do you assure yourself that HBC activities in your system are appropriately identified, selected, implemented, and are being performed both reliably and successfully?

Conclusion

This paper highlights that HBC, while an accepted error-reduction strategy in many industries, is fallible. In addition to having a weak evidence base regarding its efficacy, the process for defining, designing and implementing HBC activities has limitations.

This paper highlights that HBC warrants further examination in organisations that employ it as a risk-reduction strategy, given the limitations associated with the conceptualisation and implementation, especially in relation to safety critical tasks. At the same time, the paper proposes that HBC can be made more reliable, and form a more robust element in the safety argument, if it is implemented effectively. Safety professionals who are aware of the limitations of HBC may begin to view the role of HBC through an alternative lens using the components of the framework provided in this paper. The conundrum remains that whilst some people seem to have undue confidence in the effectiveness of HBC, others have a healthy scepticism about it, yet still rely upon it. Regardless of any one persons' view towards the role of HBC, utilisation of the framework would provide stakeholders with a greater opportunity to optimise human performance in relation to HBC, and ultimately enhance overall system reliability. Check Mate.

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