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COMFORTABLE SARDINES: THE BALANCE BETWEEN COMFORT AND CAPACITY

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Contents

Summary

This report describes the findings of a feasibility study conducted to review factors influencing the comfort of rail passengers when passenger density is high, including situations where passengers stand during the journey. The state of knowledge of passenger movement and thermal comfort in crowded trains, comfort when standing and walking in a moving environment, and high density seating is summarized. Research is proposed to assist optimisation of the trade-off between passenger density and passenger comfort on trains. The proposed studies take into account comments and suggestions provided by rail industry representatives.

The study was one of a portfolio of feasibility studies conducted under the EPSRC-funded RRUK Feasibility Account 'Factor 20 – reducing CO_2 emissions from inland transport by a major modal shift to rail' (EP/H024743/1).

1. INTRODUCTION

Over the past 10 years, rail passenger numbers have risen by about 40% and the industry is expecting demand to double over the next few decades. Peak-time timetables are at maximum capacity and it is difficult to lengthen trains. Levels of overcrowding are likely to increase with a continuing rise in the demand for rail travel. Increasing passenger density on a train will reduce the CO_2 emission per passenger. However, any reduction in passenger comfort associated with increased passenger density is expected to encourage travel by car, which would increase CO_2 emission per passenger. Minimisation of the CO_2 emission per passenger requires an understanding of the trade-off between passenger density and passenger comfort.

This report describes the findings of a feasibility study conducted to review factors influencing the comfort of rail passengers when passenger density is high, including situations where passengers stand during the journey. The state of knowledge on passenger movement and thermal comfort in crowded trains, comfort when standing and walking in a moving environment, and high density seating is summarized.

The study involved three University partners who brought complementary expertise to the study: the Human Factors Research Unit, in the Institute of Sound and Vibration Research, at the University of Southampton; the Pedestrian Accessibility and Movement Environment Laboratory at University College London; and the Environmental Ergonomics Research Centre at Loughborough University.

A symposium was organised with representatives of the railway industry to discuss ideas and proposals for future investigation (see Appendix). Research is proposed to assist the optimisation of the trade-offs between passenger density and passenger comfort on trains. The proposed studies take into account comments and suggestions of rail industry representatives.

2. FACTORS AFFECTING THE COMFORT OF RAIL PASSENGERS WHEN TRAVELLING AT HIGH DENSITY

2.1 Passenger movement into and around a crowded train

2.1.1 <u>Standards</u>

The statutory framework for the standards that refer to train carriage access for people with disabilities (HMSO, 1998; Department for Transport and Transport Scotland, 2008) is the Disability Discrimination Act 1995; 2005 (Great Britain Parliament, 1995; Great Britain Parliament, 2005). These standards specify that doorways need to be greater than 850 mm wide and that the maximum horizontal and vertical distance between the platform and the carriage floor should be 50 mm (horizontal) and 75 mm (vertical) otherwise a lift or ramp is required. In addition, 10% of the available seating should be priority seating for the elderly and disabled, with at least two wheelchair spaces (but depending on the number of carriages).

Emergency evacuation of train carriages is covered by the European Commission Directive 96/48/EC (The Commission of the European Communities, 2002). This states that the door dimensions shall be at least 700 mm × 550 mm and that they allow the complete evacuation of passengers in normal operation within three minutes. No passenger seat will be more than 16m from an emergency exit and there should be at least two emergency exits for each carriage. The Strategic Rail Authority state (UK Department for Transport, 2005) that automatic doors should take 3 seconds to open and remain open for at least 6 seconds, although they do not explain the rationale behind these requirements.

The ‘Level of Service’ concept was developed for assessing vehicle flows and subsequently adapted by Fruin (1971) to categorise space used by pedestrians. This concept categorises a space according to the number of people moving within it, assigning a functional classification from low density ‘A’ to high density ‘F’, where ‘F’ has been described as ‘crush’ conditions. The Highway Capacity Manual (TRB, 2000) has incorporated these categories into chapter 13. However there is disagreement over what each category means in practice. For example, higher individual maximum speeds and space occur in category ‘A’ whilst the highest flow rate occurs in category ‘E’. There is currently no equivalent system directly applicable to either travelling on, or boarding and alighting from, trains.

2.1.2 Experimental research

Experimental work has focussed on evacuation times or steady state movement of pedestrians on level surfaces, through bottlenecks, up/down stairs, or considered the dwell time of trains in stations. The problem with bottleneck studies, (for example, Winkens *et al*., 2008) is that the free flow of people once they are past the bottleneck is not applicable to train boarding. In addition, evacuation studies (Oswald *et al*., 2008) do not include the movements of people onto the train. Emergency evacuation times are not comparable to everyday flow rates as the number of people boarding is low in evacuation conditions but not in everyday use, and the psychological forces driving passenger movements are significantly different. References in Section 2.1.3 below on ‘Models’ include elements of experimental justification. The importance of capacity is unknown – how many people can get into train carriages given unlimited time (acceptable comfort levels for passengers) or the capacity given different internal layouts. A UCL project on train carriages for the Department for Transport examined boarding and alighting with different door/vestibule dimensions and indicated that it would be difficult to get 50 passengers through the doors in the requested 27 seconds (Fujiyama et al (2008)). This finding fits with the summary of board/alight times discussed in Wiggenraad (2001) of approximately 1 s per person measured in train stations. Lee *et al*. (2007) observed travellers at Dutch train platforms and suggested that vehicle design and crowding non-linearly affect board and alight times. Evans and Wener (2007) found that seat density (the ratio of the number of people to seats in the immediate area of the passenger) has a more important influence on passenger stress than car density (the ratio of the number of people on a passenger car to the total number of seats). Cox *et al*. (2006) suggested that high-density and crowding are not necessarily synonymous, suggesting that a high density might be achieved without perceptions of crowding.

2.1.3 <u>Models</u>

Most pedestrian/passenger models try to address how pedestrians evacuate buildings or ships in case of emergency and fire, in particular focussing on capacity issues at bottlenecks such as doorways. There are continuous and discrete methods. Continuous models calculate position based on so called ‘social forces’, parameters that reflect interpersonal psychological relations that attract or repel the pedestrian from their surroundings (Helbing and Molnár, 1995). Discrete methods apply cellular automaton techniques with rules as to how pedestrians move from one cell to another in arrays created to represent the pedestrian space (Fukui and Ishibashi, 1999).

These models either consider pedestrians as steady state flow (for example along corridors) encountering obstacles (for example bottlenecks such as doorways that affect flow rates), or in terms of evacuation. Consequently they are not interested in where the pedestrian ends up. The ‘social forces’ each passenger is subjected to may be different when boarding a carriage, travelling on the carriage, and when alighting. These states are not sufficiently understood to be incorporated into these models. In addition, the train evacuation models have not included people in wheelchairs (Capote *et al*., 2008).

One cellular-automata-based model considers boarding and alighting the Beijing metro (Zhang *et al*., 2008). The group size boarding/alighting was varied and compared to four different platforms over three stations. The trains and platforms were the same; therefore carriage layout, doorway width, and height from the platform were not considered. Models may appear to have the benefit of creating optimised results prior to a solution being built, but it is important to remember that all the models are based on assumptions and simplifications. Rogsch *et al*. (2005) reported the variations in evacuation times calculated from a number of simulation programs set with simple geometries.

2.1.4 Conclusions and recommendations for future work

'Level of Service' appears to be a useful concept for comparing pedestrian movements in different locations, but it is not directly applicable to train travel, where people board, stay, and then alight. It would be useful to expand this concept, to incorporate these phases and, importantly, include passenger comfort. The limitations of existing pedestrian models are that they are validated by macroscopic indices (for example, it took XXX seconds to evacuate the building in a fire drill and a simulation shows a similar result). In addition, all the obstacles in the existing simulations are continuous. It is likely that people's reactions change according to the shape and other properties of obstacles. Passenger comfort is not well understood in terms of physical proximity when boarding, travelling on, or alighting train carriages and the perception of comfort may be expected to vary with each of these actions, travel time, and the carriage layout. The interactions between people and between a person and a facility are not understood. Such interactions can be analysed in the Pedestrian Accessibility and Movement Environment Laboratory of the University College London. A pedestrian simulation model can be developed to include functions for stable pedestrians and their reactions to external environmental stimuli as well as their interactions with other passengers and the characteristics of the carriage.

2.2 Thermal comfort in a crowded train

2.2.1 Standards

British Standards BS EN 13129 Parts 1 and 2 (2002) and BS EN 14750 Parts 1 and 2 (2006) provide guidance on the 'bench marking' of train climate control. Tests are conducted on stationary unoccupied carriages and provide guidelines for internal temperature requirements for a range of external temperatures (-40°C to 40°C). Air flow rates are also considered.

Other standards for the evaluation of train environments are based on the responses of humans rather than the carriage (ISO 7730, 2005; ISO 7933, 2004). These standards provide guidance on how the occupant will react to a given thermal environment in the carriage.

2.2.1.1 Scope

The standards consider mainline, urban, and suburban railway carriages. The standards are applicable to both passengers and railway staff, with the exception of cooking areas. Additional standards for driver cabins are also available.

2.2.1.2 Limitations

The current applicable standards do not adequately consider occupied carriages. The published data on the thermal responses of people in densely occupied spaces provides only limited support for current standards or the development of new standards.

2.2.2 Experimental work

Few studies have specifically investigated the thermal comfort of train passengers. The focus of most published work has been on how to quantify the thermal environment to optimise thermal comfort (Berlitz and Matschke, 2002; Chow, 2002; Parsons, 2005; Underwood and Parsons, 2005). These studies considered the carriage environment based around traditional comfort models and indices (ISO 7730, 2005; Fanger, 1970). The carriage environments that were considered were fully air conditioned rather than naturally ventilated. Many factors can affect how a person responds to a thermal environment: air movement, air temperature, relative humidity, activity, and clothing. A railway carriage presents a complex micro climate. Crowding is thought to increase the level of thermal strain upon occupants, restrict heat loss mechanisms, and provide psychological stressors (Karlin, McFarland *et al.*, 1976; Walden and Forsyth, 1981; Evans and Wener, 2007). As the density of occupants in a carriage increases, heat loss into the passenger space and radiative heat exchange between passengers increase. The effectiveness of ventilation and air conditioning systems is reduced with heavy crowding, adding to heat gain within the carriage. Systems for the delivery and control of the thermal environment have yet to be optimised.

Clothing is an important confounding factor. Densely populated carriages offer little opportunity for passengers to adjust or remove clothing. Clothing may be more of an issue in the winter, when passengers are dressed for external environmental conditions rather than the ambient conditions in the train carriage.

A further factor that needs to be considered is the duration of journey. For exposures to hot environments (+30°C) of short duration (e.g., 10 minutes or less), passengers rarely suffer adverse effects. Passengers on longer journeys in densely populated carriages may find such high temperatures harmful.

2.2.3 Models

The modelling of thermal environments has become a common method of evaluating the effect of an environment on a person (Fiala *et al*., 2001; Parsons, 2003). Traditional thermal comfort indices, such as the Fanger/ISO PMV model (ISO 7730, 2005; Fanger, 1970), are steady state models that provide predications of how people will feel in a constant homogenous environment over a period of time (20 to 30 minutes minimum). However, passengers are not usually exposed to this type of environment on commuter trains. The environment is more appropriately described as transient, and a different approach applies (Zhang, Huizenga *et al*., 2004).

For more complex environments, coupled models have been developed. Fiala *et al*, (1999) proposed a human thermoregulation model placed inside a CFD model of the physical built environment, in this case the train carriage. The two models then interact with each other.

2.2.4 Conclusions and recommendations for future work

The effect of crowding on the human thermal response is an area where there has been very little research. It is therefore uncertain what interactions are likely with other environmental parameters (e.g., clothing, air temperature, air movement). A study that considered a series of different crowd densities and environmental conditions and included variations for summer and winter clothing ensembles would give information to those designing carriage heating and ventilation systems. The results may be used to improve understanding of three factors that have a significant effect on the thermal comfort of passengers:

i. Crowding: The effect of being surrounded by a large number of people is likely to affect the ability of an individual to lose heat. There would also be increases in radiation and conductive heat exchanges between passengers depending on the density of the crowd. It is not yet known at what level of crowd density the effects on the individual become adverse.

ii. Temperature and air movement variation: Air movement is reduced by increasing passenger numbers. A range of ambient air temperatures and air velocities would be evaluated so as to assist the optimal delivery of ventilation and air conditioning and achieve maximal cooling and control of the environment.

iii. Clothing variation (winter versus summer): The increased clothing worn during winter could result in winter conditions provide similar levels of heat strain as those in summer.

The study would use three investigative methods: experiments with volunteer participants, thermal manikin, and thermal model evaluation.

Crowding (standing) conditions would be investigated (e.g. very high density (8 people/m^2), high density (6 people/m^2) and moderate density (4 people/m^2)). Passenger density will affect both ambient temperature and air movement through the carriage and around the occupants, so air temperatures and air flow rates would be investigated. Two clothing conditions would be evaluated: winter clothing (1.2 clo) and lightweight summer clothing (0.4 clo). The effects of high-density seating can also be investigated in the same way.

An additional factor that should be considered is the development of 'acceptable' thermal comfort boundaries. Traditional thermal comfort research and models (Fanger, 1970; ASHRAE 55, ISO 7730, 2005) have a narrow range of conditions that are considered thermally comfortable. Recently, the idea of extending these ranges has been considered with the aim of reducing heating and cooling requirements. Research into establishing subjective thermal comfort boundaries for carriages could have significant benefits for the provision of the thermal environment on trains.

The proposed study would provide a wealth of data that would advance understanding of the thermal responses of people exposed to crowded conditions in railway carriages. The practical data should also assist train manufacturers and operators developing environmental control systems to deliver thermal comfort.

2.3 Comfort and stability when standing and walking in moving environments

To achieve greater rail passenger density, increased numbers of passengers will be required to stand during all or part of journeys. An understanding of the comfort of standing persons in moving environments is required to optimise rail carriage capacity. Rail passengers seldom stand freely, often using body supports such as bars, seats, hanging straps or inner walls to stabilise their body during train motion. To optimise supports for standing passengers, an understanding of their effects on stability and comfort is needed.

2.3.1 Standards

Standards that may be used to evaluate the whole-body vibration experienced by rail passengers are International Standard ISO 2631-1 (1997), British Standard BS 6841 (1987) and European prestandard ENV 12299 (1999). These provide methods for evaluating vibration with respect to comfort and health and advice that the vertical and horizontal motions experienced by standing people should be evaluated from the frequency-weighted root-mean-square acceleration.

2.3.1.1 *Limitations*

The relevant frequency weightings, W_d for horizontal motion and W_b for vertical motion, recommended in BS 6841 (1987), ISO 2631-1 (1997) and ENV 12299 (1999) for predicting the discomfort of standing people were derived primarily from studies of seated people. The standards do not claim to predict the postural stability of standing people but there is evidence that loss of stability contributes to the discomfort of standing people exposed to some types of motion and that the frequency weightings do not provide good indications of the discomfort of standing rail passengers.

There are no standards offering guidance on how motion affects walking people.

2.3.2 Previous studies

There is evidence that the W_d frequency weighting for horizontal vibration recommended in BS 6841 (1987), ISO 2631-1 (1997), and ENV 12299 (1999) is not appropriate for standing people. Frequency weightings derived experimentally from subject response to fore-and-aft and lateral oscillation correspond to constant velocity at frequencies less than 3.15 Hz and constant acceleration at higher frequencies, whereas W_d corresponds to constant acceleration at frequencies less than 2.0 Hz and constant velocity at frequencies greater than 2.0 Hz (Thuong and Griffin, 2010a). Loss of balance was the principal cause of discomfort at frequencies less than 3.15 Hz. There is also experimental evidence that when walking sensitivity to lateral oscillation is proportional to the velocity of the motion: the probability of transient oscillations over the frequency range 0.5 to 2 Hz causing loss of balance was similar when the motions had similar velocity (Sari and Griffin, 2009).

The provision of supports may assist postural stability but increase the transmission of vibration to the body and increase vibration discomfort. Leaning with the lower back or shoulder against a wall increases discomfort due to increased transmission of vibration to the upper-body, whereas holding a vertical bar does not increase discomfort (Thuong and Griffin, 2010b).

Passengers adopt various postures during rail journeys (e.g. standing, sitting, or leaning). Vibration may cause involuntary changes in stance and passengers may alter their stance in an attempt to reduce the effects of vibration. For example, standing passengers may place their feet further apart to increase their stability.

2.3.3 Existing models

Postural stability is dependent on a complex musculoskeletal system and on feedback from visual, vestibular, and proprioceptor senses. Various studies have investigated how models may be used to predict stability: passive models (e.g.

Graham, 1990), segmented rigid-link dynamic biomechanical models (e.g. Kodde *et al.* (1982), Koozekanani *et al.* (1980) and Stockwell *et al.* (1981)), and active biomechanical models (e.g. Ishida and Imai, 1980; Ishida and Miyazaki, 1987; Johanssan *et al.,* 1988). Most postural stability models have been developed for stationary environments and so the influence of postural supports has not been considered.

2.3.4 Conclusions and recommendations for future work

There is currently no guidance on how to provide postural support for standing or walking passengers. Passengers must often stand (due to high passenger densities) and they walk to enter and leave the train, often when the train is in motion. With increased age among the travelling public, sufficient support for standing and walking passengers is increasingly important.

It is proposed to identify methods, provide guidance, and make recommendations for the provision of suitable supports for standing and walking passengers in trains. The research will involve a review of existing methods used world-wide and experimental studies using laboratory simulations of train motions.

2.4 High density seating: perches

To achieve high densities, train passengers must stand, but it is uncomfortable to stand for long periods and the motions in trains cause greater instability when standing than when seated. Holding onto a support occupies a hand and restricts reading and other tasks, and leaning against a support increases discomfort due to increased transmission of vibration to the upper-body.

Standing perches have the potential to achieve greater comfort for standing passengers and higher passenger densities than conventional seating. This could leave wider spaces for standing commuters and wheelchair users, and greater ease of movement during boarding or alighting from the train. However, there is little experience in the design or use of perch seats on which to base guidance for optimizing comfort, stability, and convenience for a mixed population of male and female passengers of varying age and size. Perch location, orientation, composition, dimensions, angles, and contouring must be selected to provide static and dynamic comfort.

2.4.1 Standards

A laboratory method for evaluating the transmission of vibration through seats using the SEAT value method is defined in ISO 10326-1 (1992). This method is widely used to assess seat performance in road, off-road, and rail vehicles, but requires development for use with perches. Laboratory tests for the transmission of vibration through railway vehicle seats are defined in ISO 10326-2 (2001). This standard defines the vibration responses of a seat by various frequency response functions. It has not previously been used to assess perches.

2.4.1.1 Limitations

Although techniques exist for measuring, evaluating, and assessing seat comfort, these have not been applied to standing perches. Perch designs need to be assessed in terms of static and dynamic comfort, postural stability, and the ability to perform tasks (e.g. reading, writing, talking, use of phones and computers, carrying, etc.).

2.4.2 Conclusions and recommendations for future work

It may be possible to achieve moderately high passenger densities with simple perches that provide sufficient support to reduce the discomfort of long periods of standing, sufficient stability to avoid the need to hold a hand support, and yet do not increase vibration discomfort.

By means of experimental and other research, it is proposed to evolve and test designs for standing perches that allow comfortable and safe high density perching on trains.

The research would develop an understanding of the principles involved in providing comfortable perches for standing passengers. Experimental studies might also evolve methods of evaluating rail vehicle motion with respect to the postural stability and discomfort of persons using perches.

3. STUDIES TO DEVELOP THE RAIL CARRIAGE OF THE FUTURE

To optimise the design of rail vehicle carriages for increased capacity while maintaining or improving comfort, postural stability, and accessibility, collaborative studies are proposed focussing on the following areas:

3.1 Passenger movement and comfort with high density seating

Overall objective

To improve understanding of factors that influence passenger movement into, around, and out of carriages and their satisfaction and comfort during medium duration high density journeys.

Specific objectives

- To obtain empirical evidence and develop a model of carriage loading and unloading times and how they are influenced by vehicle geometry, seat configuration, passenger type, baggage, platform infrastructure, information provision to passengers, etc.
- To develop an understanding of body supports required in a motion environment for passengers, especially those with increased risks of instability (due to age, etc.).
- To understand the critical factors influencing passenger comfort in high density seating;
- To develop an understanding of how support can be provided by perches.

Methodology

- Experimental studies to improve understanding and develop a model of access to rail carriages with different levels of passenger density and different internal carriage layouts for a wide range of passengers.
- Experimental studies involving standing and walking subjects exposed to simulated rail vehicle motions to improve understanding and make recommendations for the provision of supports to provide postural stability and comfort.
- Experimental studies involving seated subjects and the development of guidance on comfort with very high density seating.
- Experimental studies to obtain subjective assessments during exposure to rail vehicle motion with different perch designs and with changes in perch height, pitch, and width.

Outputs

The investigations of postural stability, supports, perches, and seat dimensions will be used to provide design guidance that can be used to optimise seating density.

The studies of passenger accessibility will be used to create models that can be used to optimise carriage layout for improved access and increased passenger density.

3.2 Thermal comfort

Overall objective

To develop an understanding of the principal factors influencing thermal comfort in crowded trains.

Specific objectives

- To develop a thermal comfort model integrating the unique effects of densely crowded environments
- To provide guidance on desirable thermal ranges for occupants and carriages.

Methodology

It is proposed that the effect of passenger density is investigated with experimental studies using human subjects and thermal manikins. The studies could include simulation studies with and without train motion.

Outputs

The outcomes of the studies will be compared with predictions of a coupled thermal environment model. This would lead to a validated predictive tool for designers. In addition, a study investigating the subjective acceptability of thermal comfort ranges within carriages would help to establish acceptable operating envelopes for designers.

3.3 The value of comfort

Overall objectives

To develop an understanding of the value of comfort to passengers.

Specific objectives

- To develop an economic model that indicates the value passengers attach to comfort
- To conduct laboratory and field studies to support the development of the model and determine the importance of variations in density and motion during travel (e.g. standing with variable density and variable motion instability compared with sitting or perching).
- To examine existing data on usage of rail services (e.g. through LENNON ticket sales data) and customer satisfaction (e.g. through the National Passenger Survey) to determine whether passenger comfort is having a detectable impact on demand.

Methodology

- Undertake laboratory experiments with variable density and motion supplemented with attitudinal and stated preference[1] questionnaires.
- Undertake field trials, for example of a low density/good ride quality route (perhaps recently improved) compared to a high density/low ride quality route using attitudinal and stated preference questionnaires, supplemented by direct observations (e.g. of motion). Incorporate expert assessments of comfort (e.g. Walmsley, 2011)
- Calibrate stated preference models to determine the monetary values customers place on comfort using data from both the field trials and the laboratory experiments.
- Rescale the stated preference models with revealed preference data on the usage of services where there have been significant changes in comfort (e.g. through the introduction of new rolling stock – see Wardman and Whelan, 2001)). Calculate the elasticity of demand with respect to comfort factors.

Outputs

- Produce tabulations of the values of comfort, similar to those produced for other service attributes in the Association of Train Operating Companies Passenger Demand Forecasting Handbook and Transport for London's Business Case Development Manual.
- Relate the tabulated values to psychophysical data collected in the laboratory experiments and field trials, as well as physical and attitudinal measures (including data in the National Passenger Survey).
- Undertake an economic appraisal of an intervention designed to improve comfort, using the values that have been estimated.

3.4 Project partners for future proposals

Proposals for future studies build on the unique practical experience and academic knowledge of four University groups who bring complimentary expertise: the Human Factors Research Unit and the Transportation Research Group (at the University of

[1] Stated preferences are elicited from hypothetical situations. For example, rail users can be presented with hypothetical situations concerning different combinations of comfort and rail fares, and asked to either rate, rank or choose between these situations. For applications to rail overcrowding – see Wardman and Whelan, 2010.

Southampton), the Pedestrian Accessibility and Movement Environment Laboratory (at University College London), and the Environmental Ergonomics Research Centre (at Loughborough University). The academic expertise is complemented by the practical experience of the railway industry.

The Human Factors Research Unit at the Institute of Sound and Vibration Research in the University of Southampton will contribute expertise on the effects of motion on standing, walking, and seated passengers and understanding of ergonomic factors influencing the comfort of seated and standing passengers.

The Transportation Research Group in the School of Civil Engineering and the Environment, University of Southampton will contribute expertise on rail economics and planning, with a particular emphasis on the analysis of revealed and stated preference data..

The UCL Pedestrian Accessibility and Movement Environment Laboratory will contribute expertise on the movement of disabled and able-bodied people around the public environment.

The Environmental Ergonomics Research Centre will contribute knowledge of human responses to indoor and outdoor thermal environments and the effects on thermal sensation, comfort, stress and performance.

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Appendix
Minutes of Rail Research Symposium of 9th December 2010

Minutes

Rail Research Symposium

Comfortable Sardines: the balance between comfort and capacity

Date:	Thursday 9th December 2010	**Time:**	11:00 – 15.00 hrs
Location:	Human Factors Research Unit, Institute of Sound and Vibration Research University of Southampton, SO17 1BJ		

Participants:

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Agenda Items and participant comments

1. Passenger movement in trains

Presentation by Craig Childs.

In addition to boarding, congestion in the vestibule area and passenger behaviour during alighting are of interest. (Mike Jacob)

2. Thermal comfort in crowded trains

Presentation by Simon Hodder.

How might the thermal comfort of both standing people who are unable remove coats and seated passengers who have removed coats be accounted for within the same rail carriage? (Ian Rowe)

3. Comfort and stability when standing and walking in trains; seating density and passenger comfort.

Presentation by Mike Griffin.

There is a need to accommodate the requirements of different durations of journey. (Ian Rowe)

4. General discussion

Area 1: Passenger movement into and around a crowded train

There is limited knowledge of how to facilitate fast access to rail vehicles for passengers. There is a need to understand how rail vehicle design affects passenger behaviour.

It was suggested that experimental studies are conducted to investigate passenger movement with different rail vehicle designs. The influence of marshalling might be included.

Adaptive interiors might be useful.

Faster boarding and alighting might be facilitated by providing better information and training about the boarding and alighting system to passengers. (Mike Jacob)

Area 2: Thermal comfort in a crowded train

Air conditioning makes most trains too cold and is costly to run. (Ian Walmsley)

Thermal comfort is a lower priority than getting passengers onto trains quickly and increasing capacity. (Jamie Prance)

Train air-conditioning systems currently have the capability of improving the thermal comfort of passengers but there problems associated with management of the systems. (Jamie Prance)

Area 3: Comfort and stability when standing and walking in a moving train

Ticket costs affect expectations; comfort is not necessarily the highest priority.

What increase in comfort would tempt car drivers onto trains? (Richard Gostling)

Area 4: Seating density, including perches

Perches are popular with passengers. (Daniel Taylor)

Passengers view postural stability as important; grab rail design and placement is important but often unsatisfactory (Jamie Prance, Daniel Taylor)

5. Discussion of research objectives to optimise passenger comfort and train capacity

Suggested areas of investigation:

Area 1: Passenger movement into and around a crowded train

- The difference in loading times between face-to-face and back-to-face seating (Ian Walmsley)
- The influence of vestibule design and marshalling on loading times: the development of improved models. (Ian Rowe, Jamie Prance)
- Passenger behaviour: where do passengers choose to stand and why? (Mike Jacob)

- The behaviour and objectives of different passenger groups: tourists, commuter, business (Mike Jacob) and different age groups and number of luggage items - the development of improved models, taking account of demographics. (Koji Agatsuma)

Area 2: Thermal comfort in a crowded train

- Acceptable ranges of thermal conditions (Simon Hodder)
- Modelling the effects of passenger crowding (Simon Hodder)

Areas 3 and 4: Comfort and stability when standing and walking in a moving train;

Seating density, including perches

- Experimental studies and the development of guidance and standards on comfort with very high density seating and postural stability when walking and standing. (Mike Griffin)
- Optimising the shape, fabric, overall design, and placement of perches. (Jamie Prance, Mike Griffin)
- Limits of acceptability of seating dimensions, particularly of legroom. (Ian Walmsley, Richard Gostling)
- Postural stability when walking on stairs of double-decker trains (John Preston)

Possible future research themes:

It was proposed that the suggested areas of investigation listed above might be grouped into the following four research themes for possible development into future research proposals:

i. The value of comfort - how to cost and model;

ii. Loading times, including the influence on passenger behaviour of vehicle design and seating direction (face-to-face or back-to-face), ageing, passenger profile, baggage;

iii. Thermal comfort in crowded trains, including guidance on thermal ranges;

iv. Postural stability and comfort when standing and walking, including perch design.

6. Any other business

- Participants will be contacted next year to inform them of proposals arising from the meeting
- There was support for a further meeting on the balance between passenger comfort and capacity.

7. Actions arising from the post-event meeting of Comfortable Sardines partners

All: to edit contributions to report, taking into account input from rail industry representatives at the symposium

HH: to prepare minutes from the symposium.

8. Future meetings

- A teleconference will take place in the first or second week of January to agree on the focus of future research proposals.
- The organisation of a similar meeting will be considered after deciding on any research proposals that emerge from the Comfortable Sardines feasibility project.

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16th December 2010