CONNECTIONS

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Human Factors and design values for vehicle automation

Human Factors and the design of submarine control rooms

Human Factors in led outdoor education

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A word from the Director

Prof Paul Salmon
Director
@DrPaulSalmon

Welcome to the second issue of Connections, the Centre for Human Factors and Sociotechnical System's quarterly newsletter. The aim of Connections is to share our latest research with the Human Factors and Ergonomics (HFE) community and provide news on all things HFE, such as upcoming conferences, new publications, journal special issues, available PhD scholarships, and job vacancies.

The editorial team and I were delighted with the positive response to our inaugural issue, and I am excited to say that our second issue is packed to the brim with new and interesting content. The theme for this issue is HFE in design, which reflects the critical role that HFE plays in the design of safe, efficient, and healthy systems. Indeed, as technologies advance and work and societal systems become more complex, the need to embed HFE throughout design lifecycles is becoming more important than ever. Much of our work here at the Centre is focused on the use of HFE to support the design and insertion of advanced technologies in areas such as transport, defence, and work generally.

Associate Professor Gemma Read's contribution provides an overview of sociotechnical systems theory design principles based on her recent research focused on the safe introduction of automated vehicles. This work is pertinent given the spate of recent automated vehicle crashes and the questions being raised around the safe use of advanced vehicle automation. Adjunct Centre member Emeritus Professor Neville Stanton describes his Command Teamwork Experimental Testbed (ComTET) and associated research program which involves the use of HFE to support the design of new submarine control rooms and processes. Both articles showcase the utility of HFE in design as well as the diversity of areas in which HFE can be applied to help shape designs.

In our Practitioner Connections section, you will hear all about Dr Clare Dallat's work applying systems HFE in the led outdoor activity domain. Clare provides a shining example of how positive and powerful change can be enacted when research translation is done well. In our Meet the Team section Lauren Coventon tells us about her day-to-day work running the Understanding and Preventing Led Outdoor Accidents Data System (UPLOADS) program, and Samantha Jackson talks about her PhD applying HFE methods within Australian Defence Force aviation. To round out a packed newsletter, Dr Eryn Grant is this issues' alumni member, providing an interesting insight into her PhD and her current role at Boeing Defence Australia.

I hope you enjoy the second issue of Connections and that it inspires you in your HFE work or studies! Once again, I would like to thank the Connections editorial team and congratulate them for putting together another fantastic newsletter.

Enjoy!

Paul

Contents

The design of everyday sociotechnical systems: Making values explicit

Associate Professor Gemma Read, University of the Sunshine Coast

A/Prof Gemma Read leads the Transport and Infrastructure Research Theme at the Centre for Human Factors and Sociotechnical Systems.

We encounter poor design every day. In his best-selling book, The Design of Everyday Things, Don Norman famously derides numerous everyday designs. He describes door handles with cues suggesting we should pull rather than push (or vice versa) and poor mapping between stove controls and burners, leaving users frustrated as they turn the wrong burner on or off.

At its heart, Human Factors and Ergonomics (HFE) is dedicated to improving design and advocating a user-centred perspective, accounting for user capabilities and limitations. To optimise performance and safety we must focus on the design of the environments in which people operate, not the psychology of individuals (which can lead to a focus on blaming, shaming and re-training when things go wrong).

Our interaction with 'things' continues to grow in complexity thanks to emerging technologies such as artificial intelligence (AI) assistants, automated vehicles (AVs), unmanned aerial vehicles and collaborative robots. In this context, it becomes increasingly important for design to consider the whole sociotechnical system, and to jointly optimise both the social aspects (humans and their interactions) and technical aspects (including non-human agents). One influential theory that has the capacity to assist with the challenge of designing whole systems is Sociotechnical Systems (STS) theory (Badham, 2006). STS is primarily a work design theory that has generally been applied to respond to the introduction of new technologies within work contexts, in response to a general focus on technical needs, without consideration of how these technologies will integrate with the social aspects of work.

A core focus of STS theory is the design of systems that allow flexibility to successfully respond to external pressures which may be financial, political, or societal. It is underpinned by a set of values and principles that aim to support the design of organisations and wider systems that optimise performance, safety and wellbeing. There are five key values espoused by STS, and adopted more generally within HFE (IEA, 2021). One of our current projects at CHFSTS is focused on the introduction of advanced AVs into the road system, so this is used as an example to illustrate each value.

1. Humans as assets

This value suggests that instead of viewing humans as 'error prone' and the cause of problems in otherwise well-designed technological systems, we view humans as a positive force, with the ability to problem-solve and to adapt and respond to create safety. In terms of the introduction of advanced AVs, for example, this value would suggest that the design needs to support human decision making and intervention to enable recovery from unsafe situations. Existing AI algorithms cannot cope with the complexity of the road environment, including the varied movements of other road users (e.g.

"A core focus of STS theory is the design of systems that allows flexibility to successfully respond to external pressures which may be financial, political, or societal" *A/Prof Gemma Read*

pedestrians, cyclists, emergency vehicles), obstacles (e.g. animals, landslides) and variability in road infrastructure (e.g. faded lane markings, vandalised signs, diversions and roadworks). It is uncertain when, or indeed if, the technology will even be able to match human cognitive performance. Yet, instead of designing a human-automation team with shared goals, technologies are being developed that keep the human driver disengaged and out of the loop during simple tasks, but when the automation can no longer cope with the situation, the human is expected to quickly and accurately re-engage and take over control.

2. Technology as a tool to assist humans

The second value emphasises the role of technology as a tool; a means to an end, rather than an end in its own right. Technologies should be designed to meet human goals and fit human ways of working. In the context of advanced AVs, one may wonder whose goals are being prioritised. While promises of improved safety are promoted, such goals could be met through other means, such as improving public transportation, or improving land use planning to minimise the need to travel long distances and promote active transport modes such as walking and cycling, with accompanying health benefits. A cynical perspective may be that commercial goals, or a motivation to push the limits of technology and innovation, may instead be at play.

3. Promote quality of life

This value reminds us that people cannot be considered as simply machines or extensions of machines. They should be provided with quality tasks. Such tasks incorporate a level of challenge, involve variety, scope for decision-making and choice, provide opportunities for ongoing learning, incorporate social support and recognition of people's efforts, and has some relevance towards a desirable future. It may be argued here, that at least for some people, there is a sense of skill and mastery in the process of learning to drive, and enjoyment in the process of driving. Indeed, in some sense in our modern culture gaining a licence represents a 'coming of age', a marker that an individual has reached a level of maturity. The implications for car dependent societies when there is no differentiation between driver and passengers will be interesting.

4. Respect for individual differences

Here, it is acknowledged that individuals have varied needs and preferences. Design processes should recognise and respect differences and work towards achieving a flexible design that incorporates different preferences, or provide people the ability to tailor their design to their preferences. For example, AVs that allowed the user to select their preferred level of automated functions would align better with this value than those with a one-size-fits-all approach.

5. Responsibility to all stakeholders

The final value takes a broad view to consider the consequences of design choices on all stakeholders (e.g. end users, manufacturers, unions, industry bodies, government bodies, the wider community). Potential negative consequences may be physical damage or injury (e.g. accidents), economic losses, or social and environmental harms. Impacts should be considered throughout all stages of the system life cycle from design through to de-commissioning. In the case of AVs, decisions to optimise user convenience, such as AVs dropping their passengers 'at the door' of their destinations before parking themselves, may reduce incidental exercise of walking from a parking building to an office, and with that, loss of business for local cafes as commuters no longer stop in for their morning coffee. Further, while the convenience of being able to work productively while commuting may suggest the opportunity to reduce work demands by allowing employees to catch up on work, it will likely have the impact of extending working hours and placing higher expectations on employee productivity as this becomes an expectation within an organisation.

While there is more to STS than a set of values, they provide us with a starting point for conversations about design and its consequences. By making values explicit, we become more aware of the trade-offs that are being made in each design choice.

A/Prof Gemma Read

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Practitioner Connections

Dr Clare Dallat

Executive Director, *The Outdoor Education Foundation*
Director, *Risk Resolve*
Adjunct Member, *Centre for Human Factors and Sociotechnical Systems*

What is your role?

I am the Director of Risk Resolve, a consultancy that supports educational organisations all over the world to enhance their risk and safety outcomes. As a practitioner with a research background, I love to dance in the space between the two. I always think about ways to combine and communicate contemporary risk and safety thinking with practical and implementable solutions that support the achievement of desired outcomes. I am also the Executive Director of The Outdoor Education Foundation; a charity organisation that exists to increase access for more young people to experience the wonderful range of benefits that participating in outdoor education programs throughout Australia can bring. Finally, I'm honoured to be an adjunct researcher with the Centre for Human Factors and Sociotechnical Systems and serve on the Editorial Board of The Journal of Experiential Education.

What does a typical workday look like for you?

Most of my days involve interacting with individuals and teams to identify, understand, design, trial or review approaches to improving their risk and safety outcomes. This could include sitting in a canoe with an outdoor educator learning about what enhances or constrains their work, working with a Board across four time zones in the USA to increase their understanding of whole system risks, conducting critical incident scenarios for multiple stakeholders at a university, or reviewing a serious incident for a regulator here in Australia.

What HFE theories / methods do you use?

I work in organisations that have multiple people and things interacting. Systems thinking is the primary lens I use and recently I've been using Rasmussen's Risk Management Framework (RMF). The RMF has been so helpful and easily communicable and understandable to multiple audiences. Again, depending on the intended outcome or type of problem being worked, I also use methods such as Cognitive Work Analysis (CWA), AcciMap, ActorMaps and the relatively new Networked Hazard Analysis and Risk Management System (Net-HARMS), that we developed during my PhD (with my supervisors Prof Paul Salmon and Dr Natassia Goode). It's been a hoot to implement Net-HARMS in practice and see its impact on safety in the real world.

How does HFE add value to your organisation?

It's absolutely massive. I come from a sector that has largely viewed incidents (or safety) as the domain of an individual. It was not (and still is not) uncommon to see 'poor decision making' or 'bad judgement' as formal explanations of incidents. My industry is also full of second victims; folks who have experienced trauma and loss and who haven't been cared for as well as they should. HFE offers value to the education/outdoor education sector by helping shift the focus beyond the teacher or the instructor to involve the broader system. Ten years ago, we came together with academia and developed the very successful UPLOADS project (uploadsproject.org); the first incident data collection and analysis system underpinned by a systems-thinking explanation of accident causation. This project has won multiple awards and generated interest from other complex safety critical domains.

> "HFE offers value to the outdoor education sector by helping shift the focus beyond the teacher or the instructor to involve the broarder system"
> *Dr Clare Dallat*

What do you consider are the main barriers and facilitators for the use of HFE in practice?

Changing the dominant paradigm in education that accidents and incidents are the fault of a few is difficult. There are still a few of the old guard left, but it is getting better. We do not have a long history of HFE in this domain and change is hard. The education sector is renowned for being time poor and slow to adjust. It can happen though when the benefits of using HFE can be experienced. Partnerships with academia that have started with a small low-cost pilot and multiple stakeholders who experience a different view of the system (or the problem) have had an excellent return on investment. Relationships and trust need to be nurtured, and practitioners enabled and empowered to build HFE skills. We have a long way to go, but it's getting there.

Meet the CHFSTS Team

Lauren Coventon

Research Assistant

@LaurenCoventon

What is your role?

I have been a CHFSTS Research Assistant since 2017. I work across a number of projects, but my main role is administering the UPLOADS Research Project. UPLOADS is a national approach to incident reporting and learning within the Australian outdoor education sector. It is designed to help organisations learn from incidents and near misses and support the sector to understand the risks involved when conducting a range of outdoor activities (such as bush walking, high ropes courses, or canoeing), and develop incident prevention strategies.

How did you arrive into the world of HFE?

I completed the research component of my Bachelor of Social Science (Psychology) (Hons) under the supervision of the CHFSTS team. I jumped at the opportunity to work with the team upon completing my study because I enjoy working with some of the world leaders in the field of HFE and on innovative projects that use systems thinking methods to make the world a safer place.

What do you enjoy most about your job / research?

I love my job because I learn something new everyday. The CHFSTS team are very supportive and I am continuously being exposed to state-of the-art systems thinking theories and methods via the projects I am working on, as well as the many professional development opportunities offered by CHFSTS.

What's your favorite quote?

"An investment in knowledge pays the best interest." ~ Benjamin Franklin

Samantha Jackson

PhD Student

@_samjackson

What is your PhD research?

My research looks at how the HFE many-models approach can be used to analyse and optimise complex sociotechnical systems. This will be applied within the Australian Defence Force aviation setting.

How did you arrive into the world of HFE?

I am a registered psychologist and I work in the Army Aviation Psychology and Human Factors Section. I have always been interested in the interactions between humans and technology. My job allows me to see the value in applying good psychology and human factors principles within complex sociotechnical systems. This exposure prompted me to pursue a PhD to intensify my influence in enhancing systems performance, safety, and the health and wellbeing of our people.

What do you enjoy most about your job/ research?

I love to learn and understand why and how things work, then apply this knowledge to current and future systems to improve and optimise outcomes.

What book or paper most inspired you on your HFE journey?

One book I relied upon heavily when I started in aviation was Human Factors in Aviation (2010) edited by Eduardo Salas and Daniel Maurino.

What's your favourite quote?

"The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn" ~ Alvin Toffler

The quest for the ring: Using Human Factors and Ergonomics in the design of Defence systems

Emeritus Professor Neville Stanton, University of Southampton

Neville is an Adjunct Member of the Centre for Human Factors and Sociotechnical Systems

The discipline of Human Factors and Ergonomics (HFE) emerged during the second World War. It is perhaps not surprising that HFE has a long history of supporting the design, evaluation, and operation of advanced defence systems. The Human Factors team at the University of Southampton are engaged in a major program of research involving the design and evaluation of submarine control rooms which utilises their state-of-the-art submarine simulation laboratory: Command Teamwork Experimental Test-bed (ComTET). A key focus of the research was to challenge traditional control room configurations, which are often forward facing leaving the managers and supervisors staring at the back of the operatives heads, as is the case for other control rooms, such as the National Grid, European Space Agency and NASA. Since World War 2, submarine control room configurations have changed very little. For example, a Second World War submarine Captain could walk around a modern-day Astute class submarine and recognise all the work being done and in the positions they were being done 70 years ago. Obviously, the technology has changed, but the layouts have remained largely the same.

> "A key focus of the research was to challenge traditional control room configurations"
> *Prof Neville Stanton*

Over the past eight years, the ComTET program has been investigating the performance of submarine command teams in different design configurations and scenarios, such as returning to periscope depth, dived tracking, and inshore operations. The research enables judgement to be made on the impacts of the different configurations on performance and their utility for future defence systems.

Traditional submarine control configurations were designed with the sound room (where the sonar operator would be detecting contacts) separate from the control room (where the captain would be building up the tactical picture with information from the sound room). As you could imagine, this separation presents opportunities for problems regarding information flow between the sound room and the control room. For example, there is the potential for information bottlenecks between sound and control rooms, as information is passed from one to the other. This potential problem prompted the first study, which was to put the sound room and the control room together to remove the separation of people and information. Using the Event Analysis of Systemic Teamwork (EAST; Stanton et al., 2019) method, the research team aimed to understand how information was used by submarine command teams and how it flowed around the control room. In hindsight, it appears obvious that the flow of information would be improved by removing the separation of the sound and control rooms.

From this initial idea, it was decided, on the basis of the information flow, to redesign the entire control room. The performance of multiple command teams was investigated using different control room manipulations (combined control room, reduced crewing, and a ring control room) against a baseline of current configuration for A-Boats. The findings demonstrated that a ring control room configuration, with the control room management located in the

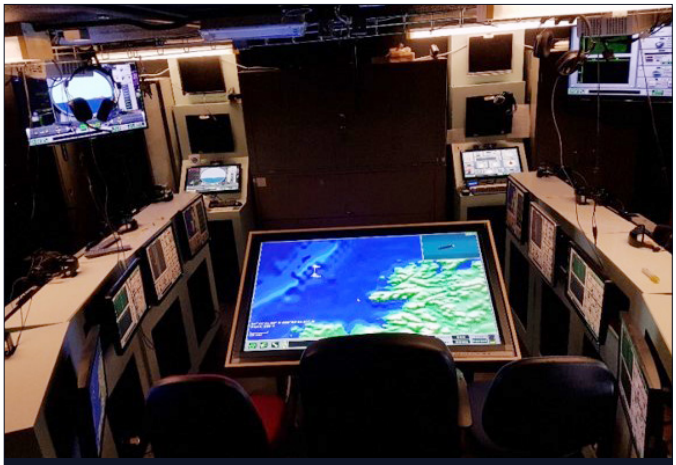
middle and the staff facing inwards, led to greater efficiency and effectiveness. What we found with the ring configuration was that people would do more work, control more contacts, and the volume of information traffic increased. Further, the number of interruptions from supervisors and management reduced because they could actually see the work that was going on. For example, the potential problems of the bottle neck of information from one room to another was removed, and by putting people in the same room allowed them to converse directly in the building of the tactical picture.

The information provided by EAST was critical for the research as it demonstrated that the command team are more flexible in their use of information in the ring configuration, dependent on the context of the operation being conducted. The increased number of nodes and edges in the ring configuration indicate that information transition was more focused, structured, and task relevant. However, compared to the baseline study, the density of the networks decreased, perhaps due to the fact that operators were no longer 'chunking' information and instead, information was passed as it was required. Such improvements in information flow appear to have facilitated the completion of a greater number of tasks, especially in high demand scenarios, indicating that the ring configuration has increased the capacity of the command team. Based on these analyses, the ring configuration is now in the program for future platform development.

> "This project is a key part of our Submarine Combat System Program - this helps us to scientifically assess and develop our people and their skills to best operate the latest submarine technology." *Captain Dave Matthews*

The work shows clearly the critical role of HFE methods and principles in the design of future defence systems. Rear Admiral John Weale (OBE), Assistant Chief of Naval Staff Submarines commented: "This is a great project and facility which is driving innovation in how we get the best out of our people and their skills, to deliver the most technologically advanced submarine capability. It further demonstrates the exciting future combination of the very best people, skills, science and technology." Similarly, Captain Dave Matthews, Acquisition Team Leader at UK Ministry of Defence stated that: "This project is a key part of our Submarine Combat System Program - this helps us to scientifically assess and develop our people and their skills to best operate the latest submarine technology."

The success of the ComTET laboratory is such that it has been emulated by other organisations. Examples include the CRUSE laboratory at the University of Western Australia (currently collaborating with



Command Teamwork Experimental Test-bed - Ring Layout

Professors Salmon and Stanton on an Undersea Decision Superiority Research Network submarine control room design project) and the DSTL secure ComTET laboratory in the UK, as well as similar facilities and BAE Systems and Thales. All of these have been inspired by the ComTET laboratory and the HFE research conducted by the ComTET team at the University of Southampton.

This research project has also demonstrated the utility of Human Factors methods when applied to complex problems, such as the working of command teams in submarines. Without the evidence that clearly demonstrated the benefits of the ring configuration across a range of scenarios, there would be no motivation to change the layout of the sound and control rooms, and future submarine layouts would remain the same as they have always been, harking back to the design of those over 70 years ago.

Emeritus Prof Neville Stanton

University of Southampton

@Prof_N_Stanton www.southampton.ac.uk

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CHFSTS Alumni

Dr Eryn Grant

Senior Human Systems Engineering Specialist, Boeing Defence Australia

When did you graduate and what was the topic of your PhD?

Officially I graduated in early 2020. My research identified common accident causation tenets from systems thinking based accident causation models and then tested them in various ways to see if they could be used predictively.

What motivated you to start a PhD with the CHFSTS?

I was frustrated that "Human Error" was still being cited as a significant cause of accidents in official reports. From the work I had done at the Centre I knew this simply wasn't true. Through my PhD studies I wanted to show that systems thinking approaches to safety are accessible and applicable to everyday problems and the application of methods can unravel system complexity.

What aspect(s) of your PhD did you most enjoy?

All the opportunities to meet our Human Factors heroes at conferences. I was supported through USC and CHFSTS funding to present research papers at conferences in Europe, USA and across Australia.

Where are you working and what is the focus of your work?

I currently work at Boeing Defence Australia within the Systems Engineering, Integration and Test capability as a Human Systems Engineering (HSE) specialist.

The HSE team work across multiple projects providing exposure to many innovative and complex systems. The focus of my work can vary, but the central focus is always Human Factors Integration. My areas include autonomous systems design, lunar exploration and battle space communication management, however I may be asked to assist with other projects as needed.

How has the information and knowledge gained during your PhD influenced your practice?

Through my PhD experience I gained knowledge in several Human Factors methods which gave me the ability to communicate the "so what" aspect of my work to engineers, project managers and leadership teams. I get asked the "so what?" question regularly – especially when presenting data related to Human Factors analysis. My job involves showing a range of specialists the benefits of integrating cutting edge Human Factors methods early in design. People are extremely supportive when they see the value Human Factors can bring – however if communicated poorly the message can be lost and with it the chance to impact change. Thanks to an excellent supervision team, I was always encouraged to communicate outcomes effectively as a PhD candidate. So, it isn't just about knowing how to apply a method correctly, it's how to communicate why the results matter. This enables me to influence systems in a positive way in my daily practice through design solution, integrating Human Factors requirements or impacting change to safety management.

What advice would you give people who are thinking about starting a PhD?

The advice I would give is, know that the PhD process takes time and therefore study something that's meaningful to you, as this will help you stay on track for the long haul. You also need to think how a PhD can influence your career and future opportunities. So, it's also important to consider the key issues impacting our world and where you can provide value in the future.

Interested in applying HFE in:

- Transport & Infrastructure
- Defence, Security, & Resilience
- Sport & Outdoor Recreation
- Organisation Safety, or
- Land Use Planning & Urban Design

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HFE Conferences

28 - 30 September 2021	**Australasian Road Safety Conference** *Online*	**20 - 24** March 2022	**International Symposium on Human Factors and Ergonomics in Health Care** *New Orleans, USA*
October 2021	**65th International Annual Meeting of the Human Factors and Ergonomics Society** *4 - 8 October, Baltimore, USA* *25 - 27 October, Online*	**April** 2022	**CIEHF: Ergonomics and Human Factors 2022** *11 - 12 April, Online* *25 - 26 April, Birmingham, UK*
8 - 9 November 2021	**Human Factors and Ergonomics Society of Australia 2021 Conference** *Online*	**20 - 22** April 2022	**Human Factors and Ergonomics Society, Europe Chapter: Annual Meeting** *Liverpool, UK*
17 - 19 November 2021	**INCOSE: Human System Integration Conference** *San Diego, USA*	30 April - 6 May 2022	**CHI 2022: Conference on Human Factors in Computing Systems** *New Orleans, USA*

Journal Special Issues

Special Issue Title	Journal	Submission Deadline
Sustainability, business responsibility and occupational health, safety and wellbeing	Safety Science	30 September, 2021
Gender and work in ergonomics: Recent trends	Ergonomics	30 September, 2021
In the face of crisis: Human Factors in organisational and operational research	Central European Journal of Operations Research	1 October, 2021
Safety, health, and ergonomics in cleaning occupations	Applied Ergonomics	30 November, 2021
Human Factors and ergonomics in cities, urban design and development	Human Factors and Ergonomics in Manufacturing and Service Industries	30 November, 2021
Safety science in the new age of work	Safety Science	30 December, 2021
Human-centric production and logistics system design and management: transitioning from industry 4.0 to 5.0	International Journal of Production Research	31 December, 2021

Recent Publications *(Email chfsts@usc.edu.au if you are unable to access a publication)*

Desmond, D., Salmon, P. M., & Lacey, D. (2021). Functional systems within cryptolaundering processes: A work domain analysis model of cryptolaundering activities. *Journal of Cyber Policy*, 1-22. https://doi.org/10.1080/23738871.2021.1948088

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