SUMMARY

The effective use by humans of any transport system is a critical success factor in the development of such systems. Careful consideration of the interaction of ergonomic and functional design with the physical and cognitive capabilities and limitations of crew, passengers and maintainers is essential to assure safe, effective and profitable rail operations.

INTRODUCTION

This paper discusses how UGL Rail has integrated the consideration of human and system interaction into the development of our latest generation of locomotive and passenger car rail products. We describe the two key elements to our approach.

The first is to ensure that the physical design of the human machine interface matches the biomechanical constraints of the user.

The second is to ensure that clear and unambiguous information is built into the interface design so that users understand what to do through natural mappings and affordances, know what is going on through unambiguous feedback and are constrained from incorrect and potentially unsafe actions by interlocks and lockouts.

A particular focus of the paper will be upon the Australian legislative requirements to provide broad accessibility to transportation systems for disabled members of the public, and how this affects the scope of the human integration design task.

NOTATION

CASE Computer Aided System Engineering
CDR Critical Design Review
DDU Drivers Display Unit
FAI First Article Inspection
HF Human Factors
HFE Human Factors Engineering
HMI Human Machine Interface
HRC Hunter Rail Car
MC Master Controller
OSC Outer Suburban Car
OH&S Occupational Health & Safety
PBS Product Breakdown Structure
PDR Preliminary Design Review
PEI Passenger Emergency Intercom
PRR Production Readiness Review
RSI Repetitive Strain Injury
SDLC System Development Lifecycle
SDR System Definition Review
SRA State Rail Authority
SRR System Requirements Review
SVR System Verification Review
TRR Test Readiness Review
UGL United Group Limited

LESSONS FROM THE WATERFALL ACCIDENT

On the 31st of January 2003 at approx. 7:14 am a four car Tangara passenger train on run C311 from Sydney Central to Port Kembla (G7) overspeed on a downhill gradient leading into a curve and left the track. The train driver and six passengers were killed and the remaining passengers suffered various injuries ranging from minor bruising and lacerations to severe disabling injuries (McInerney 2004).

The subsequent commission of inquiry found that the train driver had suffered a heart attack on the approach to the curve and that the dead man system had failed to stop the train. Because the drivers dead man system was then the only safety system fitted the end result of the failure was a runaway train and resultant crash.

The driver safety system then fitted consisted of a deadman handle combined with a floor mounted deadman pedal (Figure 2) that the driver would have to exert a force against with his leg to maintain in a set (intermediate) position. Full depression or release of the pedal would then initiate an emergency brake application.
The reasons for the adoption of this specific style of interface was to address concerns over Repetitive Strain Injuries (RSI) caused by the use of the existing single deadman handle and to improve the resistance of the deadman system to deliberate circumvention (McInerney 2004).

However, subsequent investigations into the failure of the deadman system found that the static weight of the driver’s legs was in that case enough to keep the dead man system’s foot pedal in the set position after he had collapsed.

In the case of the Tangara dead man pedal interface the design team (then the SRA and Goninans) failed to address the possibility of the static weight of a driver’s leg holding down the pedal alone.

Unfortunately for the design team the distribution of lower leg weights of train drivers overlapped the minimum force necessary to hold the deadman pedal in the set position. As the population percentage versus body mass curve of Figure 3 shows 44% of the then driver population would have been able to hold the dead-man pedal down with their leg weight alone.

The direct lesson from this error is that a static or interface design that relies upon the assumption of a fixed anthropometric value is inherently vulnerable to the actual variability of humans.

Investigation into the effectiveness of the deadman pedal interface also found evidence of continuing subversion of the system by train crews, for example by jamming a signal flag handle between drivers desk and pedal plate.

In human factors terms this type of human error is termed a ‘routine violation’ of procedure. The lesson here is that system effectiveness can be limited by the degree to which procedural shortcuts are allowed in operation of the system.

More deeply the existence of such routine violations often indicates that a system has introduced unacceptable operational restrictions or workload on the operators. A fundamental objective of human factors, that is to ensure the usability of systems, can also have significant safety benefits.

As a historical note these fundamental deficiencies of a dead-man system were recognised and task based speed sensitive driver vigilance systems were later retrofitted to the Tangara fleet.

For UGL the Tangara accident reinforces both the general need for a consistent ‘first principles’ approach to human factors as well as providing specific lessons learned for the design of safety system interfaces. UGL’s governing human factors principles can be stated simply as:

1. First, that as a specialist discipline unless HFE is explicitly required in a project or design process, it will be overlooked and neglected.
2. Second, that human beings vary both anthropometrically and behaviourally and this variability must be considered.
3. Finally when designing the human-machine interfaces the cognitive limitations of the user
The integration of these lessons and a need to operate within the Australian regulatory environment forms the core of UGL Rails human factors engineering approach.

THE REGULATORY ENVIRONMENT

The current Australian regulatory environment places far more responsibility upon both the supplier and acquire (or principal) to ensure that rolling stock meet societal expectations for transport safety and accessibility.

Complicating matters somewhat is the complex Australian legislative environment with each state having their own specific rail safety, OH&S and accessibility legislation as well as federal accessibility legislation.

Efforts to rationalise the rail safety regulators and harmonise state legislation is proceeding (slowly) but it will be several years before this effort brings fruit.

Rail Safety

Any design process for new rolling stock within Australia is actually required to consider human factors under the current state legislation for rail safety.

As a supplier of rolling stock UGL Rail is committed to the supply of safe and reliable products. This commitment includes establishing a rail safety management system, establishing processes and standards for design to ensure our products and services do not expose our employers, contractors and the wider community to harm.

UGL Rails safety management system complies with the National Accreditation Package (NAP) and state Rail Safety Legislation and regulations via the application of Australian Standard AS 4292.3 Rail Safety Management – Rolling Stock. These legislative sources collectively dictate the need to consider:

1. Human factors and the human machine interface,
2. Human errors and violations, and
3. Error tolerant design.

The legislative need to consider these issues has in turn shaped UGL’s core human factors design principles.

Accessibility

A significant number of people find using public transport difficult or even impossible because of physical or cognitive limitations. Such impairment can range from the physical (mobility, reach or coordination) to sensory (vision or hearing) and cognitive (intellectual or communication impairment).

Australia as a signatory to the Universal Declaration of Human Rights has committed itself to ensuring equality of participation in economic, social, cultural and political life for all human beings without discrimination. This treaty provides a constitutional basis for the 1992 federal disability discrimination legislation.

In 2002 the federal attorney released the Disability Standards for Accessible Public Transport (DSAPT) which provides both design rules (augmented by AS1428.1 & 2) as well as a timetable for implementation.

While UGL as a supplier, is not directly bound by this legislation our customers are and as a result addressing compliance to these standards for new rolling stock is a significant part of the passenger car design effort.

THE HUMAN FACTORS DESIGN PROCESS

The System Development Lifecycle (SDLC)

The human factors engineering process is integrated into UGL Rails general system development lifecycle (SDLC) as illustrated in Figure 4. The context of this SDLC is the delivery of a major rolling stock project e.g. a new passenger car or locomotive design and build project.

In other contexts, such as sustaining engineering for an existing product line, the full set of human factors activities are not warranted given the lesser scope or complexity. In these cases human factors activities are flexibly and intelligently tailored to the scope and complexity of the problem at hand.

One of the critical problems that arises with human factors from a management perspective is that to ensure the acceptability of the human machine interface to a user group requires the involvement of the users in the design process. However this also means that detailed design requirements cannot be established up front leading to the risk of late changes causing major cost & schedule impacts.

The UGL Rail phased development approach is intended to ensure that the HMI design is attacked logically from large scale to small scale issues. Stakeholders are engaged as early in the process as possible in turn this minimising the potential for late breaking ‘design churn’, although we have to admit it does not eliminate it completely.
A User-Centred HF Strategy for Automation

While the SDLC provides an answer to the 'when' question of the HF design process there still remains the 'what must be done and why' questions to answer. These questions have become increasingly important with the advent of automated and especially computer software controlled systems. Here the challenge is no longer the constraints imposed by the system but rather the infinite possibilities of what software can do.

Traditionally in complex system designs the urge to automate has been driven by evolutionary pressures or in response to accidents. The problem with such approaches is that they fail to address the context in which an operator must perform or the automation and operator interaction.

Problems with automation can also be further exacerbated by the application of dysfunctional approaches such as the 'left over' principle where the designer automates everything that they can and leaves the rest for the operator.

To ensure that the human/machine system is properly design UGL has firstly adopted the so called 'compensatory' principle for system design where functions are allocated to automation and operator based on their inherent abilities and weaknesses.

An example of compensatory principle in action is the reallocation of the driver control of the fresh air damper (closed for tunnel transit) for the crew cab on the OSC project. The original allocation was for a fully crew controlled function. However discussion with crew representatives identified that drivers were highly likely to forget to open on the damper when exiting the tunnel and damper opening was re-allocated to the automation as a result.

While this approach is more insightful than the 'left over' strategy it must be recognised that it does have some drawbacks in that it assumes both a static set of operator capabilities and that one can design upfront the optimal interaction between crew and automation. In the longer term we would hope to move towards the 'compensatory' strategy of Hollnagel (1998) with our key suppliers and the industry in general.

A second element of our design strategy for automation is to take a user and task centred approach (rather than the more traditional data centred approach) to human interface design to ensure that usability is appropriately addressed (Lewis & Liemann 1993). Figure 5 illustrates the general process flow and steps for a user centred design approach to the operator interface.

A final point to note that UGL’s traditional role has been that of the prime contractor and system integrator. Our general approach is therefore to engage with our major technology partners and the acquirer to implement these strategies ‘on contract’.
**REQUIREMENTS DEFINITION PHASE**

The objective of the requirements definition phase is to clearly establish the requirements for the project. During this phase HFE activities include the identification of system users (crew, passengers and maintainers) and their needs in using the system.

The most variable user population is of course the travelling public. Users of public transport can be expected to span the full spectrum of physical and cognitive capabilities. As a result, user needs can be many and varied. Examples of differing transport user needs include:

1. toilet facilities for longer journey durations versus short haul metro style journeys,
2. commuter needs for short detraining times for metro services versus luggage storage and increased seated comfort for inter-city services,
3. the needs of individual passengers versus families and the disabled travelling with carers,
4. accessibility requirements for passengers with disabilities versus the able bodied.

An example of a 'simple' HF requirement that contains unexpected complications is in the selection of a door aperture width for accessibility by disabled passengers. The obvious (And wrong) assessment would be that this width would be derived from the minimum needed for wheelchair access. However, in practice, passengers using crutches and therefore the crutch tip to crutch tip width are the governing case.

The crew, especially the drivers, also have specific requirements which needed comprehensive HFE assessments as the design progressed. A not exhaustive set of examples of these requirements includes:

1. catering for anthropometric variations, normally for the 5th female to a 95th percentile male crew,
2. the design of crew controls and displays to improve usability and decrease human error,
3. ensuring that the interior of the crew cab has minimum glare for comfort, and
4. design the crew seat & interfaces for maximum comfort.

One often overlooked user group for any transport system are the emergency service personnel who may be required to carry out fire suppression and search and rescue operations onboard a train.

The identified HFE requirements are then documented and allocated to PBS elements and managed through the design life cycle using a CASE tool, IBM Rational DOORS™.

**SYSTEM DESIGN PHASE**

The purpose of the System Definition stage is to progress the requirements and develop the concept to a point where the requirements baseline and the scope of work for the project are fully defined.

Significant effort is put into refining the requirements and identifying interfaces with other design elements. At this stage of the design requirements trade-off studies are carried out pitting HFE requirements against other competing requirements for safety, maintainability, vandal resistance, cost or functional performance.

One example of such a trade-off was in the provision of evacuation routes at the nose and tail of the OSC trains while also meeting the signal and general crew visibility requirements. The provision of an access path here must be traded against the necessity to meet track signal visibility and while the impact can be minimised it can’t be eliminated.

During this part of the design human factor requirements are also reviewed to see whether they represent significant drivers of technical complexity and therefore risk. One example would be the implementation of the crew, passenger, automation functionality recommended by the NSW Waterfall Royal Commission (McInerney 2004). In this instance the requirements for a complex sequence of timings, passenger requests and crew responses results in the requirement for a real-time distributed emergency door release system (Squair 2009).

To provide early verification of requirements modelling and simulation may be performed during the system design phase. For example in the Outer Suburban Car (OSC) passenger car project mathematical modelling was used to simulate...
passenger detraining for the OSC double deck car vestibule and plug door configuration. In this way a
general layout was derived that was initially verified by simulation as satisfying the customer performance requirements. Final verification was
carried out by a further real world demonstration using a partially populated carriage.

During the system design phase hazards associated with operation are identified in a series of preliminary and subsystem hazard analyses. At
this point the task of identifying and allocating derived safety functions (or procedural controls) starts to occur. An example of this process is given by
the OSC guard door closure function. The guard’s door is required by the specification to be automatically closed when the train achieves a
specific speed rather than prior to train movement. While this presents an obvious hazard and could easily be designed out, discussion with the
customer confirmed the validity of the operational need and that safety, in this instance, would be achieved through a mix of safety devices
(handrails) and procedure.

Human factors requirements and their cultural context can also have significant impacts upon vehicle design. For example in Australia the
accepted ‘crush’ load is 6 persons per square metre (SRA 2002) while for in Mumbai a super crush load of 16 persons per metre is acceptable value. Each of these values reflects a societal norm, which then directly affect structural load and floor deflection design requirements.

A final complication for the anthropometric design task is the dynamic nature of the population statistics and the lack of good current statistical data. Short of measuring operator and passenger populations (and in the case of the disabled their mobility aids) we are forced to base our design upon data that may not be truly representative. Our approach to this problem has been to explicitly declare such design assumptions and utilise the conduct of ‘real world’ evaluations, as well as operational experience, to validate them.

PRELIMINARY DESIGN PHASE

The purpose of the Preliminary Design stage is to progress the design to a point at which engineering can confirm that the requirements will
be met and all major technical risks have been addressed.

During this phase mock-ups of critical workstations (see Figures 8 & 9) and passenger spaces (Figure 4) are developed based on the
general layouts and interface design developed during system definition.

However, physical mock-ups are expensive, and require synchronisation with the mainline of design effort. So a reasonable question might be to ask why persist in their use in the age of 3D CAD models and virtual reality walk-throughs?

The answer is that even mock-ups of limited fidelity are valuable in providing an immersive physical environment that can be physically touched and felt. We have found that such a capability is especially important when demonstrating accessibility design features to community groups representing the disabled.

As noted previously given the limited data set of anthropometric data the conduct of physical walkthroughs and evaluations also serves to validate our initial ‘design hypotheses or set of key assumptions. Such evaluations are particularly important for disabled passengers as their anthropometric data is even sketchier. A key area evaluated for accessibility in this way was the OSC and HRC passenger toilets where a single common mock-up was used to evaluate the design for wheelchair and disabled access (Figure 6).

Mock-ups are also used to carry out ergonomic assessments and support trade off studies for both passenger & crew interface preliminary design concepts such as the general placement & grouping of displays and controls as Figure 8 illustrates.
The primary considerations for locating equipment on the console are criticality of information and frequency of usage. Switches/displays with critical information and used frequently were located such that the crew could operate the switches/look at the information without shifting from their seated position & without taking their eyes off the track in front. These include the speed display, the vigilance alarms etc. The design intent is to come up with a console design that minimises the probability of a crew error due to poor interface design, fatigue or a combination of both.

On the OSC and HRC trains, the main crew train interface is the Driver’s Display Units or Unit (DDU). The DDU is essentially a touch screen that displays critical operational and maintenance data to the crew. The hierarchy of the screens and their layout were developed in a consultative process with the user groups and included a period of trial during which a randomly selected group of drivers and maintainers interacted with the screens and provided feedback on ease of use, legibility, logical flow, relevance and depth of data. This data was fed back into the design of the next round of screen layouts. Safety alarms that need acknowledgement are accompanied by audio and visual cues.

Applying user centred design principles, and thereby reducing clutter & information overload, only critical data, i.e., that which is required to safely operate the train, is displayed to the driver. In the case of failures, only the primary failure data is displayed. Secondary data, useful in trouble shooting/fault finding is recorded for use by maintenance personnel.

To minimise glare affecting visibility of the crew displays, UGL Rail used the cab mock-up to carry out a series of simulated tests to optimise their location. For the OSC cab it was decided to have the facility to switch critical data between the screens with the flick of a switch to enable the driver to view information like speed on one screen in case the other was obscured by glare. In an elegant solution, the horizontal and vertical slopes of the two screens were varied to ensure that under identical lighting conditions, the direction of specular reflections on both screens would be different.

Another example whether HFE principles are rigorously deployed is working out the optimum relationship between the elements of the primary drivers workstation. Using a combination of 3D modelling and the crew cab mock-up (as illustrated in Figure 8 and 10), the following key parameters are taken into consideration:

1. Previously established signal sightline requirements.
2. Ability to reach critical controls from a seated or standing position.
3. Ability to engage the driver presence system.

In the passenger area, one of the key objectives of the preliminary design phase is finalisation of the seating layout and a freeze of the seat design from an ergonomic viewpoint.

HFE principles are used to assess to ensure that the seats:
1. provide comfort over long journey periods,
2. are physiologically satisfactory, and
3. function appropriately.

As an example, on the OSC and HRC contracts, the half car mock up prepared by UGL Rail was used for the ergonomic assessment of passenger seating. The following key parameters were considered as part of the analysis:

1. Seat pitch; and
2. Seat critical dimensions such as:
   - cushion to floor,
   - cushion depth,
   - backrest height,
   - seat widths,
   - aisle widths,
   - backrest angle, and
   - armrest height & width etc.
In addition a significant effort was spent in the design of the lumbar support. As the curves of the human spine have a high degree of variability, to achieve a design for a backrest profile that achieves comfort for the majority of users was a challenge. A qualitative seat comfort survey was carried out using a random cross section of user groups to come up with a design that provided a satisfactory outcome to the majority of the users. Despite this focus, and the results of the design evaluation, we still ran into problems with the perception of unacceptable seat ‘hardness’ relative to existing passenger cars in the customer’s fleet. This became an issue of concern to our customer for longer haul journeys and a significant amount of effort was expended to subsequently develop a quantitative hardness test for seats and then change-out seats that failed that criteria.

**Figure 10: OSC Flip-over style triple seat**

**DETAIL DESIGN PHASE**

The purpose of the Detailed Design stage is to complete the final details of the design that meets the requirements such that production drawings are complete and can be released for the manufacturing and procurement of parts.

At this point the detailed layout of displays and controls is finalised in the design based on selected components and the results of user feedback obtained during the preliminary design phase.

One critical interface of a driver with the crew console is the Master Controller (MC). The crew controls the acceleration and deceleration of the train using this device which is (for passenger cars) mounted to the left of the driver on the console (Figure 9).

On the recent OSC and HRC contracts, the cab mock-up was used to carry out an ergonomic evaluation to determine the optimum location for the MC. This enabled us come up with an optimum layout of the controller vis a vis the seated drivers position, taking into account the following:

1. Use by a 5th female to 95th male percentile crew population,
2. Minimising the potential for Repetitive Strain Injury (RSI), and
3. Keeping the operating forces within ergonomic fatigue limits for continuous use.

**Figure 11: HRC drivers desk final CAD layout**

During this phase critical detailed design components with a significant human factors aspect may also be developed in prototype form. For example on our OSC project a prototype emergency detrainment train to train ramp (Figure 12) was developed and demonstrated.

**Figure 12: OSC Prototype train to train ramp**

Another example of a detailed design phase HFE task is a design analysis conducted to confirm that all standing passengers are within reach of at least two hand-holds. The placement of such handholds also illustrates the impact of competing human factors requirements. The traditional approach to handholds has been to provide vertical staunchions. However staunchions located in the central aisle can impede wheelchair access (provide a barrier restricting smooth passenger flow during an emergency, eg. evacuation). To address this requirement we replaced the traditional grab-rail ‘forest’ with seat back mounted grab handles and seat to roof grab poles. For able bodied standing passengers above head horizontal grab rails also provide additional hand holds.
Because steel staunchions are inherently hard and of narrow cross sectional area they also become a significant impact injury source during crashes. Therefore the reduction in their number also assists in enhancing the crashworthiness of the rail vehicle from a passenger survivability perspective.

At the completion of this stage, purchase specifications are prepared and issued to vendors. These specifications reflect the outcomes of the Preliminary & Detail Design Phases, and include performance, interface and verification requirements, amongst others.

Key parameters like fire and smoke properties for the final selection of material are collated for assessment during this phase and a hazardous materials inventory lists compiled.

**PREPARE FOR MANUFACTURE PHASE**

The purpose of the Prepare for Manufacture stage is to finalise production planning and release all production drawings and information necessary for the manufacturing and procurement of parts.

During this phase human factors tasks include the development of operating and maintenance manuals as well as the training and instruction materials and aids that are needed to transition the new product system into service.

A significant human factors safety task conducted during this period is to carry out an audit of the technical manuals to confirm that where hazardous tasks are conducted, or procedural controls have been identified, the manuals actually incorporate these safety requirements.

On one of our recent contracts, we supplied a PC based simulation software for the Train Operating System to our customer. The objective of this was to enable them to carry out training of their engineering and maintenance personnel in a class room environment but using the final production release screen layouts and software. This is a significant change towards training, which traditionally has always happened towards final delivery.

Transition training can be a significant issue when technological step changes are introduced by a new system. When UGL introduced computer controlled AC traction systems to its locomotive product line the transition from DC manually traction systems represented a significant challenge for the driver user group.

A further step change was introduced by the change in control strategy from one of the driver directly controlling the plant to one of supervising the automation controlling the plant. Such changes in interaction between users and systems have been found to be a traditional area of machine/human contention in aviation, process and nuclear industries (Leveson 1995). In our case this led to numerous service callouts during the initial warranty period due to driver misperceptions of system performance.

In response UGL augmented our transitional training materials to explicitly discuss the difference in control strategies and operational impacts of the new technology capabilities.
As an interesting side note we also found during a review of historical records that similar issues had been experienced with the introduction of regenerative braking and wheel slip control functionality on our last generation Tangara rail cars. The rail industry is certainly not alone in going through such successive cycles of ‘technology surprise’ as parallel experiences in the aviation, processing and defence industries amply illustrate (Leveson 95).

**PROCUREMENT & MANUFACTURE PHASE**

The purpose of the Procure/Manufacture stage is to acquire through purchase, sub-contract or in house production, all sub-systems and components required for assembly of a complete System of Interest.

Vendors have to carry out qualification/ type testing to certify their equipment as fit for purpose. For example, on the OSC and HRC contracts, the vendor carried out testing to confirm the strength of the passenger seats (a vandal resistance requirement). Another example is that of the DDU, which was type tested for water proofing and impact resistance, amongst other requirements.

Apart from type tests, vendors carry out routine tests to ensure that production quality is maintained over the entire production period. As an example our passenger seat supplier carries out seat comfort level testing on each seat before delivery.

All this rigour during manufacturing phase minimises project risks and ensures that the delivered product conforms to the design requirement.

**ASSEMBLY PHASE**

The purpose of the Assembly stage is to build the Development Prototype or Production Prototype System of Interest using the component parts and systems supplied under Procure / Manufacture stage. As an example the figure sequence 8, 11 and 15 illustrates this progressive refinement of the HRC driver’s desk design concept into the final production article form.

An important element of the assembly and integration process is to ensure that where installation data has been provided by suppliers the final installation drawings reflect this and the vehicle is built to match the design.

An example of what can happen when this does not occur is given by the HRC Destination Indicators (DI) installation. During type tests the daylight readability of the DIs was found to be inadequate. A significant amount of effort was expended in investigating this deficiency but eventually we discovered that our window mask design had obstructed the day/night auto-brightness sensor. In this instance our detailed design had not satisfied the installation requirements of the supplier and generated a HFE design problem to resolve.

**TYPE TESTING PHASE**

The purpose of the Type Testing stage is to perform all remaining verification and validation activities and produce compliance documentation such that the product can be certified.

Specific HFE verification activities conducted during this phase included:

1. Egress timing demonstrations,
2. Demonstration of Mean Time to Replace for key components.
3. Demonstration of lighting & glare levels.
4. Demonstration of destination displays daylight visibility.
5. Demonstration of the ability to use crew interfaces in a safe manner
6. A safety verification audit to sign off derived safety requirements that have a HFE origin.
7. Demonstrate the use of wheel chair access, including that of the ramp.

![Figure 15: Final HRC driver’s desk layout](image)
One example of a human factors issue that was identified during this phase of the development was an unanticipated interaction between the HRC’s driver seat and the dead man switch on the master controller. In some configurations, albeit unusual, of the chair arm it could contact the controller and hold the demand switch (a throttle rotation type design) in the present state. As it turned out the fix was a simple limiter to the seats travel which did not degrade crew comfort in any way.

While this example does seem trivial it serves to illustrate that designers tend to test as they ‘know’ the system should be used and this may often be completely tangent to how the system is operated by the end user. Operational evaluation with the end user is therefore an essential part of validating the human factors aspects of any design.

CERTIFICATION PHASE

The purpose of the Certification is to issue a Design Certificate for the product which declares that the product is safe to use, is capable of meeting the functional and performance requirements and is compliant with applicable standards and legislation.

The Chief Engineer, UGL Rail issues a Design Certificate for each vehicle ‘type’ after the completion of the System Verification Review (SVR). At SVR, the projects have to demonstrate a satisfactory level of compliance to every mandatory contract requirement.

In addition, UGL Rail issues a Construction Certificate for each vehicle delivered under a contract. This certificate guarantees that the vehicle has a consistent built configuration.

CONCLUSION

For rolling stock systems success and safety is essentially determined by the degree to which human factors are integrated successfully into a rail vehicles design. Such design attributes are inherently difficult and multi-faceted often requiring iterative design effort and the conduct of complex design analyses to validate necessary trade-offs and design decisions.

Our experience is that if we engage the key stakeholders, i.e. operators, maintainers and disability access groups early in the design phase, the risk of any serious rejection or complaint of the final design is minimal. This was demonstrated during the initial trials on the OSC and HRC trains, where the drivers gave extremely positive feedback on areas of seat comfort, visibility and overall interior aesthetics of the crew cab.

To successfully execute a human factors program as part of a major rolling stock delivery project requires a supplier and acquirer to agree on a carefully planned and sequenced program of effort that spans the complete development cycle. The adoption of a systems engineering approach as used by UGL Rail gives a logical framework for this program with a good chance of delivering a successful product.

REFERENCES


