Designing Smart Motorways

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ABSTRACT

The AmeyArup collaborative design team were commissioned by Highways England to design two new Smart Motorways schemes on the M1 motorway between junctions 13-16 and 23a-25. The human factors (HF) team from Arup proved the value that could be added to the final product early in the project tender and scoping phases, including the added benefit of helping Highways England achieve their strategic aims of improved customer experience, road user safety and service delivery. This led to HF professionals being included in a smart motorways design team for the first time. As the application of a HF approach was novel to smart motorways design, there was little direction or standards to follow for its integration into the design process. The HF team had to explore methods of integrating with the variety of design disciplines and immersed themselves in various relevant design meetings. The team applied a user-centred approach to the design of all infrastructure and assets requiring human interaction. This involved ensuring the needs of all users - including customers, operators and maintainers - were considered at the beginning of the design process and that these groups were consulted during design development. The aim was to ensure the new smart motorway met user needs and enabled them to carry out their intended actions safely. The HF team identified 125 issues that were progressed to closure and accommodated 114 user-specified requirements in the designs.

KEYWORDS

Roads, Highways, Transport

Introduction

Incidents on the UK's motorway and main road network contribute to approximately 25% of the congestion currently experienced and cost Highways England an estimated £500million each year. In response to this problem, Highways England have been introducing Smart Motorways to improve road safety, ease congestion and enable service delivery. Smart Motorways use technology to analyse data collected by the infrastructure to provide information to the road users with the aim of influencing behaviour. The first Smart Motorway scheme was introduced 2006 on the M42 and was deemed responsible for a reduction in incidents by over 50%, and a reduction in the severity of incidents, when they did occur, with zero fatalities and fewer seriously injured.

Amey and Arup (AmeyArup collaborative design team) were commissioned to design two new Smart Motorways schemes on the M1 motorway between junctions 13-16 and 23a-25 and proposed the inclusion of human factors professionals on the design team with the aim of promoting safe behaviours through the design of various motorway infrastructure assets.

The problem

Human factors (HF) had not previously been integrated on a highways design project and no integration strategy or standard was present for the team to follow. The HF team therefore had to integrate with relevant disciplines and, through exploratory studies, find areas where value could be added. This involved the team immersing themselves in various design meetings and workshops with:

- Civil engineers responsible for design of the physical assets such as the road and earthworks below, drainage and bridges and structures;
- Technology engineers responsible for the utilities, telecommunications and systems that make the motorways 'smart';
- Lighting engineers;
- Operations and maintenance specialists; and
- Other specialist designers.

During early design activities, it became apparent that highways designers typically follow standards from the Design Manual for Roads and Bridges (DMRB) that specify minimum requirements for lighting, signage, road geometry, structures and more without necessarily considering the needs of the various users of the motorway. While the standards have been designed to ensure the end-product provides a safe environment, our HF team identified many shortfalls with the standard design parameters that, if addressed, could influence user behaviours to improve safety, reduce congestion and improve user satisfaction. Examples of these improvements would be; ensuring reliable journey times for customers or; easy and safe to maintain infrastructure for maintenance teams.

Our approach

The HF team implemented the human-centred design process as in Figure 1 (defined in the standard ISO 9241 - Ergonomics of human-system interaction) and first developed a HF integration plan. The plan identified the key stakeholder groups for the HF team to engage with:

- Our internal design and engineering teams to raise HF awareness and instil positive usercentred design behaviours;
- 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; and
- The roads' end users, including car, HGV drivers and motorcyclists, to understand their current concerns, their requirements and develop personas for future project stages.

The HF team held various sessions with end-user representatives and SMEs to gather information on each user's aims, goals and tasks to understand their context of use of the motorway. During these sessions, any user wants, and needs were captured and translated into user requirements that were continuously updated throughout the project and shared with the wider design team to enable them to produce design solutions while considering the needs of the end-users (a total of 114 user requirements were identified). The HF team also produced a set of design principles specific to motorway design for the wider multi-disciplinary design team to use and consider when producing their solutions. Examples of these included:

- Timely provision of information to users;
- Information in a clear and concise format;
- Design is consistent; and
- Use / operation / maintenance is intuitive.

The HF team integrated with the multi-disciplinary team to assess and evaluate designs as they were produced. Given the type of project, it was determined the most appropriate evaluation methods were to:

- Involve end-users during design workshops with 3D visualisations to gather their feedback; and
- Use personas (developed during the user engagement and research phase) and walk them through a variety of scenarios developed based on critical infrastructure elements or areas of known safety concern.



Figure 1 - Human-centred design process (from ISO 9241-210:2010)

Following design evaluation, 125 areas for improvement or user requirements that were not met were captured in an issues log. The HF team managed these either by instigating a design iteration to solve the issue or addressing the issue through change to operational processes if deemed a beneficial opportunity.

Examples of value added

As a result of this engagement, the human factors team worked with motorway designers and engineers to ensure that 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 improve 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. An example of where the human factors team considered the need for maintenance staff (who are often forgotten in infrastructure designs where the focus is on customer experience) can be seen in Figure 2.



Figure 2 - Human factors value add - Motorway gantry signage

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 expertise 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. The inclusion of human factors in the design of these smart motorways schemes has aided Highways England to deliver their strategic aims of improving road user safety, customer experience and service delivery.

Further Information

Highways England. 2018. Smart Motorways | Improvements and major road projects. [ONLINE] Available at: https://highwaysengland.co.uk/programmes/smart-motorways/. [Accessed 1 November 2018].