PRACTICAL APPLICATION OF AS7470:2016 HUMAN FACTORS INTEGRATION IN ENGINEERING DESIGN – GENERAL REQUIREMENTS

Gareth J Hughes
MBA, BSc Hons Ergonomics
C.ErgHF, CPE
Asset Standards Authority (ASA), Transport for New South Wales (TfNSW)

Summary

In November 2016 RISSB published the new standard “AS7470:2016 Human factors Integration in Engineering Design – General Requirements" [1]. One of the aims of the standard is to improve the recognition of the application of human factors integration (HFI) during the design process as a tool to improve the effectiveness and efficiency of systems in addition to the more widely accepted benefits for safety. With this in mind the standard was written in such a way as it can be applied by both specialists and non-human factors specialists as a starting point for HFI within the design process.

The content of the standard was derived from an existing human factors standard developed by the Asset Standards Authority (ASA) in collaboration with the NSW transport industry in 2014. A wider engagement process was facilitated through the Rail Industry Safety and Standards board (RISSB) to review; the existing document from a national perspective, identify any gaps or further material required and to account for industry experience in its application.

The standard provides a scalable and practical approach to human factors integration that enables both HF specialists and non specialists to deliver effective human factors integration into a wide range of projects. Specifically for non-human factors specialists it provides an appropriate starting point to determine the HFI requirements for a project and to enable decisions about the level of human factors expertise that may be required.

1. INTRODUCTION

On October 31, 2014, VSS Enterprise, a Virgin Galactic Scaled Composites Model 339 SpaceShipTwo experimental spaceflight test vehicle, suffered a catastrophic in-flight breakup and crashed in the Mojave Desert, California, United States while performing a test flight. The co-pilot was killed and the pilot, seriously injured.

Following the incident and as a result of the subsequent investigation the National Transportation Safety Board (NTSB) issued a press release entitled ‘Lack of consideration for human factors led to the inflight break up of SpaceShip Two’ [2]. Specifically the feather system, which was designed to pivot the tailboom structures upward to slow the vehicle during reentry into the earth’s atmosphere, was to be unlocked during the boost phase of flight at a speed of 1.4 Mach. The copilot unlocked the feather at 0.8 Mach; once unlocked, the loads imposed on the feather were sufficient to overcome the feather actuators, allowing the feather to deploy uncommanded, which resulted in the breakup of the vehicle.

The NTSB found that Scaled Composites, the company that was developing the craft, failed to consider the possibility that a test pilot could unlock the feather early or that this single-point human error could cause the feather to deploy uncommanded.

Therefore it appears that the benefits of human factors integration (HFI) within the design process are not completely universally recognised. Yet, there is a plethora of human factors standards in existence and in certain industries such as defence, nuclear, aviation the principles and requirement for HFI are generally well established and form an integral and essential part of the design process.

It is more difficult to identify case studies where the effectiveness or efficiency of systems has been detrimented by the lack of HFI as the consequences are less catastrophic and tend not to be reported.

One example is that on a train originally designed in the 1980s the pantograph down button was located next to the crew cab light. Subsequently on a number of occasions a train was depowered unintentionally. This problem was later rectified during a refit where the pantograph down button was physically relocated to a position where it was much more unlikely to be accidentally activated.

The reason as to why the awareness and uptake of HFI on a wider scale and across other industries is still limited is beyond the scope of this paper. Perhaps one reason is the complexity of the existing standards as they are primarily designed for a specific audience of human factors specialists and practitioners.

Following the formation of the TfNSW Asset Standard Authority (ASA) in July 2013 it was recognised that there was a need for a general HFI standard that would be applicable to the whole range of TfNSW projects. For the purpose of the development of the standard the following definition of Human Factors integration was adopted:

"the formal process to integrate Human Factors into the system-engineering life cycle. It involves applying a systematic and scientific approach to the identification, tracking, and resolution of issues related to human-system interactions. Effective HFI ensures the balanced development of both the technological and human aspects of the system and delivers the desired safety and operational capability." [1]

It was also recognised that the document should be aimed at a wider audience than just human factors practitioners which would include project and bid managers, designers and project engineers. To meet the requirements of this audience it was recognised that the document had to be short and practical and that it was not a replacement for existing more detailed standards. It was deliberately designed to be a starting point which would be supplemented by more detail as required. As a result of the working relationship between the ASA and RISSB a project to develop the existing ASA document into a RISSB standard was put forward into the RISSB project prioritisation process for 2015/16.

The proposal was successful and a project was initiated. A RISSB sponsor, lead author and a project technical committee was appointed to the project. The ASA took the role as lead author. The project technical committee comprises a number of individuals from the industry who were either human factors practitioners or industry representatives of organisations that may have to apply the standard. A list of organisations that participated in the technical working group can be found on page 1 of the standard [1]. As such the development of document represents a consolidated view of rail industry good practice in Australia.

Through a process of workshops and detailed review and comment the existing document was updated to reflect the needs of the industry across Australia and new content on the topic of 'way finding' was added. In line with the RISSB standards development process the document was then subject to independent verification prior to it being published as an official Australian Standard in November 2016.

It should be noted that the standard is about incorporating HFI into the design process such that the end product (design) can be used and maintained both safely and efficiently.

2. STRUCTURE OF AS7470:2016

There are two parts to the standard the first part deals with the HFI process requirements. The second part describes a set of specific HF requirements that were developed as a result of past experience in heavy rail projects.

2.1 Process Requirements

In an attempt to make the content of the standard more familiar to the intended audience the HFI process requirements are based on the risk management process described in ISO 31000:2009 [3]. Each step has been contextualised for human factors and to help bring a focus on tasks and users to the forefront of design thinking. A full description of the requirements for each step of the process can be found in the standard [1].

The process is illustrated in figure 1 which is located in Section 7 - Appendices.

The first element of the process is to establish and document the context of the use of the system, and in particular identify the users of the system and the tasks they are likely to carry out under normal, degraded and emergency conditions.

Having achieved this, a list of human factors issues or topics can then be developed. The content titles of the second part of the standard provide a useful checklist for doing this.

The requirement is then to analyse and manage the human factors issues and this is where it may be necessary to bring in human factors practitioners or specialists depending on the nature and level of human factors expertise required. For the majority of simple projects a good design engineer should be able to conduct the activities themselves. This principle and the distinction between simple and complex projects will be discussed in more detail in the following section on 'practical application.'

The assessment part of the process refers to the mechanism through which the results of any human factors analysis are discussed at a project level. This would normally occur through multi-disciplinary design workshops or design reviews. Within this process the human factors recommendations should be treated as integral and in similar fashion to any other 'engineering' component. It is normal practice to identify that in any design process compromises may have to be made for example through lack of physical space etc. but the essence of this activity is to make conscious and informed decisions to 'optimise the compromise.'

The final stage is to adopt those recommendations that are agreed and to test and verify that they are appropriate and are working. To this end HF requirements can form part of the overall test plan and or depending on the complexity of the project be subject to a specific set of user testing/acceptance activities.

Throughout the adoption of this process there is of course the requirement to consult and communicate. A point of note is that for human factors interventions to be successful it is essential that users of the system are consulted. I use the term 'users' as the people who will interact with the system as opposed to the use of the more general term 'stakeholder'.

Finally in order to identify opportunities for continual improvement there is a requirement to monitor and review the HFI contribution both on a project and an organisation scale.

2.2 Human Factor Topics

The second part of the standard provides a set of detailed requirements around a number of human factors topics. These topics were identified as being indicative of areas where there had previously been a lack of human factors considerations within heavy rail projects. The list of topics included in the standard are:

- Design requirements.
- Anthropometric data.
- Information content.
- Audibility and intelligibility of messages.
- Alarms and alerts.
- Controls and displays.
- Workspace and task design.
- Glare, reflections and line of sight.

- Customers and the public.

The section on design requirements provides a broad brush approach to good practice HFI principles applicable to all projects. The requirements in the other sections may or may not be applicable depending on the actual project itself and may provide guidance on a new area of knowledge for the reader.

As identified earlier in this paper, this list can provide a useful checklist for the identification of potential human factors issues early on in the design process.

3. PRACTICAL APPLICATION OF AS7470:2016

The purpose of AS7470:2016 is to provide a mechanism for the optimisation of overall system performance through the systematic consideration of human capabilities and limitations as inputs to an iterative design process. From a practical perspective this means the required HFI process must be scalable and fit for purpose and must not place unnecessarily burdensome requirements on design. However it must enable appropriate consideration of human factors to the level of detail required in order to achieve the benefits of HFI.

The first step in the practical application of the standard is therefore to determine the level of complexity of the project (asset) from a human factors perspective, as this will determine the scale and complexity of human factors effort required. Note, this may not always directly correlate with the technical difficulty of the project. For example, due to environmental factors it may be technically difficult to design a bridge but from a human factors perspective this would be considered a simple project.

Throughout this section we are going to use three examples to illustrate the level of complexity and therefore scale and complexity of effort required for three different design projects;

- a railway bridge
- a station
- a new rolling stock procurement

From a human factors integration perspective designing a bridge can be considered to be a relatively simple asset. The reasons for this are that the human (users) interactions with the system can be easily identified and are relatively straightforward. A simple table can be used as illustrated in Table 1.

User	Condition	Task
Train Driver	Normal	Drive train at line speed
	Degraded	Drive train at slow speed looking for obstructions Protect train using detonators etc.
	Emergency	Evacuate passengers to safe place
Customer (passenger)	Normal	None
	Degraded	None
	Emergency	Access and walk to position of safety
Maintenance	Normal	Routine inspections of track etc.
	Degraded	Inspect track/equipment for faults or repair Inspection of bridge structure or drainage
	Emergency	Access for emergency vehicles etc.

Table 1 – Example of Identifying Users of an Asset and Tasks for a Railway Bridge

Note: If the bridge were to cross a roadway then additional users such as car drivers, pedestrians could also be identified.

From the table it can also be seen that a number of the tasks are standard processes which are more than likely to be covered by appropriate standards. Even so it is worth mapping these out in this way in order to provide assurance that they are not overlooked or that they can be improved.

For example explicit consideration of what is actually required for inspection of the bridge structures early in the design process may facilitate easier access or better ways of doing the task than is currently the case.

In the case of station design there are some similar issues with respect to the physical design of the station and station buildings but there are also some more complex interactions that need to be considered. Customers will interface with a wide variety of systems including buildings, information systems and the platform train interface in order to conduct their tasks. Therefore in this case the same sort of approach can be used. In this case there will be a larger group of users than for the railway bridge for example, some additional groups that spring to mind include train crew, station staff, cleaners, commercial tenants etc. Consequently the number of interactions will be much more numerous and will include a mix of simple and more complex due to the nature of the tasks being carried out.

Procurement of new rolling stock is considered to be complex from a human factors perspective. This is because of the number of interactions and the complexity of the tasks involved. In this case there is the need for detailed consideration of the design of the tasks and provision of the required information, the workplace layout and overall work design. For example optimising the design of the drivers cab is a complex task that requires a high degree of analysis and compromise and therefore in this case there is a need to conduct specific analysis such as:

- Cognitive task analysis
- Workload analysis
- Alarms and alerts design and integration
- Detailed anthropometric analysis
- Systems integration and workstation layout
- etc.

The customer areas also need to provide adequate customer-systems interactions and therefore the design of customer seating and standing areas and vestibules is of equal importance and also includes some level of complexity and compromise.

Having determined the level of complexity required, a good starting point for the next step is to identify the HF topic areas in the standard that may be applicable to the project. It should be noted that this is not meant to be an exhaustive list and other human factors issues may also be relevant.

Table 2 provides an example of this for the three examples listed earlier.

HF Topic	Railway Bridge	Station	New Rolling Stock
Design requirements	✓	✓	✓
Anthropometric data*		✓	✓
Information content		✓	✓
Audibility and intelligibility of messages		✓	✓
Alarms and alerts			✓
Controls and displays		✓	✓
Workspace and task design	✓	✓	✓
Glare, reflections and line of sight			✓
Customers and the public		✓	✓

Table 2 - Identification of HF Topics for Three Example Projects Using the Topic List in AS 7470:2016

* Anthropometric data are about the measure of people. It is fundamental to all physical considerations for users. Many standards provide prescriptive sizes for access and reach. These values are often based explicitly on anthropometric data or long experience that the dimension is needed to allow people to access or reach. So although anthropometric data is the basis for decisions it is often already included in standards and does not need to be explicitly reviewed. In this example it has been assumed that this is the case for

the railway bridge. It is still advisable to review design for a range of users.

The final step is integrating the relevant activities into the design process.

For simple projects our experience has shown that incorporating the appropriate information into an organisation's existing Safety in Design (SiD)/ Safe Design process is sufficient to meet the requirements of the standard providing that:

- users and their tasks have been explicitly identified
- there is a focus on efficiency and effectiveness of operations and maintenance as well as on safety
- there is appropriate 'user' representation at any workshops that are conducted.

In order to facilitate this process many organisations have built simple checklists into their SiD process to act as specific prompts for the consideration of these items.

It is considered that in the majority of simple projects these activities can be carried out by a competent designer or engineer with a basic level of understanding of human factors. Their focus needs to be on who the users are and the tasks they need or want to carry out. Facilitated workshops are not the end point in the SiD process and it is possible that an issue raised during a workshop would require more specialist investigation. It is necessary to conduct this type of analysis in a timely fashion in order that changes can be made in the most efficient way before the design progresses too far.

For complex projects, such as the procurement of new rolling stock, it is highly recommended that the services of a human factors practitioner are engaged as the nature and complexity of the work will require the application of detailed knowledge and expertise.

In this instance a series of activities will be required including but not limited to:

- identification of the relevant detailed human factors standards applicable to the project
- development of a human factors integration plan which identifies tasks, resources and HF reporting requirements
- maintenance of a human factors issues register with the same level of rigour as the project hazard log (may be incorporated into one document)
- detailed HF analysis including where appropriate observation of current tasks and facilitation of 'end user' involvement into the design process
- conduct of user testing and trialling including the identification of the use of various levels of mock ups/models throughout the process and incorporation of HF into project verification and validation plans and activities
- participation in project multi-disciplinary design reviews
- etc.

Experience has shown that for these types of projects it is essential to identify HF resource requirements and activities up front in order that they are able to be appropriately costed and conducted in a timely manner. This is particularly important where there are novel elements of the design.

The effectiveness and efficiency of the HF input can be reduced if HF specialists are only invited to input when problems have been identified or as an afterthought to meet a tick in the box. General experience has shown that for these types of projects the role of HF is reasonably well established. Although a recent study published by ONRSR [4] indicates that there are still areas where improvements can be made. This now leaves the projects that are somewhere in the middle. For example, clearly a station is not simple as there are multitudes of human interactions with different systems to be considered. However not all of the elements are complex either and much of the design will be satisfactorily covered by existing standards and good design by competent architects and engineers.

In these cases it is strongly advised that a human factors specialist be employed to help the organisation scale and scope the level of human factors effort and identify those areas where more than the 'simple' approach is required. Note that in this type of environment the term 'customer centric design' is often used to describe the human factors approach specifically relation to the customers.

4. DISCUSSION

As stated earlier the purpose of AS 4740 is to provide a mechanism for the optimisation of overall system performance through the systematic consideration of human capabilities and limitations as inputs to an iterative design process.

The content of the standard has been developed specifically to provide a framework for both human factors specialists and non-specialists and to provide a starting point for HFI.

The guidance in this paper has described how to categorise projects on a simple – complex human factors scale. The benefit of this activity is that in addition to the application of the content of the standard it could enable an organisation to scope out the HFI requirements for a specific project. Furthermore it may also be a way of helping an organisation to identify whether there is a need to seek specialist human factors support or not.

What then could be the barriers to the widespread take up of the standard across the industry?

Experience has shown that the most common reason may simply be a lack of awareness of the topic itself and of the simple but practical ways that the benefits of HFI can be achieved within the majority of projects.

Additionally it may also be the case that there is the perception that the potential for the 'unknown' to prove overly costly or detrimental to project delivery.

The content and requirements of the standard and the guidance specified within this paper should help to alleviate these perceptions. However it should also be acknowledged that if we are dealing with a complex situation then the conduct of appropriate HFI activities will be a cost to the project, in the same way as for any other engineering discipline. As indicated by the case study at the start of the paper the cost of not addressing HFI is probably much greater!

In New South Wales any organisation that conducts engineering services for TfNSW must be an Authorised Engineering Organisation (AEO). One of the mandatory requirements for an AEO is to manage all human factors relevant to the scope of the authorised engineering services. This has enabled us at the ASA to raise awareness with all of our potential suppliers on how they are able to meet these requirements and also puts an onus on them to demonstrate that they are able to do so.

In other jurisdictions it may still be the case that an appropriate mechanism may be to specify compliance with AS7470:2016 as a mandatory item within the procurement framework.

Of course the end game is to develop a culture within industry where the importance of human factors is acknowledged and HFI is considered to be part of business as usual.

5. CONCLUSIONS

In conclusion it is proposed that AS7470:2016 is a fit for purpose standard that represents a consolidated view of rail industry good practice. The standard should enable industry to meet the aim of achieving the optimisation of overall system performance through the systematic consideration of human capabilities and limitations as inputs to an iterative design process.

The standard provides an appropriate starting point for non-human factors specialists that enables a scaled approach to HFI to be achieved.

Through the application of the content of the standard and using the practical advice within this paper, HFI activities can be easily integrated into the majority of simple transport projects through enhancing an organisation's existing SID/Safe design process. It also facilitates an appropriate approach for more complex projects.

Given the above it is anticipated that industry uptake of this standard will be high and that it will help move us towards the desired culture where HFI is part of business as usual.

6. REFERENCES

[1]RISSB AS7470:2016, Human Factors Integration in Engineering Design – General Requirements
[2] NTSB Press Release, 28 July 2015, Lack of consideration for human factors led to the inflight break up of SpaceShip Two.
[3] ISO 31000:2009 Risk Management
[4] Road Rail Vehicle National Project – Human Factors Observations, ONRSR

7. APPENDICES

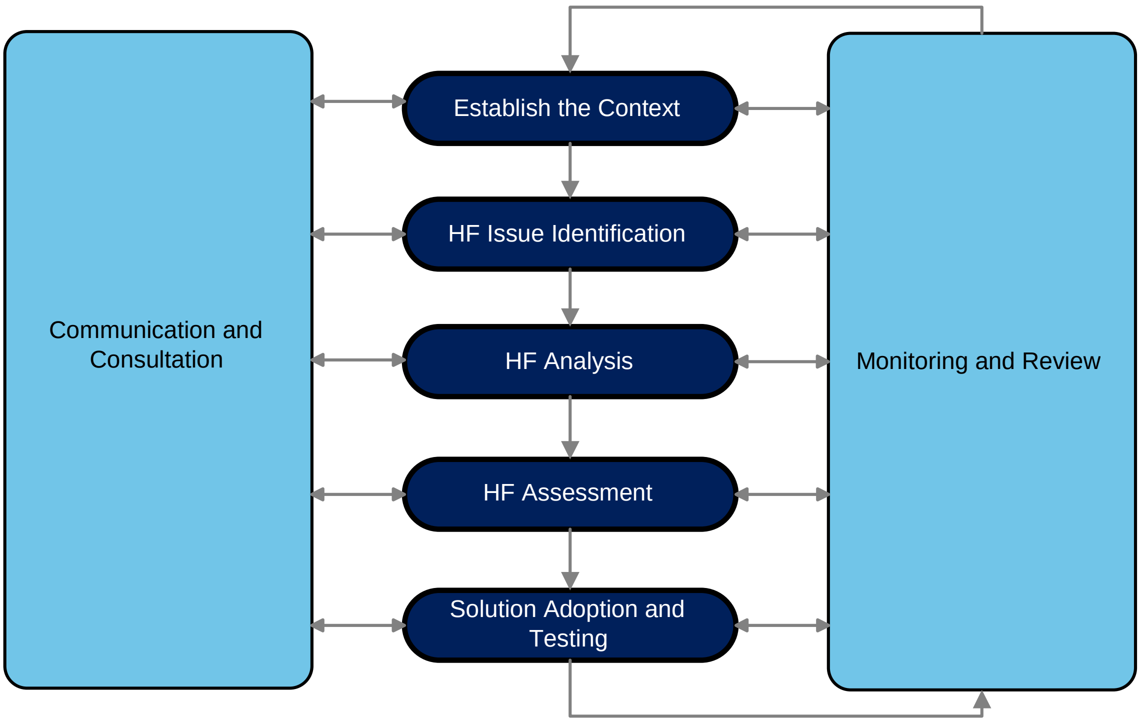

Figure 1 – The HFI Standard Process Requirements