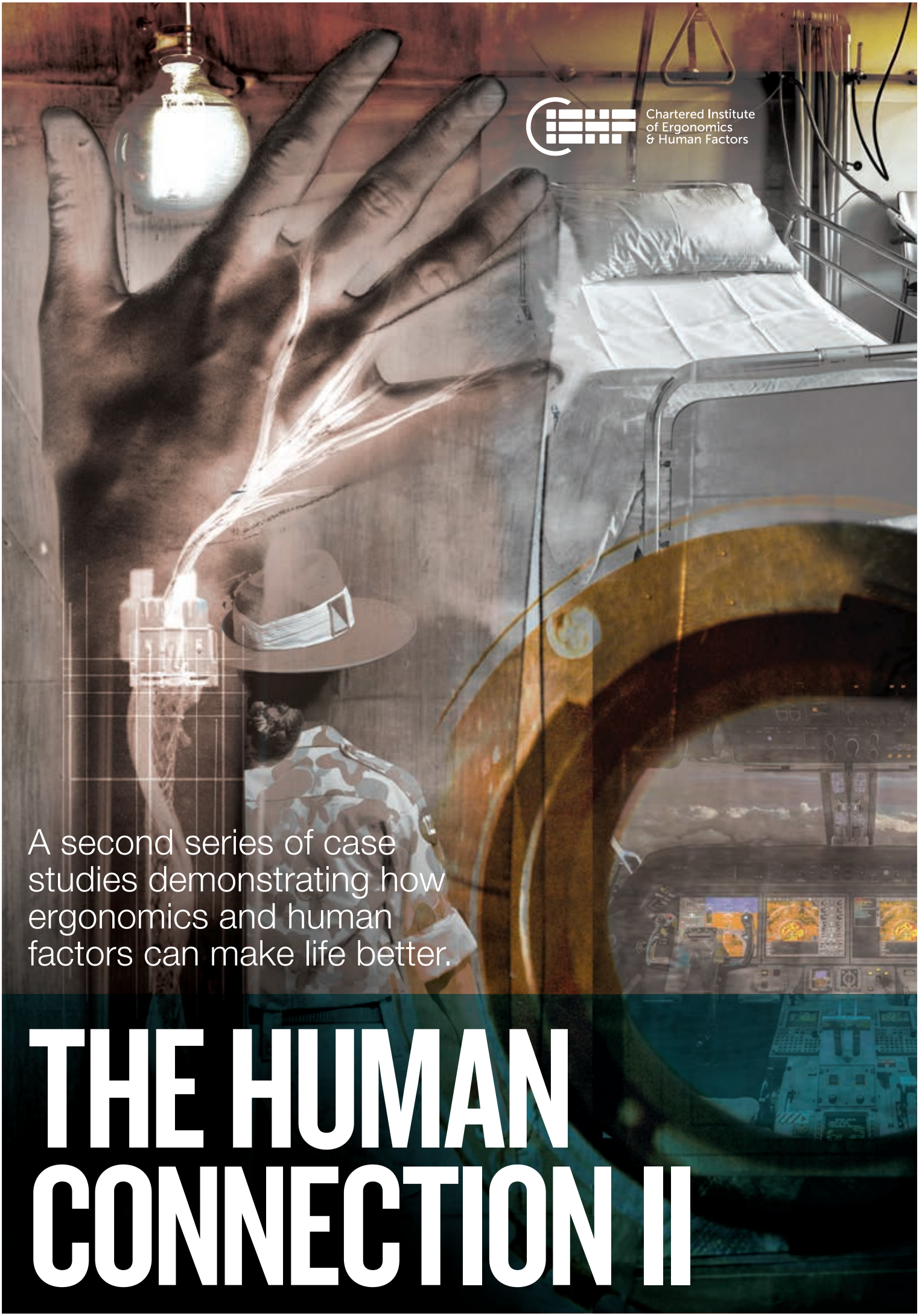
Chartered Institute
of Ergonomics
& Human Factors
A second series of case studies demonstrating how ergonomics and human factors can make life better.
THE HUMAN CONNECTION II

2

At the Chartered Institute of Ergonomics & Human Factors, our Royal Charter obliges us to demonstrate to a wide audience how an ergonomics and human factors approach adds value to virtually every aspect of life, from the devices you use at home, to the transport you take, to the work you do. I think this is incredibly important.

The case studies in this document highlight how a better understanding of people can make a positive difference. Keeping people central to design, focusing on their needs, and optimising how they interact with others, with their workspaces, and with technology and equipment, leads to work being made easier and more efficient, and systems being made simpler and safer.

The Human Connection II, like the first edition published in 2015, is intended to assist people in industry, in government, and in any business, to understand and influence how work is designed. Good work is good for us but sometimes identifying how to effect change and what that change looks like needs some inspiration. If reading these case studies stimulates ideas on how you can influence or bring about change for the better, using ergonomics and human factors to inspire you, then our job is done.

Dr Claire Dickinson
CIEHF President 2017/18

3

ERGONOMICS & HUMAN FACTORS

Ergonomics and human factors is a science-based discipline that contributes to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, wants and capabilities of the people who use them.

Although the two terms have been, and remain, synonymous to professionals and the CIEHF, and are used in this way throughout this document, more popular usage has at times accorded different shades of meaning to each term. Human factors may be considered by some to imply the cognitive areas of the discipline such as perception, memory and behaviour, where ergonomics may be used to refer to physical aspects such as workplace layout, product design, displays and controls.

Ergonomists and human factors professionals take a scientific, systematic approach, using robust and reproducible methods using proven tools and techniques, all of which are centred around users. A 'user' is anyone who interacts with products, equipment, spaces or systems and all of these will have been designed to some extent. Sometimes designs accommodate the specific needs of a target group, but even then, there will be significant differences between individuals. Understanding these differences and how to accommodate them is a key principle of good practice.

The phrase 'user-centred design' appears in several of the case studies. It refers to a design philosophy where the focus is on the end-user's needs, wants and capabilities at all stages of the design and development process, and representative users are involved throughout. The result will be a better design that accommodates users to a greater extent in terms of satisfaction, safety, efficiency, productivity and, in many cases, enjoyment.

IMPROVING INTERACTIONS WITH TECHNOLOGY

Technology is advancing at a rapid rate and the challenge is to use it to best effect to bring about change for the better, including increased safety, improved efficiency and a more enjoyable experience. The possibilities can seem limitless and sometimes overwhelming but a human factors approach brings clarity to design by understanding the user's needs in achieving the required end result, as these case studies demonstrate.

ENABLING SAFER WORK

Safety is one of the top priorities in every sector and safe practice can take many forms. Identifying, reducing and managing risk is always included in human factors investigations and solutions can involve tools and equipment, or equally methods and processes. The following case studies show that the answers are not always hard to find, but simply need consideration.

MAKING EFFICIENT USE OF SPACE

With space at a premium due to building constraints or to financial limitations, it becomes increasingly important to use the built environment efficiently. A human factors approach can identify the functional and spatial needs of everyone who uses a particular environment, as the following case studies show.

INFLUENCING BEHAVIOUR CHANGE

Understanding what people sense and perceive, what they understand and how they behave in any given set of circumstances is central to human factors and ergonomics. The design of processes, tasks, equipment and the environment all combine to influence behaviour and this is the focus of the last set of case studies.

Chartered Institute of Ergonomics & Human Factors

About the CIEHF

The Chartered Institute of Ergonomics & Human Factors (CIEHF) is a professional membership body open to all that recognises, protects and promotes standards of achievement demonstrated by ergonomists and human factors specialists.

In 2014, the importance of the discipline was recognised by the award of a Royal Charter. This allows the Institute to confer Chartered status on members who meet specified criteria. This includes a high level of qualification and experience and the ability to demonstrate continuing professional development, such members becoming the only 'Chartered Ergonomists and Human Factors Specialists' anywhere in the world.

The Institute organises events and activities that encourage and foster collaboration, networking and sharing of ideas and information. The compilation and publication of this document is just one example of such activity. For more information about the Institute, its aims and objectives and how you can get involved, please visit www.ergonomics.org.uk.

Acknowledgements

Thanks to Dr Claire Dickinson, CIEHF President 2017/18, for her idea to follow up the first edition of The Human Connection with this further collection of case studies. Thanks to Claire and to Jean Page, Human Factors Engineer, for their time in reviewing the submissions. Thanks to Louise Jenkins for her administration of this project and for assisting Tina Worthy, Chief Operating Officer and Editor of the CIEHF, in bringing this document to publication.

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Picture credits

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OPTIMISING PRODUCT IMAGES

6

THE PROBLEM

Images of products on e-commerce retailer websites, such as tesco.com, typically consist of product photographs. These images often fail to communicate critical product information, such as brand, product type, product variant and size. When the information is present, it is often so small and unclear that very few people can see or understand it, which may result in a wrong purchase or no purchase at all. This issue is increasingly important as more people shop from mobile devices. In 2016, for example, more than 50% of UK e-commerce transactions were conducted on mobile devices, and this figure grows year on year.

THE SOLUTION

Unilever commissioned work to develop product image proposals that:

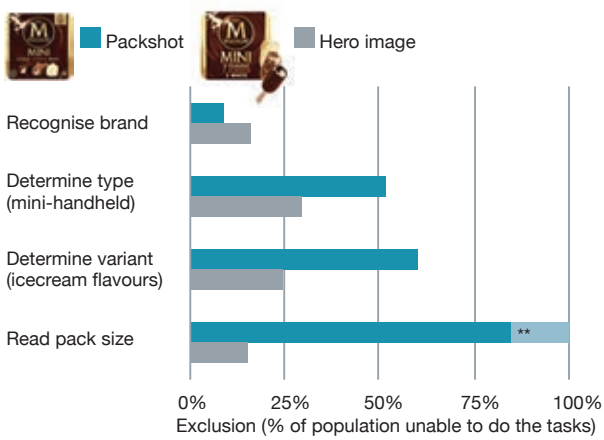
- Improved visual clarity of key information such as brand, product type, variant and size.
- Maintained consistency across products to help the consumer find information.
- Made it easy to create new images to aid roll out on a larger scale.

Key inclusive design principles and methods were used which included simplifying images, removing unnecessary elements, challenging assumptions, using iterative design and testing visual clarity to improve inclusion.

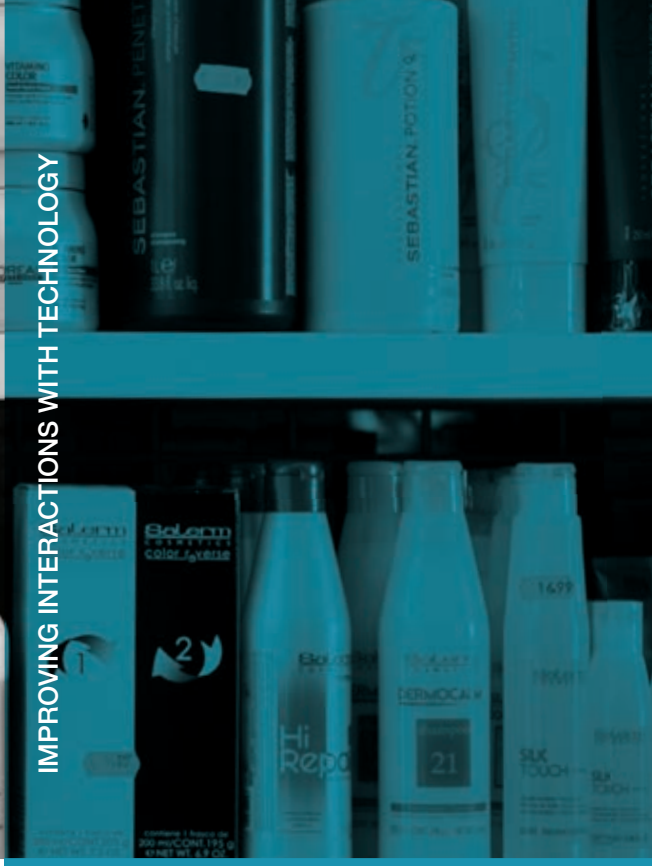
Visual clarity was tested using the Sight Exclusion Estimator - Interactive Tool, or SEE-IT, a method for assessing exclusion. This involves determining the distance at which the information in an image can be clearly discerned. This distance is then calibrated against the assessor's visual acuity and survey data on vision capability in the British population. SEE-IT then estimates the proportion of the population who would be excluded from seeing the information comfortably.

These methods were initially applied to product images, known as pack shots, from the Unilever brands Dove and Persil. Product images were digitally rendered, unnecessary information removed and important information made clearer. Off-pack communications were added such as stripes and lozenges containing product information. The SEE-IT method was used to examine the visual clarity of key information in these images, and designs were developed iteratively in discussion with key stakeholders.

This approach was then applied to a large number of Unilever brands by each brand team who created their own 'Hero images'. This resulted in images that were visually clearer but lacked consistency. Further development was needed to create a more consistent set of images, with clearer guidelines. As before, inclusive



**Note that the model used to calculate exclusion goes out of range above 84.7% exclusion.
Exclusion in the starred range lies between 84.7% and 100%



design principles were used to develop these guidelines, and SEE-IT was used to compare alternatives such as different fonts and font sizes.

A key decision was to use a vertical stripe next to products with a tall, thin shape such as a bottle, even though some retailers would have preferred a horizontal stripe with horizontal text. Adding a horizontal stripe would reduce the size of a standard (unedited) pack shot further, making much of the information even less clear.

Once the basic guidelines were established, they were rolled out across Unilever brands as a whole, and made freely available to other companies by hosting the guidelines and downloadable templates online.

THE IMPACT

- Increased accessibility and visual clarity: The SEE-IT tests show that many more consumers are able to discern the critical product information from the images.
- Improved shopping experience: Consumers are able to find the products they want more quickly and easily and without having to resort to reading through longer product descriptions.
- Sales uplift for brands that adopt these recommendations: For example, tests found sales uplift of 20% on Unilever's Simple range, and 24% uplift on the Magnum range. On the Coles website, Surf branded products saw an average weekly sales uplift of 74% when they changed from conventional pack shots to mobile-ready Hero images.

As of August 2017, images that follow these guidelines have been developed by Unilever, P&G, GSK, Reckitt Benckiser, Bayer, Nestlé and many other global suppliers. These enhanced e-commerce images have been accepted by over 68 retailers from 28 countries.

Wider applications

Inclusive design methods and principles can be applied to any user experience to measure and reduce exclusion. For example, similar audit methods to those in this case study have been applied to mobile phones, vehicles, public transport, medical devices, domestic appliances, pharmaceuticals, consumer electronics, software, apps, websites and consumer goods.

Further information

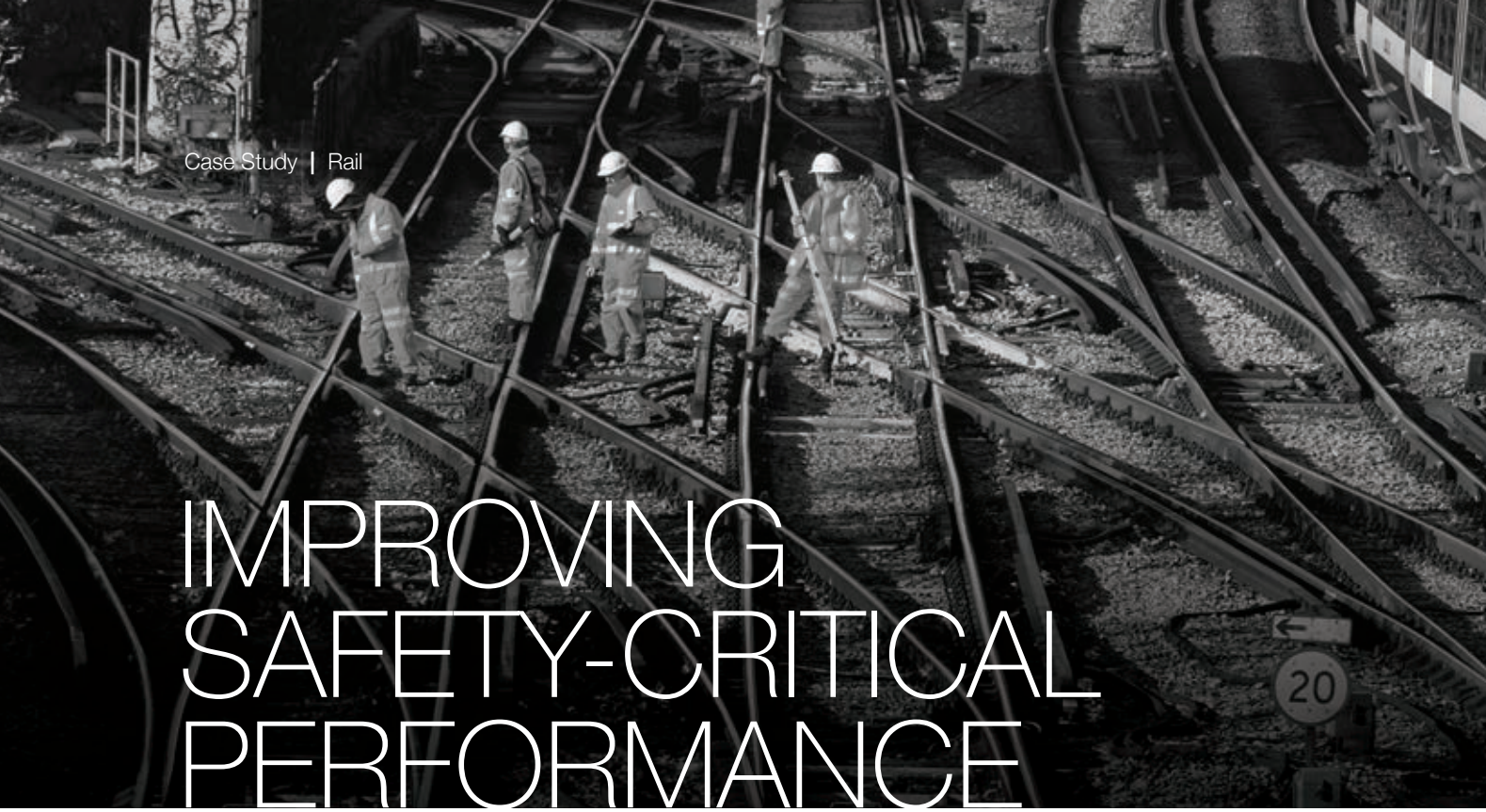
Inclusive design methods and principles:
www.inclusivedesigntoolkit.com
The SEE-IT method and materials for putting it into practice:
http://seeit.inclusivedesigntoolkit.com
Mobile-ready Hero image guidelines:
http://ecommerce.inclusivedesigntoolkit.com

Case study contributors

Joy Goodman-Deane, Research Associate & Sam Waller, Mike Bradley & John Clarkson all from the University of Cambridge. www.cam.ac.uk

Acknowledgements

This work was commissioned by Unilever. Hero images were championed by Oliver Bradley at Unilever. The standards were developed in collaboration with the Unilever e-commerce team and the design agencies they work with.



IMPROVING SAFETY-CRITICAL PERFORMANCE

THE PROBLEM

Engineers work round the clock to maintain Network Rail's vast and complex infrastructure. Providing a safe and reliable experience for the millions using the railway each day, and delivering the complex upgrades required to future-proof Europe's fastest growing railway, necessitates continuous improvement and human-centred innovation.

In order to streamline processes, reduce reliance on paperwork, and ultimately aid safer and quicker decision-making, a need was identified to utilise mobile devices and software applications for track workers and other frontline railway staff.

THE SOLUTION

Although often perceived as simple software solutions, apps have the capacity to provide advanced capabilities and rich functionality. The potential offered from the deployment of mobile devices to frontline railway workers is virtually limitless, however the ensuing interactions between humans, safety-critical processes and advanced mobile technology, make ergonomics integration work vital to the app design and development process.

Network Rail's in-house ergonomics team initially worked on a programme of development of applications for maps, location services, data capture, reporting, standards and guidance, and in doing so created design principles, guidelines and processes to lay down the foundation for future work.

The apps were designed using a structured agile development process that was refined over time as methods matured and the team's expertise grew. The following design process was established as a framework for successful app development:

1. Put user needs first: Conduct research to understand user needs, goals, activities and contexts. Analyse and share insights to inform product development.

2. Define the user experience vision: Specify the critical elements of the user experience, and define why customers will view the system as a success.

3. Design the user experience: Design the structure, flow and interactions of the system. Start the design before development and focus on behaviour not decoration.

4. Iterate using prototypes: Test concepts, prototypes and beta software early and often. Analyse feedback to inform iterative development cycles.

5. Measure the user experience: Track performance metrics against agreed success measures. Use data, not assumptions, to inform decision-making.

The development of these first mobile applications for Network Rail allowed the multidisciplinary design team to understand what makes a successful app for railway maintenance and engineering. Designing apps for use at night, in the rain, with gloves on, alongside other equipment, and in areas with poor data connectivity, requires levels of understanding and empathy that are hard to achieve for those without direct experience of working trackside.

The insight from user research, collaborative design, and usability testing activities, during the first tranche of development, informed the delivery of design principles relating to simplicity, utility, trust, data and context. These principles were presented alongside wider considerations and tangible guidance for physical ergonomics, to allow future applications to benefit from this original detailed

research and analyses.

The work also documented reusable design patterns through the provision of documentation and reference applications, so that future projects could review the design rationale, download digital assets and interact with the reference patterns on mobiles and tablets.

THE IMPACT

Network Rail has rolled out more than 25,000 iOS devices (iPad and iPhone) to its workforce, with more than 18,000 of these across the frontline maintenance, operations, and safety and engineering teams.

The first set of mobile applications was downloaded to more than 12,000 devices and used over 700,000 times. The successful adoption of the technology has been demonstrated by the Close Call app which helps employees report safety hazards so that problems can be addressed quickly. Within the first two years of launch, Close Call was used to report almost 63,000 close calls, representing 80% of all reports made in that period.

Participative design approaches have ensured the delivery of the right digital tools for the job. The introduction of mobile devices, and more than 60 bespoke applications, has helped modernise the Network Rail workforce, banishing paperwork and helping improve the performance and safety of those working on the railway. Staff working on site, miles away from the nearest office, now have data at their fingertips and can update and process information faster and easier than ever before. It's estimated that the use of modern technology will help realise over £700 million worth of efficiencies over the next ten years.

Wider applications

Ergonomics and human factors expertise, methods and guidelines continue to help Network Rail projects meet strategic business objectives by supporting user needs and goals in the operational context of use. Delivering new mobile applications, to unlock further benefits from this investment in technology, builds upon the integrated user-centred approach, with a benefits-led implementation to develop useful and usable technology.

Further information

Bye, R, 2013. Designing mobile user experiences: disruptive innovation in railway asset information. In Dadashi et al, Rail Human Factors: Supporting reliability, safety and cost reduction
Taylor & Francis:
https://doi.org/10.1201/b13827-59

Case study contributor

Richard Bye, Principal Ergonomics Specialist at Network Rail, www.networkrail.co.uk

Acknowledgements

This work was carried out by the Network Rail ergonomics team in conjunction with external suppliers and members of the Network Rail ORBIS team.

"All the information I need and use every day to do my job, on my mobile...WOW! Thanks."

Network Rail track worker

MANAGING PILOT WORKLOAD

10

THE PROBLEM

Aviation is often described as an ultra-safe sector. The standard practice of having a two-pilot flight crew has, in many circumstances, prevented accidents, notably mid-air collisions. With the increased complexity of aircraft systems though, pilots are now having to assimilate many sources of information in order to maintain situational awareness.

New cockpit technologies have been developed to reduce workload in critical situations and to help manage the unexpected incapacity of either one or both pilots of an aircraft. A large number of discrete technologies are offered by different agencies that have been tested in diverse scenarios. But how do you analyse and validate the different interfaces, task activities and crew roles? How do you evaluate the overall impact of these new technologies when they are combined in an operational setting?

THE SOLUTION

A research and development project called ACROSS was set up to investigate this issue. Firstly, an integrated set of tasks was established and developed at three levels: operational, task and crew, human-machine-interface (HMI) to cover each of the local technological functions:

- **Aviate:** Departure Assistance, multi-touch screens, and Tactical Flight Control and Upset Detection reduce immediate task demands.
- **Manage mission:** New capabilities reduce demand in weather avoidance, re-routing to an alternate airport, aircraft separation and vertical situation display.
- **Communicate:** The Future Radio Management Panel interface improves flight planning, briefing and anticipation, simplifying cockpit communication in long-haul flights, severe weather and peak workload.
- **Manage systems:** Automating lower level actions and co-locating system commands and information in functional interfaces reduces demand. The Task Manager introduces a timeline that facilitates the anticipation of workload.
- **Monitor crew:** Technologies in this area identify changes in crew capacity.

Human factors analysis was carried out which included scenarios, critical points and dependencies in flight operations, tasks, HMI design and validation, workload assessment, management of crew operations and risk analysis of critical points.

An advisory group of pilots, air traffic controllers, weather experts, legal experts, medics, trainers, crew resource management specialists, accident investigators and risk management experts provided extensive input to the human factors programme through interviews, focus groups and workshops.

A group of human factors specialists, technology developers and operational personnel ran workshops to link core human factors concepts in flight operations to the technological functions used at specific points along the flight path.

Another group ensured common definition and understanding of key concepts such as workload, stress, fatigue, situational awareness, communication and decision-making.

A new three-layer workload management concept was developed which put the crew at the centre of operations. It emphasises the ‘situation awareness bubble’ which includes anticipation and planning, and review of recent activity, as well as monitoring current activity.

- **Proactive Workload Management** uses timelines and other schematics to enable anticipation, which in turn enables planning and allocation of resources

along the timeline. This enables the crew to spread the anticipated workload better and to be more prepared and more capable of absorbing unexpected spikes in workload.

- **Immediate Workload Management** uses automation to reduce demand and, together with enhanced decision support, reduces crew workload in the here-and-now.
- **Reactive Workload Management** is focused on the Crew Monitoring System which can detect pilot incapacitation and suggest mitigations.

This 'Crew Manage the Operation' concept enabled the analysis across flight functions of the combined roles of diverse technologies in supporting the management of peak workload and incapacitation.

THE IMPACT

Rethinking automation involved new HMI concepts which took into account schematic representations, delegation of functions, new human-machine interaction patterns and increased intuitive use.

The human factors analysis showed that use of automation can be under pilot control with new technologies extending the 'situation awareness bubble' enabling better anticipation and planning, and better system diagnosis and rectification.

If one pilot is incapacitated, the remaining pilot would require increased support from air traffic control and ground stations. If both pilots are incapacitated, clear criteria would be needed for transfer of control to ground stations. So the crew concept needs to be extended beyond the flight deck to include ground support.

Wider applications

Any sector can benefit from the advances that new technologies bring. The real challenge is to understand how these technologies can work together to ensure a system is designed to be fit-for-purpose. New concepts such as human-centred automation will change the role of the human operator but, by applying a human factors approach, investigations can be undertaken systematically in order to fully understand and manage the operational implications of such changes.

Further information

The ACROSS project: www.across-fp7.eu/

McDonald N, Kay A, Morrison R & Ryan M, 2017. How automation may transform the ways in which crew managed peak workload and incapacitation, *International Symposium of Aviation Psychology*, May 2017, Ohio, USA.

McDonald N, Kay A, Liston P, Morrison R & Ryan M, 2015. An integrated framework for crew-centric flight operations, *HCI International*, August 2015, Los Angeles, USA.

Case study contributors

Nick McDonald, Alison Kay, Rabea Morrison & Margaret Ryan from the Centre for Innovative Human Systems, Trinity College Dublin, www.tcd.ie

Acknowledgements

Thanks to the partners in the ACROSS project, particularly the human factors partners in NLR, DLR- Brauschweig and DeepBlue. Financial support for this research was given by the EC through the ACROSS project (Contract No ACP2-GA-2012-3141501).

SUPPORTING RESUSCITATION OF NEW-BORN BABIES

12

THE PROBLEM

A stethoscope is currently used to assess heart rate during resuscitation of new-born babies but the device gives inaccurate feedback in about a third of cases. Failure to deliver appropriate resuscitation can result in the death of an infant so there is a clear need to standardise and facilitate heart rate recording at this critical time.

An appropriately-designed device could ensure clinicians are provided with accurate information in a timely, precise and clear manner to allow them to form appropriate opinions about treatment. What information is needed for such as device and how should it be displayed and controlled?

THE SOLUTION

A human factors study focused on understanding the tasks involved, the cognitive requirements and the potential for error during a neonatal resuscitation scenario. The aims of the study were:

1. To identify gaps in existing knowledge about user requirements for the interface design of a novel resuscitation device.
2. To maximise usability of the device's touchscreen interface.

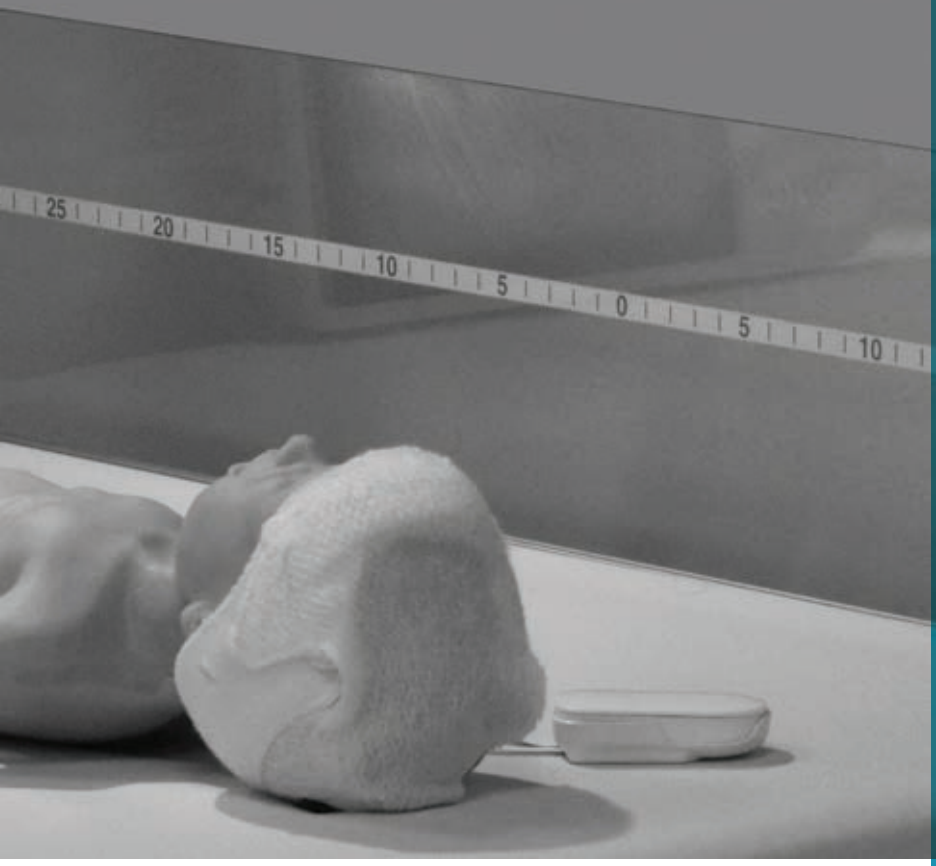
A user-centred design approach called Applied Cognitive Task Analysis (ACTA) was used which aids understanding of the cognitive requirements of clinicians carrying out a particular task, and translates them into design requirements for system designers. The approach included:

- Creation of a task diagram to provide a broad view of the task and identify difficult cognitive components.
- A knowledge audit interview that highlights the aspects of the task that require expertise and which cues and strategies are relied upon.
- An interactive scenario-based workshop for appropriate healthcare professionals which determines the cognitive processes involved with key tasks, and any potential for error.
- Creation of a cognitive demands table which summarises and integrates the information obtained from the previous three steps, together with interview data gathered prior to the study. This is a comprehensive record that focuses the findings on the goals of the study.

To explore the cognitive requirements and elicit insight from all practitioners, two workshops were carried out in parallel and involved paediatric doctors, qualified and student neonatal nurses, advance neonatal practitioners and midwives. Each group worked through the simulation task discussing the cognitive needs, decision points and potential errors, whilst discussing ways in which the interface of the new device could be designed to meet their needs and reduce the likelihood of errors. Relevant international and British standards were consulted to provide direction for the designers on medical device recommendations.

This study ensured a participatory approach in producing a comprehensive description of essential and preferred user requirements for the interface of a new-born neonatal device. The outputs were:

- A high-level representation of neonatal resuscitation tasks.
- Identification of the cognitive requirements for key tasks, critical information and decision points.
- Analysis of the cognitive demand associated with key tasks and potential errors.
- User opinion on interface design options to support cognitive requirements, reduce potential for error and record neonatal resuscitation events.



- A comprehensive outline of user and design requirements for the interface design and relevant standards.

THE IMPACT

This participatory approach ensured a systematic analysis of the resuscitation process, described as 'logical and rigorous' by the subject matter experts involved. The study and its outputs have been used to develop an interface which prioritises simplicity of use whilst optimising performance and minimising error, and which fits into the current clinical pathways for neonatal resuscitation.

The workshop and interviews identified factors relevant to both the device and the design of the interface not previously considered by the design team. Additionally, clinical practitioners discussed the potential for this device beyond the original context considered by the developers.

FURTHER INFORMATION

FDA, 2016. Applying Human Factors and Usability Engineering to Medical Devices. www.fda.gov/downloads/MedicalDevices/.../UCM259760.pdf

IEC 62366-1.2015. Medical devices Part 1: Application of usability engineering to medical devices. www.iso.org/standard/63179.html

MHRA, 2016. Human Factors and Usability Engineering Guidance for Medical Devices Including Drug-device Combination Products. http://bit.ly/MHRAmedicaldevices

Privitera, M B, Evans, M and Southee, D. Human factors in the design of medical devices - Approaches to meeting international standards in the European Union and USA. *Applied Ergonomics* 2017, 59:251-263.

Wider applications

This study demonstrates the value of the ACTA approach to inform the development of resuscitation devices, and could be used more generally for any medical device development. A human factors study such as outlined here contributes to the development of devices with regards to patient safety and wellbeing through meeting the varied needs of clinical users, whilst also understanding the sensitivities and needs of relatives.

Case study contributors

Dr Alexandra Rosewall Lang of the University of Nottingham, www.nottingham.ac.uk & Dr Laura Pickup of the University of Exeter, www.exeter.ac.uk

Acknowledgements

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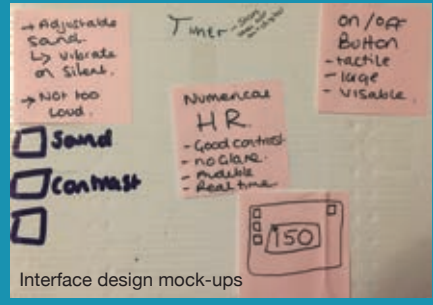


Interface design mock-ups

COMBINING DIFFERENT SYSTEMS

14

THE PROBLEM

As the European Rail Traffic Management System (ERTMS) is gradually rolled out across the GB rail network, it will need to operate together with existing older train protection systems such as Automatic Warning Systems (AWS) and Train Protection Warning Systems (TPWS). Operating over both conventionally signalled infrastructure and ERTMS-fitted infrastructure will mean that these older systems will need to be displayed to the driver through a single interface. But in a safety-critical environment, how do you present the driver with consistent system behaviour and an intuitive display, irrespective of the system supplier or train class?

THE SOLUTION

A human factors research project was carried out to define the requirements for the co-existent operation of ERTMS and AWS/TPWS when presented to the train driver via the European Train Control System (ETCS) Driver Machine Interface (DMI). The project phases included:

- Defining the current operation of AWS/TPWS in addition to the system interactions between AWS/TPWS and ETCS.
- Setting out the future operational and functional requirements for the integrated DMI.
- Reviewing the requirements of equipment suppliers.
- User testing of the integrated DMI design.
- Taking end-user and supplier input to refine and agree final proposed integrated DMI design and system behaviour.

Trials were completed with 20 train drivers from a range of different passenger and freight operating companies. Participants each completed ten operational scenarios on a purpose-built simulator. The following operational scenarios were tested:

- SPAD (Signal Passed at Danger) brake demand.
- TPWS overspeed brake demand.
- AWS fail to cancel brake demand.
- Train Stop Override to pass signal at danger.
- AWS fault and AWS isolation.
- TPWS fault and TPWS/AWS full isolation.
- TPWS temporary isolation for temporary block working.
- Transition to ERTMS Level 2 with AWS and TPWS fault active.
- Transition to ERTMS Level 2 with active brake demand (TPWS overspeed).
- Simultaneous AWS fail to cancel and TPWS overspeed brake demand.

The usability of the proposed controls and indicators on both a touchscreen and softkey DMI were tested. Driver interactions with the system were observed and errors, comments and recommendations recorded. As a result, a new design was produced which received a positive response from potential users, and participants were quick to learn the processes required.

THE IMPACT

The project showed that caution is needed when integrating a hard panel system with a touchscreen interface as consistency might not always produce the most intuitive design, for example, replicating flashing fault indicators on a touchscreen interface. However, even with little or no formal training drivers were quick to learn the processes which reflects the intuitive and consistent operation intended.

Using this approach:

- Drivers will be presented with consistent train

protection system behaviour and functionality.

- There will be savings to the rail industry by reducing driver training costs and work duplication.
- Safety will be improved as drivers will experience less confusion and make fewer mistakes when operating the DMI.
- There will be savings on space in the cab via an integrated solution.

Wider applications

The research successfully highlights an approach and thorough methodology to deal with the integration of new systems with legacy systems. The outputs from this research will feed into the development of relevant Railway Group Standard documentation including: GK/RT0036 - Transitions between signalling systems, GE/RT8000 - Rule book and GE/RT8075 - AWS and TPWS interface requirements or the associated Railway Industry Standard which is being developed: RIS-0775-CCS.

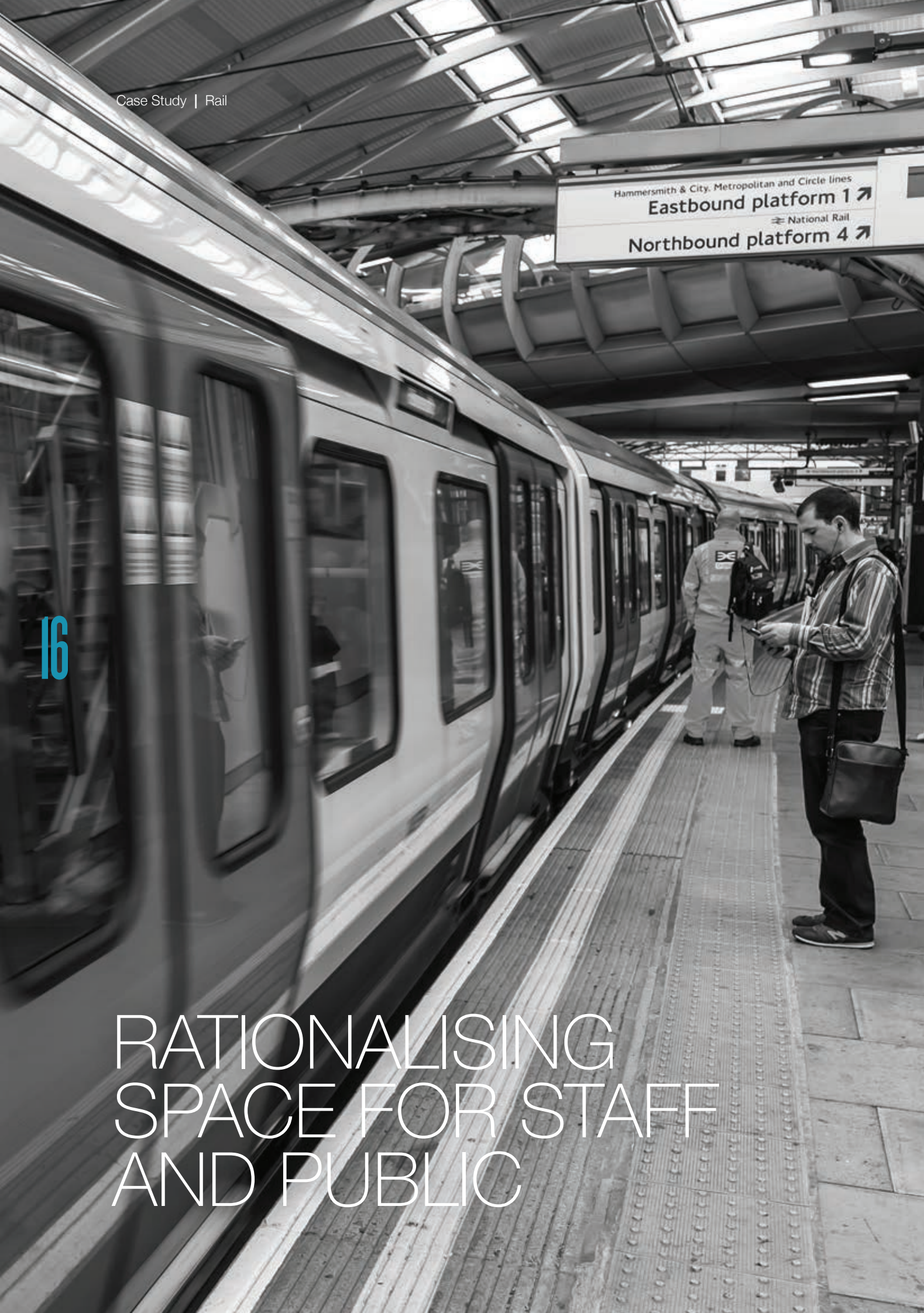
Further information

SPARK, The Rail Knowledge Hub: www.sparkrail.org/Lists/Records/DispForm.aspx?ID=22223

Case study contributor

Dr Ann Mills, Professional Head of Human Factors at RSSB, www.rssb.co.uk

16



RATIONALISING SPACE FOR STAFF AND PUBLIC

THE PROBLEM

Longer trains were to be introduced to a London Underground line to meet growing demands and platform extensions were required at some stations to accommodate the extra carriages. At one of the terminal stations, it was decided that extending the platforms outward would not be viable due to the position of the tracks, signals and other trackside equipment. So the only option was to extend into the station but this would cut into the space of this small but busy station considerably.

Congestion was already an issue at this station at peak hours and the platform extension would make it worse, taking out part of the ticket hall as well as an existing back-of-house area which included the ticket office, ticket machine room, mess room, an office, and various plant and machine rooms.

Extending the station footprint was not an option as it is located in a heavily built-up area. The only space that could be made available for the renovation was an existing soon-to-be-vacated retail unit situated alongside the main thoroughfare into the ticket hall.

An initial proposed design involved using the retail unit to re-house the ticket office and back-of-house area. But after reviewing the design and conducting a preliminary passenger flow analysis, there was concern that with the back-of-house area taking up the entire unit, the ticket windows and ticket machines would be located at the front of the unit immediately next to the busy thoroughfare. This would mean passengers stopping for tickets, information, enquiries and so on, would obstruct the passenger flows to and from the ticket hall. A different design was required.

THE SOLUTION

Using workplace design methodologies such as task analysis, consultation with station staff and site visits, ergonomists were able to establish the spatial requirement of the ticket office and other staff areas, taking into account the amount of desk space staff would require for their tasks, the number of workstations and the space needed for other furniture, floor mounted equipment, storage and access. The space required for the plant and machine rooms were identified through working with relevant engineers, taking into account not only the sizes of the machines and equipment but also the space needed for operational and maintenance access. Structural engineers were also consulted to identify design constraints due to load bearing walls and columns in the unit.

An alternative design was developed and accepted enabling a more rational use of space in the retail unit, with the back-of-house area occupying less space than in the initial design. In turn, this had allowed the creation of a small passenger area in the retail unit for people to get tickets, information, and so on, away from the main thoroughfare.

THE IMPACT

A viable design solution was provided to meet the considerable challenges caused by the platform extension into the station. The design minimised crowd congestion, and improved crowd safety and passenger experience at the station.

There were improvements to the station's operations. Other solutions with shortfalls in design could lead to operational issues and increased operating cost in future such as if extra staff might be required for crowd management duties at the station entrance.

Wider applications

Ergonomics methods can be applied to any design project to identify user requirements and potential issues. Usually the earlier in the design process they are identified the better it is for the project. Ergonomics can contribute to a design especially where compromises are needed to overcome design constraints and a balance has to be struck between different demands.

Case study contributor

Zachary Au, Independent Human Factors Specialist at Human Interactions Ltd.

Acknowledgements

This work was conducted in conjunction with Atkins.

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SAFELY MOVING A HOSPITAL

THE PROBLEM

A regional paediatric NHS Trust hospital in the North West of England that currently has 270,000 patients and families visit each year was moving from one site to another. The logistics for moving staff, patients and equipment must be worked out in fine detail before any move is carried out in order to maintain staff and patient safety at all times. But what is the best way to minimise risk in this situation?

THE SOLUTION

An orientation and system testing process was led by a multi-professional team that included clinical, simulation and human factors expertise. The process enabled a group of NHS staff moving into the brand-new hospital site to have the opportunity to orientate themselves and test systems. They also had the opportunity to suggest redesigns and developments to safe processes prior to the arrival of patients. This was the first phase of the move.

A formal orientation process included tours of the new build and use of healthcare simulation to test established processes and design. A group specifically looked at supporting the move of the operating theatres to a new area containing 14 operating theatres over two floors.

Three simulations were devised to test the location of emergency equipment and processes:

- Responding to an unexpected unplanned airway emergency during introduction of anaesthesia.
- Responding to a major blood loss event during surgery.
- Evacuating the theatre suite due to a fire emergency.

Groups where taken through the simulations in multi-professional speciality groups that included theatre staff, surgeons and anaesthetists and representatives from other areas. Initially simulations were carried out in a completed area of the new build and the location of emergency equipment was indicated with pictures. Following the simulations, a robust debriefing and learning conversation was facilitated to identify issues and use the extended team to suggest appropriate changes to processes. Further development and testing was carried out along with other procedures such as movement of patients from one area to another.

Phase two of the move included simulations which were used to test the clinical areas. A multi-professional team was assembled for each theatre area and a case was simulated to ensure all equipment was available and working. Only after successfully completing these simulations were areas used for patients.

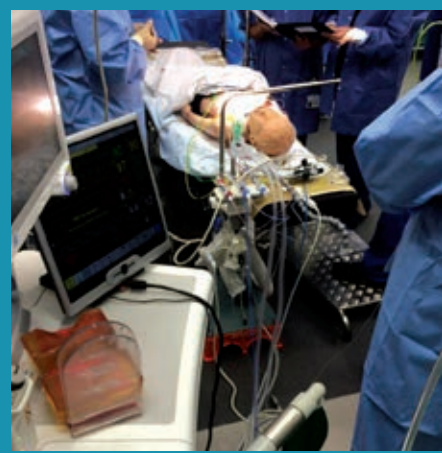
THE IMPACT

This approach enabled identification of numerous processes that required modification due to the different layout in the new build, including siting of emergency equipment, flow of patients through departments, and the optimal configuration and layout of rooms and areas.

Errors in organisational systems and processes were identified and redeveloped prior to patient arrival. Front-line staff were engaged and helped develop appropriate, safe processes, increasing their confidence in working in the new areas.

Case study contributors
Mark Hellaby, NWSEN Manager; Sarah Wood, Consultant Paediatric and Neonatal Surgeon & Neil Herbert, Clinical Lead for Anaesthetics, all at NHS Health Education England across North West, mft.nhs.uk

Acknowledgements
Thanks to the staff from Alder Hey who participated and assisted in the process.



DESIGNING FIT-FOR-PURPOSE EQUIPMENT

20

THE PROBLEM

Negative articles about sub-optimal Australian soldier equipment would regularly hit the press in the mid-2000s. The protracted and bureaucratic procurement processes that are appropriate for buying battleships were not providing good outcomes for soldier equipment. Body armour was cumbersome and individual projects were typically stove piped so that integration of everything onto the soldier became a goal that was rarely even articulated, much less achieved. The result came to be known as the 'Christmas tree' effect and had an impact on soldier operational performance, satisfaction and an increasing perception that user needs were not being addressed.

THE SOLUTION

Previously separate entities of Army (end user), Capability Acquisition and Sustainment Group including the Land Engineering Agency (procurement) and Defence Science and Technology Group (research) came together in 2011 and a Memorandum of Understanding was signed. The new organisation was based in Melbourne and named 'Diggerworks', inspired by the US Marine Corps 'Gruntworks', but with the Australian slang term for a soldier.

As issues of equipment usability and integration were some of the key instigators for the situation, two of the Human Systems Integration Team were (and still are) seconded part time to sit within the new organisation to provide specialist advice. Other science disciplines such as ballistics and injury biomechanists would regularly be called upon, but the human factors support has been an enduring part of the equation.

Their role is to work within the new paradigm of Adaptive Acquisition, where Army buy small amounts often and continuously iterate equipment to make improvements and ensure it is more reactive to the ever-changing environment and threats that our service personnel experience. Design iterations are based on user feedback and technology developments with equipment being developed, trialled and deployed within months rather than years. User-centered design is now embedded as a minimum starting point rather than as an afterthought. Diggerworks does not procure equipment directly but rather works alongside project offices who enable the design changes and procurements to happen.

One key aspect of Diggerworks' remit is to run scientifically-based user equipment trials that yield valid data so that Army can make decisions with confidence. This is important as anyone can set up and run an equipment trial, but if they have no scientific training then the outcomes are often questionable. Human factors qualified personnel are typically well prepared to address situations such as these. They are also able to draw from best practice in Human Factors Integration as part of a more holistic approach to de-risking equipment development.

THE IMPACT

Key examples of the impact that Diggerworks has had are:

- **Tiered Body Armour System:** an Australian-specific body armour system with data on mobility and thermal load to inform trade-off decisions, continuously adapted, deployed and sought feedback. Now on version 5.
- **Operational deployment:** feedback is systematically gathered from operational rotations on a wide range of equipment types to inform future design evolutions and new work programs.

Diggerworks
FOR THE WARFIGHTER

- Evaluation and adaption of partner nation methods for assessment of soldier combat ensemble, for example, the Load Effects Assessment Programme obstacle course, to enable information sharing and collaboration.

Surveys show that soldiers are now far more positive about the equipment they are being provided with and there are far fewer negative reports. There is an ethos of user-centred design and an organisational structure designed to remove barriers and work together to deliver better equipment. There is improved operational performance and acceptability of soldier equipment.

Human factors knowledge during planning and conduct of test and evaluation activities produces valid and defensible results and improved targeting and delivery of human factors research activities are starting to meet longer term objectives.

Wider applications

Australia is sharing experiences of this operating model with allied countries. Most have soldier development cells of some type, but without the relative balance of uniformed personnel, engineering and human science permanently available. The embedding of expert support is not a new concept, but represents a different way of business in the public service and defence.

The means to effectively link short term engineering and human factors effort with longer term research provision is an enduring issue for many organisations. The key to Diggerworks is shared risk and building trusted partnerships.

Further information

Department of Defence, Australia. Diggerworks: Driving innovation and effectiveness in the defence sector. www.defence.gov.au/publications/docs/20130521-Diggerworksbookletsmall.pdf

Case study contributor

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Acknowledgements

Thanks to the Human Systems Integration Team and DST Land Division Scientists, the Capability Acquisition and Sustainment Group including Land Engineering Agency and Soldier Modernisation Systems Programme Office, and the Australian Army.

USING MACHINES FOR MANUAL HANDLING

22

THE PROBLEM

Repetitive manual handling by moving and turning heavy logs can be a particular problem in sawmills. Partially sawn logs with at least one flat side (cants) have to be turned in order to orientate them properly for the next phase of sawmill operations. Tasks like these exert extreme biomechanical loadings on workers and work-related musculoskeletal disorders are common.

In one sawmill where an ergonomics study took place, operators had to move cants more than 500 times per hour, and turn them more than 100 times per hour. With the high hand grip force required due to the weight and shape of the cants and the relatively high frequency of the task, the job was considered hazardous. Lifting and turning the heavy cants also resulted in significant risk to the lower back.

Biomechanical analysis showed that only 32% of typical male workers would have the strength to perform such heavy lifting.

THE SOLUTION

The sawmill managers recognised this hazard and confirmed that it was possible to improve the jobs based on experience in other sawmills. Initially they decided to make a significant investment and install a commercial board turner. But when the managers presented the idea to the employees and asked for comments, one of the employees volunteered to try a new and inexpensive solution. He used two pneumatic cylinders and constructed a home-made board turner, at a cost of only $150. The system performed very well and obviously resulted in considerable savings for the company.

THE IMPACT

The pneumatic board turner meant that the operator no longer had to manually turn the cants, but needed only to guide them while the board turner did the work. Both the high hand grip force and heavy lifting risks were significantly reduced as a result.

Recognition of the problem and action by management provided assurance that the company seriously considered improvements in working conditions. Workers were encouraged to provide ideas that resulted in effective, economic and feasible solutions.

Wider applications

Management commitment and worker participation are two important components of successful ergonomics programmes and can be applied in any sector.

Further information

Ergonomics demonstration project at Columbia Vista Corporation Sawmills in the USA, 2002, http://lni.wa.gov/safety/SprainsStrains/demofnl/ColumbiaVistaCorpCamas.pdf

Case study contributor

Stephen Bao, Senior Ergonomist at the Washington State Department of Labor and Industries, www.lni.wa.gov

Acknowledgements

Thanks to Washington State Department of Labor and Industries and Columbia Vista Corporation in Washington, USA.

REDUCING MOTION SICKNESS FROM WORK ON CONVEYORS

24

THE PROBLEM

Early testing during a feasibility study of a new Royal Mail parcels sorting machine found that a high proportion of individuals suffered from motion sickness due to working beside high speed conveyors.

This is a recognised problem in relation to conveyor belts whereby motion sickness is caused by a mismatch in the information coming to the brain from the eyes, inner ear and musculoskeletal systems. Health & Safety Executive guidance states: "Operators working perpendicular to the belt may feel 'carsick' with conveyor speeds greater than 10m per minute." It is also known that there is a wide variation in individual susceptibility, and of those affected, some people adapt quickly whilst others fail to adapt at all. However, behaviours can be adopted which reduce the impact of motion sickness.

Workstations and work tasks at Royal Mail had to be developed which processed parcels at sufficient rates, minimised musculoskeletal risks and did not cause significant motion sickness problems for operators. A key goal for the design was that the number of operators who were unable to undertake the tasks due to motion sickness problems should not exceed 5%. In addition, the machine had to fit within the size and layout constraints of existing buildings.

THE SOLUTION

An iterative ergonomics approach was adopted by Royal Mail with distinct phases.

Phase 1: Feasibility & task design

Initial user testing was conducted with specialist conveyors and a scanner to explore the potential functionality and task design where operators are required to face the conveyor and separate out parcels already on it. Up to 50% of participants complained of dizziness, visual symptoms and nausea when working this way.

Further rounds of user testing were conducted with four different conveyor surfaces and three different conveyor speeds to explore options to reduce symptoms. Results showed that although reducing the speed of the belt and changing the texture did reduce symptoms, it could not be reduced enough to be fully effective and still retain adequate throughput, and so a task redesign was explored.

Operators were re-oriented to stand or sit sideways to the conveyor and place the parcels on it. This increased the physical element of the task and the conveyor speed had to be increased to allow space for the parcels. Further development resulted in sit-stand workstations where parcels were slid onto the conveyor to minimise musculoskeletal risk but early testing showed that motion sickness symptoms were still likely to occur.

Phase 2: Symptom prevalence testing

A larger study was carried out aimed at determining the likely prevalence of symptoms for two methods: separating parcels already on the conveyor; sliding parcels onto the conveyor.

Testing involved 20 participants working for one hour sessions using the two methods and recording results using an exposure checklist, subjective opinions and observations of behaviour which may indicate symptoms.

The pattern of symptoms varied between individuals, but dizziness and eye strain were the most common symptoms. More severe symptoms were reported when separating parcels already on the conveyor rather than when sliding them onto the conveyor, when symptoms were also easier to control. Other contributing factors were found to be the colour contrast on the conveyors,

other bright or moving objects or acceleration and deceleration in the visual field, and posture and fatigue.

Phase 3: Development of parcel machine workstations

Sliding parcels onto the conveyor seemed most promising from the testing so a parcel machine workstation was designed to optimise this method. The workstation, conveyor and work tasks were developed to minimise symptoms and maximise throughput. Testing involved prototype workstations on which 24 operators tried simulated tasks.

The final design involved operators working sideways to the conveyor using a sit-stand workstation to maximise their comfort and allow changes in working posture. Light and motion shielding was placed around the conveyors and scanners to protect against other visual problems whilst the operators retained the ability to rest their eyes by looking into the distance.

THE IMPACT

The key operational requirements set out in the project brief were met and the workstation and task designs were a success: to reach throughput rates with minimal manual handling and risk of musculoskeletal problems; to accommodate space constraints; and to maintain a low incidence (less than 5%) of motion sickness symptoms.

Wider applications

The development of a workstation and work tasks which successfully manages the potential motion sickness symptoms associated with high speed conveyors could be used in other industries. The key findings indicate high chances of success if operators use sit-stand workstations oriented side on to the conveyor, shielded from flashing lights, acceleration/deceleration and other motion in their peripheral vision, and colour contrast on the conveyor is minimised.

Case study contributors

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Robin Ellis, Principal Consultant at RED Design Ergonomics Ltd, www.red-designergonomics.co.uk

Acknowledgements

Thanks to all the trial participants (agency workers, Royal Mail staff and managers), and apologies to all those who felt sick in the process. Thanks too to Parcels Automation Design & Deployment Team members and suppliers, (Datalogic, RoMEC and Intralox), who facilitated the testing and modified designs. And finally, thanks to the Human Factors Research Group, University of Nottingham for their expert consultancy.

GETTING READY FOR REFINERY RESTARTS

26

THE PROBLEM

A restart following a major maintenance outage is one of the highest risk activities a refinery undergoes. The risk of material releases can be great because of the complexity involved with keeping track of the status of all parts of the system and the dynamic manner in which work activities are completed towards the end of these large maintenance activities.

One challenge is that operations personnel have to manage this complexity to get the units restarted on time but without the tools and organisation to effectively verify that every bleed has been closed, every line-up is correct, and every instrument is functional. Systematic management of human performance so that the system is 'hydrocarbon-ready' has been identified as challenging in the past.

During the restart at one refinery following the last major turnaround (TAR) in 2012, two reportable loss of primary containment events (LOPC) occurred due to improper line-ups and drains being left inadvertently open. Additionally, restarts have been delayed due to breakdowns in communication between areas (particularly the process units and the tank field) about proper valve line-ups.

THE SOLUTION

In preparation for the refinery's 2016 TAR, an operations completions programme was developed. The aim of this programme was to eliminate LOPC incidents at startup associated with human performance, such as drain valve left open incidents. In addition, the programme would provide Operations with the confidence that every stretch of pipe had been checked and that the unit was ready to bring in hydrocarbon.

'Walk the Line' is a programme that focuses on the human factors that lead to LOPCs. Our programme was designed to apply the principals of Walk the Line specifically to the time between maintenance handing over the unit to Operations and hydrocarbon entering the unit. A overview drawing of the unit broken down into several circuits was developed for each of the 18 units that underwent maintenance during the TAR. These drawings were designed to be used in tandem with circuit checklists to help Operations verify that each circuit was ready for hydrocarbon entry. Handover checklists specific to restart were added to board and field operator logs a few weeks before restart to facilitate clear communications within and between shifts.

Building and sustaining engagement in the programme was a key objective during preparations and execution of the TAR. To foster this:

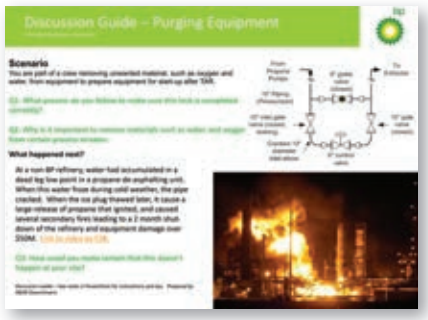
- Each Area TAR lead, Area Superintendent, TAR Ops lead, and Operations Manager all impressed upon Operations personnel the importance of the programme.
- Posters were developed and hung throughout the units acting as a reminder on human factors and the Walk the Line approach. A helmet sticker was also designed and issued.
- Initial training was delivered to Operations prior to shut down and refresher training was given to each shift a week before the end of maintenance.
- Human factors-themed toolbox talks reinforcing the importance of the programme were shared with crews near the end of maintenance.

Once maintenance handed the unit back to Operations at the end of TAR, the Shift Supervisor assigned operators circuits to walk down. Using the circuit drawing as a reference, operators walked down their assigned circuit and completed the associated checklist. Hydrocarbon

TOL TOOLBOX TALKS

Toolbox Discussion Guides shared uniformly during restart week

1 Low boiling point liquids sent to hot tank
2 Responding to excursions during start-up
3 Purging Equipment after TAR



4 Drains Left Open
5 Checking Line Up
6 Blocked In RV

could not be brought into the unit until a copy of all completed circuit checklists had been sent to the Shift Manager and reviewed for completion at the Operational Readiness Review.

THE IMPACT

Use of this programme helped the site achieve its primary goal, a refinery restart without a single LOC incident. It also helped reduce misalignments during start up by improving communication between process units and the tank field.

Following the TAR, users of the programme gave feedback which was used to develop a set of recommendations to improve future use of the programme, including improvements to the handover checklists. Details of the programme, learnings, and recommendations were compiled and passed on to other BP sites to aid in future TARs. The programme was also presented at an Operating Practices Symposium in 2016

Wider applications

Complex maintenance on process plants relies on effective performance of the team of personnel to have the system set up properly. This is highly dynamic and demanding to achieve without a systematic process to support it. A similar programme could be used in other sectors that rely on reinstating complex systems post-maintenance.

Further information

Report in Chemical Processing, 2016. Process Safety: Walk The Line – Company-wide initiative eliminates operator line-up errors, www.chemicalprocessing.com/articles/2016/process-safety-walk-the-line/

Case study contributor

Simon Monnington, Human Factors Advisor at BP, www.uk.bp.com

28

DESIGNING FRAMES TO HANDLE HEAVY PARTS

THE PROBLEM

A manufacturing facility for heavy duty exercise equipment included fabrication, welding, painting, assembly and packaging. Workers frequently handled heavy metal parts such as frames of treadmills, elliptical fitness cross-trainers and exercise bicycles. High biomechanical loading was often experienced in the operations, and as a result, workers in most jobs were exposed to a high risk of developing musculoskeletal disorders.

THE SOLUTION

The company asked for input from the different parties involved in the manufacturing processes with the aim of reducing manual handling and making the job easier for most workers in the production system. The inputs included how the components would be handled at each of the workstations and what kind of fixtures could be used to make the lifting and handling of the components easier.

After prototypes of the fixtures were built, they were tested by workers involved in the different manufacturing processes who gave feedback to inform further improvement of the designs. As a result, a purpose-built cart was designed for use in:

- **Fabrication** - where parts could be gathered into a kit.
- **Welding** - where parts from fabrication could be welded on the cart.
- **Painting** - where welded frames could be pulled from the cart and replaced on the cart after painting.
- **Final assembly** - where the frames on the cart could be easily transported onto the assembly line where other components could be assembled before sending to the final shipping station.

THE IMPACT

Manual handling was reduced to a minimum. Using a systematic approach with worker involvement, musculoskeletal hazards were significantly reduced, and productivity and efficiency were improved.

Wider applications

Many manufacturing projects can have a higher chance of success if ergonomics forms an integral part of production planning, leading to a systematic approach including worker involvement.

Further information

Ergonomics demonstration project of a manufacture and assembly operations, 2002, www.lni.wa.gov/safety/SprainsStrains/demofnl/precor_fnl.pdf

Case study contributor

Stephen Bao, Senior Ergonomist at the Washington State Department of Labor and Industries, www.lni.wa.gov

Acknowledgements

Thanks to Washington State Department of Labor and Industries, and Precor, Inc. USA.

ENABLING PHYSICAL ACTIVITY IN VISUALLY IMPAIRED PEOPLE

30

THE PROBLEM

Sport England reports that in the UK 38% of people over the age of 16 participate in sport each week. In the visually impaired (VI) population it is only 11%. There are many reasons why the VI struggle with access and involvement in sport. The sensory deficit of visual impairment reduces the engagement of young children in physical activity. Children blind from birth find it very difficult to hop, skip or jump when both feet come off the ground as they lose their sense of 'place'. How do we overcome this barrier?

THE SOLUTION

An ergonomics approach was used to replace the visual stimulus with tactile, audible and physical guidance to allow independent running. Exploratory investigations investigated how the VI children interact with the world as they run. A series of prototypes of a 'Running Line' were built and evaluated which lead to a specification to create a robust testable product.

Much of the development came directly from working with children though visits to schools, VI activity groups and a weekly running club with an RNIB college. With direct observations, the equipment was modified incrementally to best suit a variety of children. Many VI children have an additional disability, so it was important to design for more than visual impairment in mind. The inclusion of auditory and tactile cues added to the usability and inclusion.

The investigation showed that the design required:

- A line under tension to guide the runner in a straight line.
- The tension in the line to be adjustable depending on the speed/confidence of the runner.
- The height of the line to be adjustable to incorporate anthropometric variation with age.
- A comfortable low resistance hand piece that gives directional information to the runner and allows reciprocating hand movement.
- Audible information to inform the runner of the movement being delivered by themselves and other runners nearby.
- Tactile and audible warnings when the runner approaches the end of the line (a buffer).
- A resistance mechanism to prevent the runner reaching the end of the line at speed.
- A high contrast colour against green grass on the ground.
- Lots of protection to prevent trapping, tripping, etc. and improve confidence of the younger children.

This design iteration informed the construction of six prototypes which facilitated a large number of events where the project team has been able to trial the equipment with visually impaired children and adults. Data recorded during the development of the product showed high levels of enjoyment when using the Running Line. Specifically, the children commented on how they valued the independence and the freedom it provided them. Other experiments measured if the children who use the product improved in confidence during repeated exposures over three weeks.

THE IMPACT

As an advanced prototype the Running Line has been demonstrated at many public, charity, sporting and school events. The public perception and the responses of both VI and blindfolded sighted participants is that it provides a comfortable, supported and safe environment in which young people can develop their activity.

The design and safety provisions in the product clearly match the requirements of the VI and provide them with a route to safe, enjoyable, independent running. The Running Line shows:

- Rapid and comprehensive improvements in confidence.
- High levels of engagement with the activity: participants report high levels of enjoyment, fun and safety after supported learning.
- Clear improvements in speed, cadence and straight line running over short term and long term exposure to the Running Line.
- Children can complete independent repeated runs with no assistance from teachers, family and friends, after a short introduction period.
- Better engagement, and in special needs classes with multiple mixed ability children, much higher levels of activity.
- Children enjoy competing with their friends in public demonstration sessions.
- Children enjoy being able to race with their parents and siblings.

This human-centred design process has created a product that can deliver major improvements in a young person's experience of physical activity which could have life-changing effects for them.

Wider applications

The design approach of participatory ergonomics and human factors can be used to develop assistive devices that can have a profound effect on someone with sensory deficit.

Further information

How does the Running Line Work?
www.youtube.com/watch?v=OKVT2XihdXg
Sally and The Running Line:
www.youtube.com/watch?v=whGV04ffuPw

Case study contributors

Dr Mike Fray, Victor Jeganathan & Winta Satwikasanti of Loughborough Design School, www.lboro.ac.uk

Acknowledgements

Mark Beeby, an inclusive sports coach of Mayfields Life-Skills Centre, collaborated in this study. Six prototype Running Lines were developed with the assistance from Loughborough University Enterprise Grant Funding. Thanks to those who participated in trials from the RNIB college in Loughborough, British Blind Sport, the Childhood Eye Cancer Trust and Action for Blind People.

The children commented on how they valued the independence and the freedom it provided them.

COUNTING CRATERS

32

THE PROBLEM

Online citizen science platforms allow non-scientists to take part in scientific research across a range of disciplines, anywhere and at any time. As a relatively new form of activity, online citizen science research has tended to be driven by concerns around the core science rather than being considered as something that can be designed to suit its user population. This is perhaps remiss given the importance of the 'citizen' to the endeavour, as the effectiveness of citizen science is related to its ability to attract and retain engaged users, and to ensure the quantity and quality of the data collected.

Through this work, a first attempt is made at applying human factors approaches to the design of online citizen science platforms. Such platforms involve processes, mechanisms and methodologies that have historically been used in other systems, and as such there is a wealth of research regarding their design and implementation. They often require the user to analyse visual stimuli on-screen, through completing tasks in a repetitive manner – a scenario analogous to that concerning the mechanisms of industrial work. As such, the relevant insights of perceptual psychology and work design have been applied to the citizen science case.

Factors including autonomy, variety, task type and the user judgement required have been identified as operational at the design stage of a citizen science project, whilst several decades of human factors research have confirmed their potential influence on performance and engagement. But do they apply in the same way in the online citizen science domain?

THE SOLUTION

In conjunction with the internationally recognised citizen science platform, the Zooniverse, a website called *Planet Four: Craters* was developed allowing the online public to mark craters on the surface of Mars. The website incorporated three different interface designs that presented different workflows to the user, comprising different task types and judgements, and differing degrees of variety and freedom. This approach also provided an expert set of data to use as a ground truth with which to compare the volunteer data.

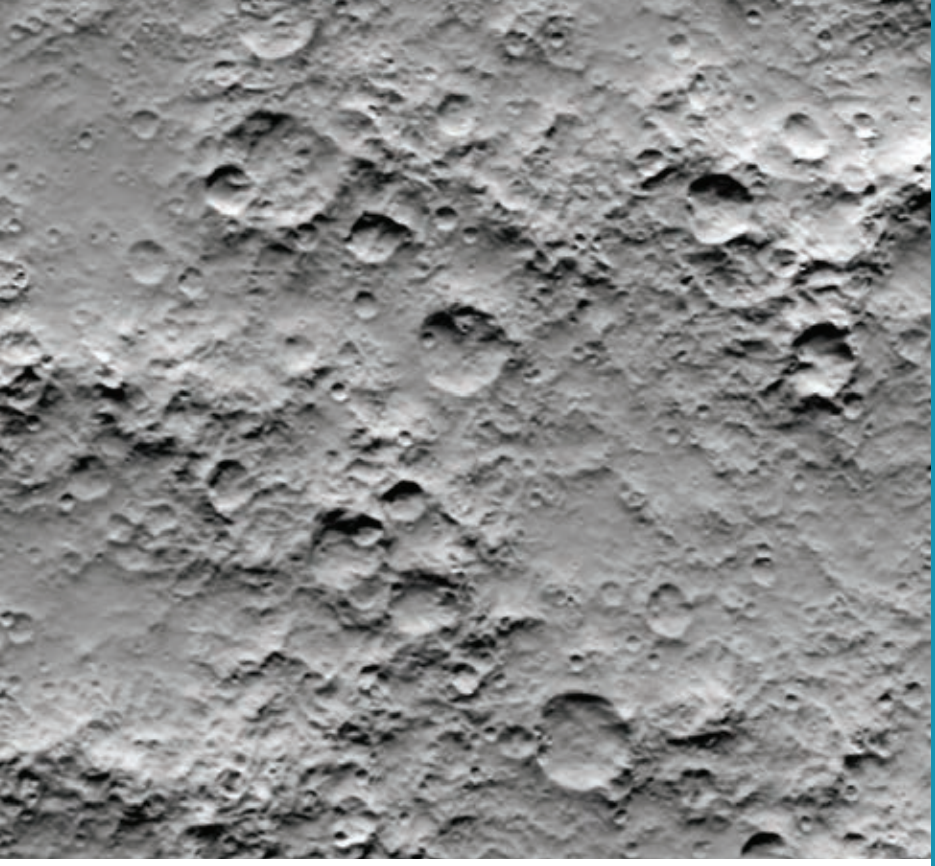
In addition to the task interface, the site incorporated information about the science being addressed and a community forum for communication with both other volunteers and the scientific experts.

The site went live in March 2015, with data collected through until the end of June 2015. Over this time approximately 2000 volunteers from over 40 different countries contributed a total of around 27,000 separate crater markings over the three different task interfaces.

As well as making direct communication about the website through the forum, volunteers also had the opportunity to fill in an online questionnaire to share their opinions on the tasks, interface and imagery presented, in order to better understand how task and interface design affects volunteer website behaviour.

Analysis of the data collected showed that an interface that presents a simpler task resulted in more data being collected, and an interface that restricts the volunteer to do tasks in a step-by-step fashion, becoming more complex over time, provided more accurate results when compared to the expert.

Visitors were more likely to return to the site when presented with an interface that allowed more freedom to choose what task to do, and more variety of task. Volunteer feedback showed that this preference depended on their knowledge of the platform, with new users preferring more guidance and less freedom compared with returning users.



THE IMPACT

Human factors considerations learnt from similar systems can be applied to the online citizen science case. Additionally, the factors identified can be easily adapted at the design stage of the project to develop different approaches even if the overall scientific task remains the same. Such considerations can have a significant influence on both the data produced and the engagement of the volunteers, suggesting that future citizen science developers could tailor the design of task and interface to achieve the appropriate outcome for their particular science goal.

FURTHER INFORMATION

Planet Four: Craters:www.craters.planetfour.org
Citizen Science Association:www.citizenscience.org

J Sprinks, J Wardlaw, R J Houghton, S Bamford & J Morley, 2017. Task Workflow Design and its Impact on Performance and Volunteers' Subjective Performance in Virtual Citizen Science. *International Journal of Human-Computer Studies, Vol104, pp50-63.*

J Sprinks, R Houghton, S Bamford & J Morley, 2015. Citizen Scientists: The Importance of Being Needed and not Wasted. *CHI PLAY '15 Workshop: The annual symposium on Computer-Human Interaction in Play*, Oct 2015, London, UK.

J Sprinks, R Houghton, S Bamford & J Morley, 2015. The Impact of Task Workflow Design on Citizen Science Users and Results. *Contemporary Ergonomics and Human Factors 2015, pp371-378, Apr 2015, Daventry, UK.*

Wider applications

Although this work has online citizen science as its focus, other platforms exist requiring the volunteer to act as data collector, utilising mobile technologies. Beyond citizen science, the research has the potential to be applied to other crowd-based, online systems. It could well assist with identifying design opportunities for performance gain, for instance 'Mechanical Turk' type platforms could use the research to adapt the tasks they present to their online workforce, improving both data output and user motivation. Online citizen science developers should consider the type of data required, the amount that needs analysing and the prospective size and motivation of their volunteer community.

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DESIGNING SMART MOTORWAYS

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THE PROBLEM

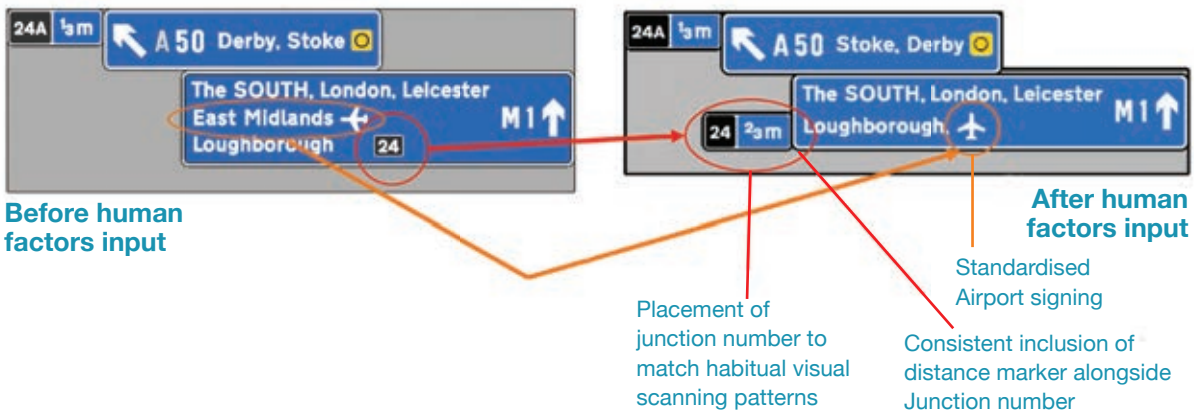
Smart motorways use technology to actively manage traffic flow. Regional control centres monitor traffic and can activate and change signs and speed limits to help keep traffic flowing freely. When creating smart motorways, designers follow various standards that specify compliance with minimum requirements for lighting, signage, road geometry, structures and more. However, Highways England, the body responsible for smart motorways in England, has strategic objectives to improve safety, customer experience and delivery, and is looking for innovative solutions to meet these objectives.

THE SOLUTION

A team, including human factors professionals, was commissioned to design the new Smart Motorway sections for the M1 J13-16 and J23a-25 schemes. The human factors team engaged with three types of stakeholders to assess the human element of the motorway design:

- The internal design and engineering teams to raise human factors awareness and instil positive user-centred design behaviours using modelling techniques such as personas with scenario walkthroughs.
- Operational users of the motorways, such as motorway maintainers, emergency services, Highways England's Traffic Officers and Control Room Operatives, to understand their needs and requirements relating to different motorway assets.
- The road's end users, including car, HGV drivers and motorcyclists, to understand their current concerns with motorways and their requirements to inform the personas used when reviewing designs with designers and engineers.

As a result of this engagement, the human factors team worked with the relevant designers and engineers to ensure that motorway features and assets such as emergency refuge areas, motorway signage and maintenance access routes were designed with their respective users in mind to enhance user experience



and safety.

Using personas alongside scenario-based walkthroughs helped the designers to understand the need for a user-centred design, and to visualise the impact that different design options would have on the different users.

Highways England reintroduced a requirement for motorway gantries to have permanent fixed access arrangements to reduce risk to maintainers during maintenance work whilst at the same time not compromising the safety of road users.

The human factors team engaged with infrastructure maintainers to understand their requirements for access, maintenance delivery and safety by holding workshops to assess existing gantry designs against future maintenance requirements. The workshops elicited user requirements in addition those already considered by the design team and enabled development of a clear understanding of how the design could positively influence the maintainer's behaviour.

THE IMPACT

The introduction of human factors as an approach to motorway design has enabled other technical disciplines to consider people at the centre of their designs. Using human factors ensured that all technical design solutions had considered the people who would either use the road or be involved in its operation and maintenance. Buy-in from the motorway operators and maintainers has been promoted to ensure their needs and requirements were considered during the design.

Highways England has developed capability in human factors in line with other sectors such as rail and aviation. Human factors has contributed to Highways England's strategic aims of improving road user safety and customer experience.

Wider applications

A user-centred design approach can be applied to the design of all assets, artefacts and systems. Ensuring all users including customers, operators and maintainers are engaged and considered at the start of and throughout the design process will ensure the final design meets their needs and enables them to carry out their intended action safely and efficiently.

Case study contributors

Nic Bowler & Kate Fairhall of Arup, www.arup.com

Acknowledgements

AmeyArup formed the collaborative design team working on the M1 J13-16 and M1 J23-25a projects.

Following reviews and workshops we have modified our designs to make them more intuitive and consistent

Henry Hoggarth, Signing Lead M1 J23a-J25 and J13-J16

CHANGING LEADERSHIP BEHAVIOUR

THE PROBLEM

Highways England has placed a high priority on the health, safety and wellbeing of all its stakeholders including employees, contractors and road users. Safety is the most important of its three business imperatives and is its overarching value, sitting above ownership, passion, integrity and teamwork. As a key business imperative, Highways England created its five-year plan to deliver health, safety and wellbeing. One of the first actions in this plan was to create a training programme designed to change the behaviour of all its leaders. The challenge was to ensure that through this programme all Highways England leaders had the tools and the understanding to drive appropriate behaviours and deliver a healthier and safer organisation.

THE SOLUTION

Highways England wanted the training programme to be based around a small set of proven principles and tools shown to be effective in delivering behavioural change. They engaged in an ambitious project to create a programme that would deliver the change the organisation sought. The organisation committed to measuring the effectiveness of the programme and to check that colleagues who attended the programme changed their behaviours and applied some of the tools they were given.

A four-stage process was used to design the programme to ensure that is was fit to meet the organisational needs. Firstly, a comprehensive literature search was undertaken to discover what others had done to change leadership behaviours around health, safety and wellbeing, with the emphasis on what worked and what to avoid when designing a programme. A series of interviews was then carried out with organisations who were either implementing programmes or who had experience in running these programmes. Of particular interest was how successful these programmes had been in affecting long-term change in behaviour. A review of commercial off-the-shelf products determined what themes these products identified and what success stories were associated with their use. Finally, a series of workshops was run with colleagues within the organisation, asking them to identify challenges and barriers, opportunities, and what good would look like.

The programme had an overarching theme to support the development of a just culture within the organisation. All the evidence supported the idea that central to changing the behaviour of leaders was to provide a supportive culture in which change could occur, so a range of tools was provided for leaders together with a set of techniques they could apply to help themselves and colleagues change and ultimately produce a just culture.

Three broad themes were identified:

- **Access.** Provide leaders with information and tools that: increase their knowledge and allow them to practice understanding of what drives behaviour; enable them to understand who is accountable for health and safety, and what we mean by safety culture and climate; allow them to measure and improve safety culture.
- **Manage.** Provide leaders with the ability to: understand how to identify and describe health and safety risk; prioritise and communicate about risk to other stakeholders; measure and reward effective health and safety performance.
- **Relate.** Provide leaders with the ability to: understand leadership styles and attributes; develop and share a vision for health and safety leadership; improve

communication about behaviours, vision and leadership.

Ten attributes of brilliant leaders of health, safety and wellbeing were identified and tools were provided to allow leaders to develop and improve those attributes. The programme was run over three days; the first two days were followed by a gap of at least four weeks of practical application in the delegates' roles, before the final day was delivered.

THE IMPACT

The programme was delivered to around 300 leaders. The initial results indicate that the programme had an immediate effect on some of the reactive measures of safety such as accident frequency rate. More importantly, leaders are now acting to support the delivery of a just culture and the ideas and tools are becoming commonplace within the organisation. The most popular tools leaders applied were:

- A simple behavioural model that seeks to understand behaviours in terms of an individual's capability, opportunity and motivation.
- A culture change tool based on applying a just culture model to incidents (accidents and near-misses) and other errors while trying to understand error-provoking conditions.
- A risk tool that allows leaders to work with their teams to identify and quantify risk so that the right risks can be prioritised and resourced at the right time.

Wider applications

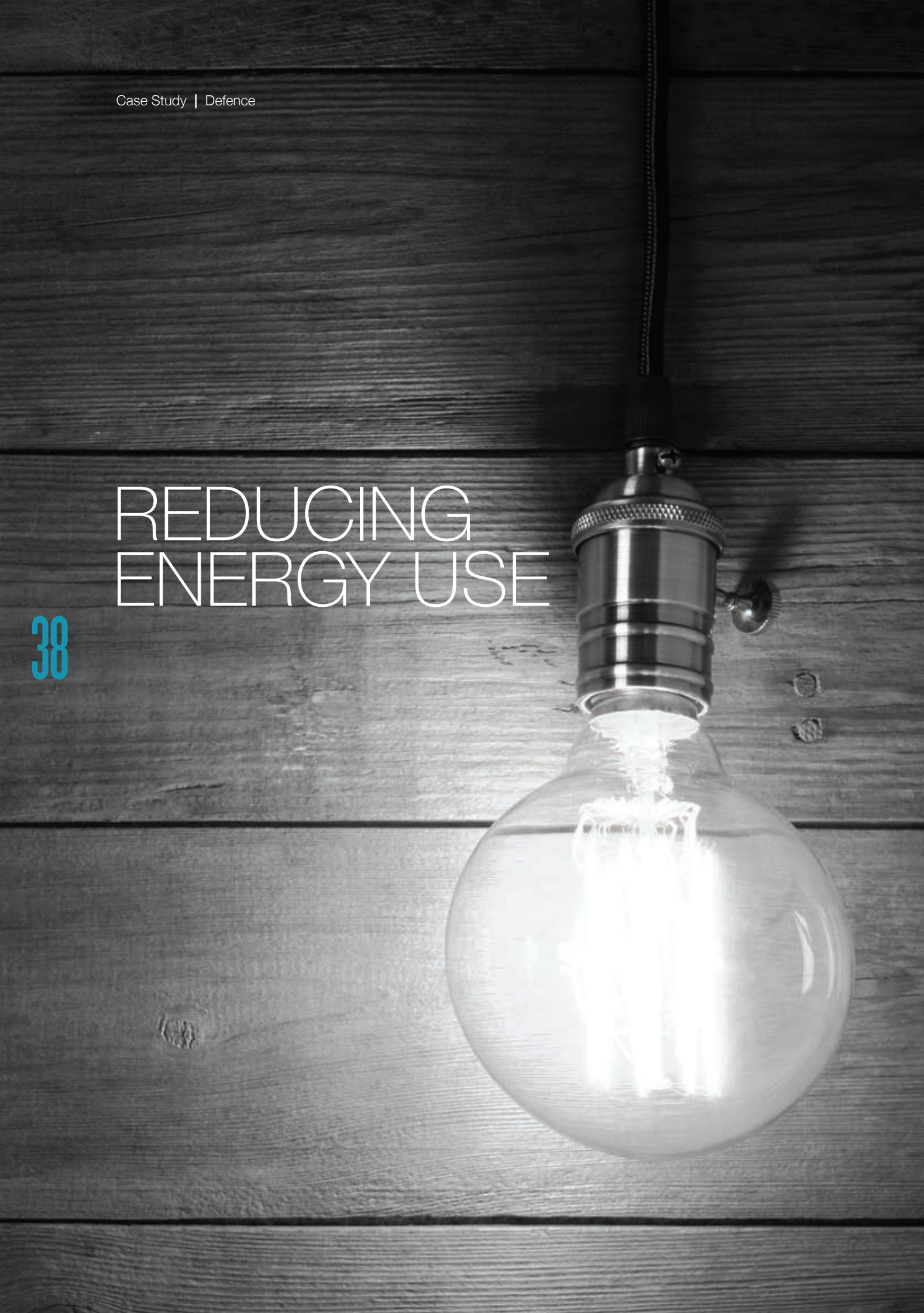
It is clear that producing a non-proprietary, tailored, evidence-based programme using the latest ideas from human factors can effect real organisational change. A similar approach could be used to engage and involve stakeholders in other organisations to meet health, safety and wellbeing goals.

Case study contributor

Nigel Heaton, Director of Human Applications Ltd, www.humanapps.co.uk

Ten attributes of brilliant leaders of health, safety and wellbeing were identified and tools were provided to allow leaders to develop and improve those attributes.

REDUCING ENERGY USE



THE PROBLEM

The UK Ministry of Defence (MOD) is a significant consumer of energy, both in delivering effective military capability as well as powering the infrastructure requirements at home and abroad. In 2012, the MOD set itself a target to reduce fossil fuel expenditure by 18% by 2020/21, against a 2009/10 baseline. Previous research suggests that an understanding of behaviours, the context of those behaviours and attitudes is essential for identifying how to reduce costs and improve resilience whilst maintaining capability. The question was how to get this information.

THE SOLUTION

A research project involved several overlapping steps. The first was a literature review to identify energy behaviour change best practice. The second was summarising the root causes of MOD energy expenditure and determining current individual and organisational energy behaviour through an MOD-wide survey. The third step involved analysing and establishing an effective approach for identifying energy behaviour change interventions.

From this, an approach called the Future Interventions Start Here (FISH) was developed, which is a simple, systematic process designed to identify effective behaviour change interventions at low cost. The approach is broadly based on the Behaviour Change Wheel which encompasses capability, opportunity and motivation as influencers on behaviour.

Three case studies were designed to empirically validate the suitability of the FISH approach in identifying multi-intervention behaviour change strategies. One case study concentrated on developing energy efficiency savings in a complex, three-storey, multi-use MOD building. The focus was on switching off equipment and lighting over a four-month period. The objectives were to understand the energy behaviours and their specific context, to identify appropriate behaviour change interventions, to design and implement interventions using best practice principles, and to measure the outcomes.

THE IMPACT

Energy savings were made of up to 26% per month which exceeds MOD targets, and also translated into meaningful financial savings. This demonstrated that the application of a behaviour change process, which helped identify multiple supporting interventions, led to savings which exceeded the peak expected savings of 20%. Overall, the interventions resulted in a significant change in awareness, attitude and behaviour change, as well as energy use and financial savings.

The research concluded that the FISH approach is a scientifically robust approach to behaviour change that is easy for stakeholders to understand and helpful for uncovering important contextual factors. It encourages better specification of interventions and is effective at providing a common understanding of behaviour that improves energy efficiency.

Wider applications

The FISH approach is designed to be used by non-psychologists and is a simple, systematic approach for identifying and developing effective interventions, underpinned by robust human behavioural science, that are more likely to succeed. The process and behaviour change model on which the FISH approach is based was originally developed for the healthcare domain but has now been used successfully in an administrative setting for the MOD. It is likely that the approach is relevant to sustainable behaviours in other areas such as waste and water management.

Further information

The Behaviour Change Wheel: www.behaviourchangewheel.com

Case study contributor

Eleanor Forrest, Human Factors Researcher at Bright HF Ltd, www.brighthf.co.uk

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IMPROVING POSTURE FOR SELF-INJECTION

THE PROBLEM

Although self-injecting to manage medical conditions has increased over recent years, there has been little research on what injection technique and posture provides the best combination in terms of increasing comfort, efficiency and effectiveness, whilst at the same time reducing strain for the user.

Two identical studies to investigate user capabilities when depressing a syringe plunger were found to have been carried out a year apart but they showed little correlation between the results. The first study showed greater differences between a participant's imagined 'typical force' exerted and their 'maximum force' than the second study. But what was causing such inconsistencies?

THE SOLUTION

Video analysis of the two studies was undertaken which included the 'maximum force profile' exerted for each participant when simulating an injection and whether they were injecting into their thigh or abdomen. In total there were 140 simulated injections to reassess. Participants had to exert the maximum achievable force for between eight and ten seconds. The instructions used for participants were the same in both studies: pinch the skin and angle the syringe at 45 degrees at the point of injection.

The first assessment included how each participant supported their hand during the injection by looking at whether the chair had armrests and whether they were used; whether the participant kept their hand steady; whether their fingers rested on the injection site and whether they pinched the skin. The video footage showed that the postures adopted by participants during these simulated injections varied greatly so the angles of the wrist, forearm and upper arm were also assessed.

A literature search was conducted to look further into how posture of the torso, arm and hand might create undue strain for the thumb whilst trying to exert the maximum amount of force on the syringe. The force profiles were correlated against the postures to identify a set of optimal postures which included wrist and arm angles and whether or not the armrest was used.

A third study was then conducted, where all participants were asked to adopt the same sitting posture in order to achieve a greater degree of consistency across the study. There was some room for variety, for example, for their own comfort they could hold their wrist anywhere from straight to flexed up to an angle of 15 degrees. It was found that by minimising the effect of posture, participants could apply a greater maximum force to the syringe.

THE IMPACT

The proposed posture could benefit those who need to self-inject medication by increasing comfort and improving the efficiency of the injection.

Further information

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Case study contributor

Natalie Shortt, Human Factors Consultant at Medical Device Usability, www.medical-device-usability.com

Acknowledgements

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TRANSFERRING INNOVATION EFFECTIVELY

THE PROBLEM

Transferring innovation or initiatives from other sectors is a common starting point for human factors initiatives. This transfer process is usually ad-hoc based on transferring a tool or technique from another sector without a proper analysis of whether it is transferable to the destination sector, or assuming equivalence of a problem experienced in two diverse sectors and transferring the solution which works in one sector. There is a clear need for a systematic, and systemic framework to analyse whether a tool or technique is transferable, feasible in the destination sector, and implementable.

THE SOLUTION

The SEAHORSE project proposes to address human factors and safety in maritime transport by transferring the well-proven practices and methodologies from air transport to maritime transport in an effective, collaborative and innovative manner. A five-step methodology was developed in cooperation with three maritime organisations to identify challenges and resilience resources from aviation which could be feasibly transferred and implemented.

1. Industries comparison and database of aviation resilience resources

This step was an analysis and comparison of the two sectors involved in the transfer process, and the identification of successful safety and resilience resources adopted in one of the two domains. Then a comprehensive review of the aviation industry identified the successfully implemented solutions in aviation, and these solutions constituted the basis for the mapping process (step 3). The two activities ran in parallel and were performed as independent tasks, without any information or data exchange.

2. Maritime user needs and gap analysis and resilience resources evaluation and selection

This step consisted of the analysis of gaps found between aviation and maritime sectors, together with the identification of maritime user needs. At the same time an evaluation of the resilience resources was conducted with respect to their potential application to the maritime sector to shortlist the most promising ones.

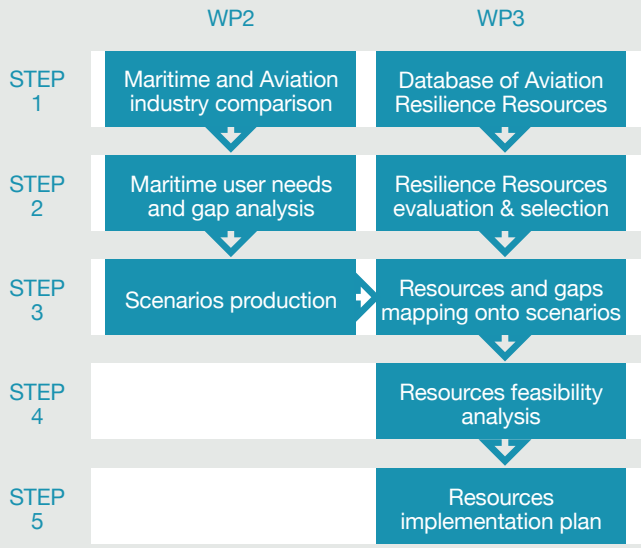
3. Scenario production and resources mapping onto scenarios

The next step was that of mapping the gaps and the solutions onto the scenarios. The scenarios were the focus of the research and development efforts and they were the drivers of all activities. They represented some of the current safety challenges faced by maritime end-users in the operational environment. The resilience resources with the highest potential to solve the issues presented in the scenarios were selected.

4. Feasibility analysis

At this stage, the strengths and weaknesses of the selected solutions with regards to applying them to maritime transport were objectively and systematically analysed. In-depth feasibility analyses were carried out and the benefits were identified which these solutions could bring to the problem expressed in the scenarios. The main aim of this step was the identification of a principled and rigorous approach to gathering feasibility data on the shortlisted solutions and facilitating a practical decision about how feasible each solution would be to develop, implement and adopt in the maritime sector.

SEAHORSE TRANSFER METHODOLOGY



5. Implementation plan

The final step was the development of an implementation plan for each feasible solution. The output of the feasibility reports is needed to evaluate the integration of the solution into the current maritime safety management system and regulatory framework.

THE IMPACT

The results highlight the utility of combining bottom-up (identifying problems) and top-down (identifying a database of resources) approaches at the outset. A comprehensive workshop-based feasibility analysis is key to ensuring the identified resources can be implemented in the destination sector. This approach validated a roadmap to guide transfer of safety innovation and is currently being implemented by shipping companies for procedure improvement.

Further information

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Transferring innovation or initiatives from other sectors is a common starting point for human factors initiatives

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