Simulator-Based Driver Training: Moving up a Gear

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ABSTRACT

Introducing simulator-based training to civil markets poses various challenges – from public acceptance of the validity of simulator-based training to simulator adaptation syndrome (SAS).

This paper describes a methodology for establishing an approved commercial facility designed to offer simulator-based driver training. This methodology is based upon observation and evaluation of XPI's experience of setting up and running a Driver Simulation Centre (DSC) offering simulator-based training to commercial drivers. The methodology will inform readers about the challenges associated with provision of such training services, and provide particular focus on the approval of the training centre by the UK Royal Society for the Prevention of Accidents (RoSPA).

While relevant to all audiences, the paper specifically examines aspects relevant to delivery of training within commercial domains, such as engagement of new user communities with limited exposure to simulation and certification by relevant authorities. Common aspects relevant to driver training delivery applicable to all domains, such as device- and system-level user engagement, measurement of training effectiveness and use of consumer technology are also addressed.

ABOUT THE AUTHORS

Timothy Coley has held the role of Product Specialist at XPI Simulation since May 2017. He is responsible for defining the company's product roadmap and ensuring its alignment to customer requirements. Timothy plays a key role in determining and executing company strategy; he is also responsible for coordinating XPI's research activities in autonomous transport solutions. Prior to joining XPI, Timothy performed a variety of roles at Thales UK, XPI's parent company, encompassing government relations, procurement, market analysis and product management. Timothy graduated from King's College London with a first-class joint honours degree in War Studies and French in 2010 and joined Thales UK in 2011.

Steve Dethick has been a road safety professional for over 25 years, initially as an Approved Driving Instructor teaching learner drivers in the Armed Forces and as a self-employed instructor running his own business. Steve progressed to delivering advanced driving training through his career with DriveTech, where he carried out a variety of roles over 18 years including Driver Training Manager, Director of Training and Head of Specialist Training. Most recently Steve has managed the development and opening of XPI Simulation's Driver Simulation Centre (DSC). Steve has designed the DSC's training programs for both simulator- and classroom-based instruction, and gained approval from the Royal Society for the Prevention of Accidents (RoSPA) for both the course material and DSC facilities. This is the first centre of its kind to have achieved this prestigious endorsement.

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INTRODUCTION

Driver-in-the-loop (DIL) simulators have a long history of use for training, automotive development, academic research and entertainment. There are numerous different types of DIL simulator depending on the task in question, but the fundamental benefits of providing a safe, repeatable and data-rich environment in which to instruct, evaluate or examine drivers and automotive systems remain constant. These benefits, however, have not been made widely available to commercial users for a variety of reasons. This paper explains how the recent establishment of a simulator-based driver training facility has sought to overcome these hurdles and propose a methodology for the use of synthetic driver training in civil settings.

In particular, this paper focuses upon the approval of the Driving Simulation Centre (DSC), and the associated driver training course material, by the UK's Royal Society for the Prevention of Accidents (RoSPA). This approval – the first for any such driving simulation centre – represented a challenge to both approver and approved alike, as the concept of simulator-based driver training had to be considered within a matrix that typically covers on-road training activity.

The relatively low uptake of simulator-based driver training in civil markets is explained by a number of factors. In exploring these reasons, one is immediately presented by the relatively low costs of on-road and classroom based training. These have meant that the use of simulation-based training has typically been limited to niche markets for specialist applications where operating costs, or risk to driver safety, can be prohibitive – such as professional motorsport and military driver training. Moreover, the limited public exposure to synthetic training environments means that there is no established public acceptance of the validity of simulator-based training – in contrast to the widespread use of such technology in military environments.

A confluence of factors now brings synthetic driver training within reach of commercial audiences, namely: the reduced cost of simulator equipment through exploitation of commercial-off-the-shelf (COTS) hardware – such as consumer computing and display equipment; the growing awareness of the cost and environmental impact of on-road training; the improved simulator experiences brought about by use of advanced computer graphics, borrowing heavily from the burgeoning video game industry. All of these considerations are supported by a growing evidence base that demonstrates the validity of simulator-based training and its impact on driver skill levels (see, for example, Dorn and Edmunds, 2011, as cited in Grüneberg and Schröder, 2012, Kotilainen, 2014; Sullman, Dorn and Niemi, 2015).

XPI DRIVING SIMULATION CENTRE ESTABLISHMENT AND EQUIPMENT

Through supplying driver simulators to various civil, military and institutional customers, XPI has gained a wealth of understanding in the application of DIL simulation to driver training. XPI has also participated in studies that have validated the use of its driving simulation equipment for providing effective driver training (Defence Science and Technology Laboratory, 2013)

In establishing the DSC (see Figure 1), XPI sought to apply this experience, with particular reference to the South Wales Police simulation-based training establishment (for which XPI provided simulators), as well as accepted state-of-the-art approaches employed across industry and academia.

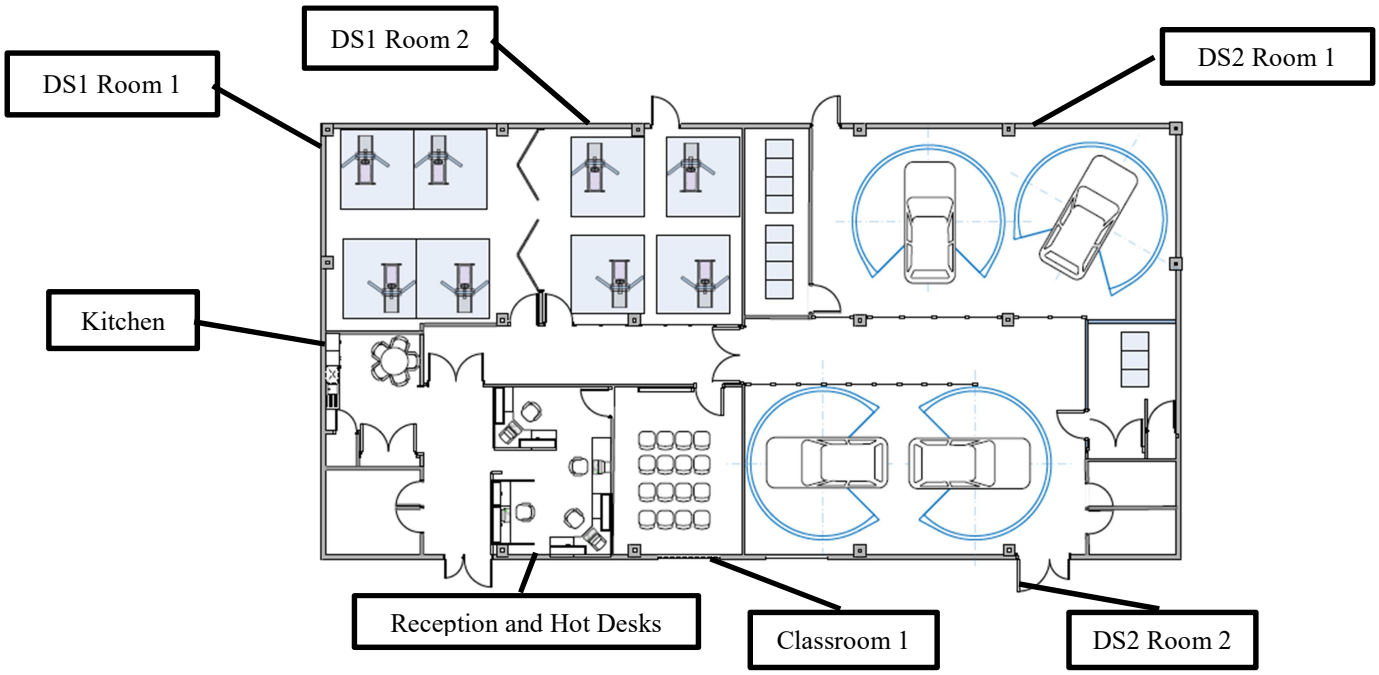

Figure 1

DSC Simulator Equipment

The DSC is equipped to house up to eight single-seat simulators (DS1) and up to four full-car simulators (DS2). The DS1 (see Figure 2) provides a field of view of approximately 180° through use of three 50" television screens, and employ a number of car specific components, such as the handbrake (parking lever) and indicator stalk, as well as a COTS gaming steering wheel, pedal and gear stick (gearshift/shifter). The DS1 devices are static.

Figure 2

The DS2 (see Figure 3) is based on a converted small family car. Five projectors mounted above the vehicle deliver a 270° field of view, with a television screen mounted behind the rear windshield to provide imagery in the rear-view mirror, as well as monitors embedded in the wing-mirrors. The DS2 is equipped with actuators that provide three degrees of freedom (DOF) for motion-cueing purposes.

Figure 3

XPI drew upon its experience of supplying simulators to customers in order to maximise the likelihood of driver trainees undergoing a positive experience of simulator-based training. Noting that the DSC is targeted at existing licence holders, rather than at *ab initio* trainees, particular efforts were made to ensure that the overall driving activity was suitably representative of actual driving and that simulator sickness (formally referred to as simulator adaptation syndrome – SAS) would therefore be minimised.

Considerations for Simulator Adaptation Syndrome

The field of SAS has been well-examined and is understood to result from a disconnect between cues of speed and motion transmitted to the brain by the trainee's visual and proprioceptive systems (Reason and Brand, 1975). This disconnect can be exacerbated by latency between trainee inputs and the outputs of the simulator. Moreover, difference in latency between simulator subsystems – such as visual, motion and audio systems – can cause user discomfort (Kennedy, Hettinger and Lilienthal, 1990). A minimum visual update rate of 60Hz and maximum latency of 100ms was therefore set as a baseline for the devices in the DSC.

Beyond the characteristics of the simulator device, the training activity and the environment also plays a role in reducing SAS; for example, use of braking and repeated 90° turns increases the prevalence of SAS (Romano and Watson, 1994). Early demonstrations at the DSC resulted in some participants experiencing nausea – at a level that XPI had not encountered in previous deployments of simulators. In evaluating the potential reasons for this it was found that the typical introductory scenarios in which trainees participated were situated in built-up areas – with numerous junctions, bends and interactions with other traffic entities. The time spent on the simulator was also limited to 15-20 minutes depending on the training package, and efforts were made to keep the room at a low temperature. XPI had previously found that these mitigations were of use in addressing SAS.

Feedback from existing customers also enabled anecdotal evidence to be gathered on strategies to minimise SAS when using XPI's simulators. The key items identified from this were to brief participants in advance of the simulator session in order to set expectations – highlighting the risk of discomfort but not overplaying the potential for SAS – and trying to get users immersed in the driving task without excessive cornering in the initial training phases.

Optimising Immersion

Aside from the mitigations against SAS, XPI sought to optimise immersion in the DSC simulators through the application of general best practices gleaned from experience of supplying driving simulators to various customers. At a hardware level, these included use of actual car components in both the DS1 and DS2, use of high-quality

projectors to avoid unwanted visual effects, implementation of audio systems to provide suitable auditory input and, for the DS2, use of actuators to provide motion cues.

From a software perspective, the simulators incorporate advanced graphics based on the Unity graphics engine (see Figure 4), representative driving databases, traffic and pedestrian entities that behave in a suitably realistic manner, and PhysX-based vehicle dynamics models tuned to provide representative handling and response.

Figure 4

However, it needs to be recognised that the simulation platform and software in use is only one aspect of the execution of effective simulator-based driver training. The training facility, the training delivery method and courseware are also critical in ensuring the efficacy of the approach. All of these were evaluated by the RoSPA in order for the DSC to become approved.

APPROVAL OF THE DSC

In evaluating how to demonstrate credibility to potential customers seeking driver training services, it was deemed appropriate to pursue accreditation of the DSC by a respected body. This accreditation was intended to demonstrate that the centre provided a certain level of training capability in an appropriate setting, and that this training met the stated aim of improving driver behaviours through the application of simulation-based training.

Several bodies were considered as potential accreditors that could be approached for accreditation of the DSC. A qualification developer and provider – City and Guilds – was initially proposed as a potential partner for the establishment of an externally recognised certificate for trainees attending the DSC. However, it was evaluated that the DSC was not in a position to formally examine trainees in order to assess whether they had reached a certain level of competence, and City and Guilds typically provides accreditation for examination rather than training facilities.

Accreditation by the UK's Driver and Vehicle Standards Agency (DVSA) was also considered as a potential option. The DVSA is an executive agency of the UK's Department for Transport (DfT), with its remit covering the execution of theory and practice tests for novice drivers, approval of driving instructors and ratification of training courses for qualified drivers. However, the DVSA, while laying down standards for drivers, does not offer accreditation for individual driver training centres.

RoSPA's approval proposition was viewed as attractive because it is a well-known organisation with a global presence in health and safety – including, but not limited to, driver training. RoSPA's activity is widely publicised across various media, and the reputation of the body as a thought-leader in matters pertaining to safety is well-established. RoSPA's approval services are used by emergency services, as well as other training providers, adding

credibility to the organisation's views and ethos. This credibility, and the ability of the organisation to provide approval for both the DSC as a facility and the courseware delivered therein, meant that pursuit of RoSPA approval was deemed appropriate.

Introduction to RoSPA

RoSPA traces its origins back to December 1916 with the holding of a public meeting at Caxton Hall whereupon it was decided that a London "Safety First" Council should be elected to tackle a deterioration of road safety, which had been exacerbated by wartime restrictions on street lights. The organisation took the title of RoSPA in 1941 with the approval of its patron, King George VI (RoSPA Website 'About us', 'History', 2018).

In order to achieve its vision of: "Life, free from serious accidental injury", RoSPA's current mission is: "Exchanging life-enhancing skills and knowledge to reduce serious accidental injuries" (RoSPA Website 'About us', 'Vision and Mission', 2018). As a key part of this mission, RoSPA has a focus on the promotion of road safety activity covering drivers, passengers, pedestrians and other road users alike.

Based in Birmingham (UK), RoSPA employs 110 people as of 2017, and has over 3,700 registered members. The organisation has close links to the UK Department for Transport, which provides grants to support RoSPA's road safety activities in the UK.

RoSPA Approval Process

RoSPA offers a two-tier approval process for organisations offering driver training – course approval, and course and centre approval. In addition to this service, RoSPA is able to accredit centres that employ RoSPA-qualified personnel as driver trainers. For the DSC, course and centre approval was pursued. This approval, once granted, is valid for two years, upon which a re-inspection is necessary in order to retain approved status.

The course and centre approval process involved the evaluation of the DSC against a number of criteria, grouped under five headings:

- Course Materials
- Training Methods
- Administration Procedures
- Quality Procedures
- Facilities

In evaluating the DSC's course materials, a RoSPA consultant read, reviewed and commented upon the material generated to support delivery of driver training in the DSC. This material included written descriptions of simulator-based training exercises, as well as traditional training material, such as slides, videos, worksheets and so forth. Scoring was made against a matrix held by RoSPA that evaluated the different elements of the training material, such as 'Topics Covered', 'System of Driving' and 'Pre-Drive Checks'.

Fundamentally, the review of the training material sought to address the following key matters:

- Does the training material deliver the intended training benefit?
- Does the training material fit trainee needs?
- Does the training material meet prevailing industry norms and government standards?

Training method evaluation was conducted through observation of a mock training session, and focused predominantly upon the delivery of training, such as the use of learning/training aids, facilitated delivery, appropriate use of rest breaks and adherence to timings. Again, scoring was made against a matrix held by RoSPA.

A key element of the training method evaluation concerned the appropriate capture and delivery of feedback to trainees. XPI evaluated a number of potential feedback models, including Kaufman, the Success Case Method and the Kirkpatrick Model. The Kirkpatrick Model, which covers four levels of training evaluation (reaction, learning,

behaviour and results) was chosen owing to the high level of familiarity with this evaluation approach and its proven use in other driver training environments. The Kirkpatrick Model enables rapid feedback to be delivered to trainees across a variety of tasks, and provides trainee managers with a simple overview of the risk level associated with the various trainee behaviours demonstrated during the exercises.

Evaluation of administration procedures focused upon the pre-training and post-training activity associated with the delivery of the courses, while quality procedures were largely evaluated by demonstration of alignment to extant health, safety and environment legislation and ISO 9001.

The DSC facilities were assessed to ensure that they provided a suitable learning environment, with a focus on the distribution of private and collective classroom areas for one-to-one or group feedback, as well as making appropriate provision for trainee comfort through air conditions and availability of refreshments.

Feedback from RoSPA

In terms of specific feedback from RoSPA regarding the facility, the most salient point to XPI was to make specific reference to Goals for Driver Education as part of the overall courseware provided to trainees. This matrix – developed by Hatakka, Keskinen, Gregersen, Glad and Hernetkoski (2002) – provides a wider perspective on the requirements that drivers need to satisfy in order to drive effectively, beyond control of the vehicle and an understanding of the road environment around them. A summary of this hierarchy of driver behaviour levels is shown below (see Figure 5, Hatakka et al., 2002).

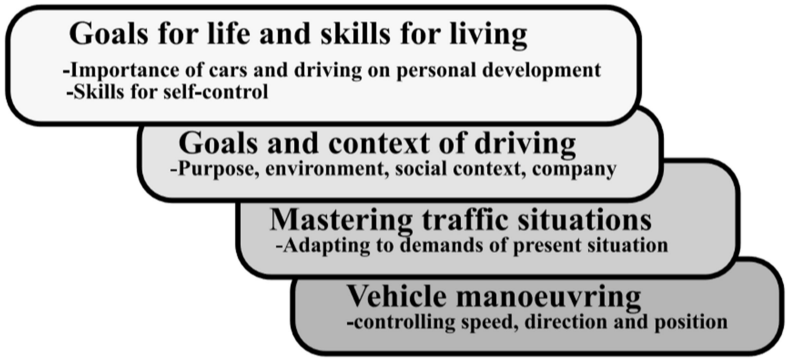

Figure 5

Simulation-Specific Considerations

There were also several areas where the novel use of simulation attracted comment from the RoSPA consultant. It was noted that the simulation-based training was ideal in enabling trainees to follow a reflective learning approach, with the record/replay function facilitating this.

The assessment of the centre did not include a formal evaluation of the platforms – the DS1 and DS2 – that the DSC makes use of to deliver simulation-based driver training. RoSPA as an organisation is not able to deploy consultants with suitable technical proficiency to conduct the evaluation of such equipment, nor is there an agreed (and objectively measurable) set of standards to guide any such evaluation. As simulation becomes more widely deployed for driver training, it may be appropriate to consider the development of such standards encompassing matters such as field of view, degrees of motion, latency and so forth – in the same way as civil flight simulators for pilot training undergo an independent certification procedure to demonstrate fitness for purpose.

FURTHER TRAINING ESTABLISHMENT CONSIDERATIONS

Training Facility

Regarding the training facility, location and accessibility should be considered to minimise trainee travel time and ensure the widest possible audience, as with any other such training site. One key distinction for civil driver training compared to, for example, military or government agency training approaches, is that commercial organisations do not typically decamp *en masse* to a training centre for specific training. This means that centres must be located as close as possible to target audiences to minimise disruption to regular working patterns. Alternatively, facilities should be able to offer a mobile training capability (as the DSC does) in order to provide training at a company site.

The DSC was therefore located in a densely-populated suburb of London (UK), with good road and public transportation links enabling access to a large target audience of trainees. The deployable nature of the DS1 simulator also means that the provision of training at customer sites is straightforward.

In terms of the DSC building, due consideration was given to the provision of appropriate, modern facilities for trainees, something that is perhaps not such a priority for military training centres. The environment itself must be in line with consumer expectations regarding a certain level of comfort, access to refreshments, cleanliness and so forth.

Training Delivery Method

The training delivery method also imposes certain requirements on the facility – namely an adequacy of space to facilitate both simulator-based and classroom-based instruction. In order to optimise simulator-based training effectiveness, and to minimise any potential effects of SAS, XPI's experience (as discussed above) is that brief exposure to simulation, interspersed with non-simulator based training activity, is optimal.

Training delivery in a commercial setting must also take into account the diversity of the training audience that is likely to be encountered. Unlike military driver training, which predominantly focuses on instructing young men (albeit with increasing proportions of women) with similar levels of driving experience in vehicle handling, tactical manoeuvres and so forth, civil driver training audiences are likely to exhibit a greater diversity of gender, age, health, skill level and so forth. Moreover, while military training typically follows a regimented, standards-based approach, commercial training environments have greater scope to embrace a diversity of learning styles and approaches in order to tailor training to individual needs.

In fulfilling these requirements for the delivery of training in a commercial setting, the DSC primarily followed the guidelines laid down by the RoSPA evaluation matrix (described above) in ensuring that a variety of learning styles were catered for through use of a mix of learning materials. Moreover, instructors at the facility have been trained on the blending of simulator-based training with traditional means of instruction (such as presentations, workshops, written exercises and so on). There is also recognition from instructors of the need to tailor this approach to individual needs – as recognised in the RoSPA feedback to XPI.

Courseware

The development of appropriate courseware was also critical in ensuring that the training delivered at the DSC would meet commercial user needs. As with any other training activity, the courseware needed to be relevant to trainee challenges, cover a range of environments, provide variable levels of difficulty and so on. The preceding section on the RoSPA approval of the courseware is pertinent to this topic.

METHODOLOGY FOR ESTABLISHING SIMULATOR-BASED DRIVER TRAINING

In summarising the methodology pursued for the establishment of the DSC, it is useful to consider that much of the preceding recommendations are borne of XPI's considerable experience in the provision of over 100 driving simulator devices to numerous customers, spanning road safety to professional motorsport and armed forces – and not just the isolated example of the DSC. Although not discussed in this paper, XPI's supply of a police driver

training simulator to South Wales Police, a car driving simulator to Mitie (a large UK outsourced facilities management company) and the supply of car and truck driving simulators to the Grimsby Institute for Further and Higher Education has enabled XPI to gather a useful evidence base on the best practices associated with such facilities.

In terms of simulator platforms, the primary objective is to provide a representative training environment comprising devices with suitable fidelity (visual, audio, tactile and proprioceptive), with due regard for mitigation of SAS, and accompanied by training material and scenarios that have clearly defined learning outcomes and provide representative driving environments.

Pursuing an approval method such as that provided by RoSPA is a useful mechanism to ensure that course materials, training methods, administration procedures, quality procedures and facilities meet required standards for commercial driver training. This also gives consumer confidence that the centre is of a suitable level for the delivery of effective training.

With regard to the training centre, location near population centres is critical in order to enable ease of access for trainees – while a mobile option is also a clear advantage.

FURTHER RESEARCH TOPICS

Enriching the methodology described in this paper would be facilitated by a broader consideration of simulation-based driver training establishments – both targeted at military and civil trainees.

In considering the scope for approval and accreditation of driver training centres it would also be worthwhile to examine the validity of the approach pursued by aviation authorities in certifying civil flight simulators for pilot training. The evaluation process and grading of such simulators could enable a more rigorous and standards-based approach to be implemented in the driving simulation domain, providing confidence to potential consumers and a clear basis for informed decision-making regarding the appropriateness of simulator solutions for the training task.

CONCLUSION

In conclusion, the engagement of an external organisation in order to validate training centres targeted at civil markets is a useful endeavour in promoting this capability to an audience unused to the use of simulation for driver training. This approach not only ensures that training aligns well to existing best practice in driver training, but also demonstrates credibility in this new domain.

As an internationally respected promoter of road safety and driver training, RoSPA is an ideal organisation for the promulgation of such an approval – and their approval criteria provide an ideal means of ensuring that key areas around delivery of driver training have been given due consideration.

In deploying simulators at the DSC, XPI has been able to gain further understanding in the application of methods to reduce SAS and ensure that the simulation experience delivered to new audiences is optimised. Moreover, the RoSPA evaluation matrix, and feedback after the inspection, provided a useful mechanism for the refinement of training methods, feedback models and the incorporation of Goals for Driver Education into XPI's courseware.

The conclusions from this paper are of relevance to other organisations seeking to establish similar commercial driver training facilities, in particular in countries – such as the UK – where there has not been wide public uptake of driving simulation for training purposes. It is also of interest to non-commercial training providers, such as armed forces, where on-road driving is a key activity and risk factor; the recommendations from RoSPA on best practice in driver training from a civil perspective are a useful input for continued improvement existing military training approaches.

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