Annex C. Modelling of potential and outturn safety risks

C.1 This annex focuses on the third main source of evidence, the modelling of safety risk. It describes the approach taken by Highways England and our assessment of that approach. We have drawn on our experience as the rail safety regulator and consulted subject matter experts with experience in rail and aviation.

C.2 Although the legislative and regulatory frameworks for rail and road differ significantly, we found it useful to compare what has been done by Highways England with expectations of operators in the rail and aviation sectors. That said, as Highways England operates in a very different framework, standards from other sectors are not directly comparable.

Background

C.3 Testing the robustness and reliability of this source of evidence was complicated. The Health and Safety Executive's (HSE) definition of good practice states '… good practice is the generic term for those standards for controlling risk which have been judged and recognised by HSE as satisfying the law …'. In the rail sector ORR (as the sector specific safety regulator) provides guidance against which judgements can be made on good practice. There is direct equivalent in the roads sector but ORR is not the safety regulator for that sector. HSE is the independent regulator for work-related health and safety. Road traffic collisions where there is an injury are investigated by police forces. We have kept this in mind as we undertook our examination.

C.4 Best practice, on the other hand, has no such definition and is commonly referred to as achieving standards higher than good practice, examples may include continuous improvement or goal setting.

C.5 In line with the scope of our assurance work we did not undertake a detailed review of Highways England's wide ranging risk management processes, but rather a high-level examination of one aspect, the Generic Hazard Log and the relevant underlying business processes. In general terms we looked at whether a sound methodology had been employed and whether it was supported by available information and intelligence.

Generic Hazard Log

C.6 Highways England, and its predecessor Highways Agency, has been responsible for risk modelling. An understanding of the risk profile of the strategic road network was achieved by documenting all the credible foreseeable unsafe states and events that might result in harm (“hazards”). This activity produced a list of hazards, these were recorded in the hazard log. A hazard log is a document where conditions that could lead to an accident (hazards), their related measures, their origin, and the reference to who has to manage them, are recorded and referenced.

C.7 The original concept for the Generic Hazard Log for conventional motorways was established in around 2003 and was led by a mixture of engineering and technology consultancy firms (Mouchel (now WSP), Arthur D. Little and Cambridge Consultants) as part of the M42 Active Traffic Management (ATM) pilot scheme. Following a series of workshops, the log was validated by data contained within ControlWorks (the Traffic Officer System “Command and Control System” which logs key actions such as calls, dispatches, and sign setting), and STATS19 (See Annex A for a full description), and intelligence drawn from manually reviewing CCTV footage. This resulted in an approach where expert judgement was verified by available data to produce a quantified figure. This is a common approach across sectors that can be considered sound.

C.8 The original hazard log for the M42 pilot scheme was based on identifying hazards that were specific to motorways and not typical of driving in general. For example, road condition is not within scope as this is dealt with elsewhere in the wider framework.

C.9 In 2012, to establish a Generic Hazard Log for ALR, Highways Agency took the M42 pilot scheme log as a starting point and expanded it to encompass new or novel hazards.

C.10 Since then Highways England has periodically reviewed the Generic Hazard Log for ALR to make sure that it is maintained and provide assurance on its quality. These reviews usually occurred following an update to the relevant Highways standard (Interim Advice Note “IAN”) or when new intelligence was gained from monitoring activities.

C.11 Hazard logs are commonly used in other sectors. From our experience, facilitated workshops that are validated with data are standard practices across sectors. The approach is established within Highways England but we did not have time to

investigate whether similar practices (better or worse) happen in other highway authorities. The hazard log itself is a sophisticated spreadsheet and the outputs rely on accurate inputs.

Classification of hazards in the Generic Hazard Log for ALR

C.12 In reviewing the log we identified some anomalies with the establishment and categorisations of hazards.

C.13 While generic cross-sector workplace guidance from HSE proposes that hazards are activities, processes or substances that could cause injury or illness, Highways England expands this to "States" and "Events" to categorise hazards as it considers that this approach is more specific to its network.

C.14 When reviewing the hazard log, we found some apparent inconsistencies in the approach to hazard identification; there are different hierarchies and classifications which meant that some hazards appeared not to be comparable to others.

C.15 Hazards within the log are presented with underlying causes to establish what a likely preceding event might be. A clear example is 'Tail Gating' (hazard H91) which is preceded by the underlying causes of: driver being distracted, or vehicle in front driving slowly, or influence of drugs and alcohol.

C.16 However, a less clear example is 'Driver Fatigued - unable to perceive hazards effectively' (hazard H138). Drugs and alcohol affect the perception of hazards in a similar way to fatigue, but the hazard log considers drugs and alcohol to be a preceding cause while fatigue remains a hazard in itself. The reason this is treated differently is partly because STATS19 has separate causation factor codes but also because Highways England considered it more appropriate for fatigue to be treated as a hazard in its own right.

C.17 Other anomalies are:

(a) H97 - "TO[1]s/ emergency services go to wrong location (incident)".

(b) H98 - "TOs/emergency services despatched but cannot reach scene".

(c) H99 - "TOs/emergency services not despatched in a timely manner".

C.18 All three of these defined hazards could be deemed to be a cause of the single hazard of "delay in attending incident leaving the original incident exposed to live

[1] Traffic Officers

traffic". Therefore, the log has presented potentially a single hazard as three separate defined hazards. Highways England has explained that it had deliberately separated some of the hazards relating to emergency services (H157 and H158) to account for different traffic flows and operating protocols.

C.19 When using data to validate the hazard log, the lack of distinction between hazards can affect proportionality. In an example where multiple tailgating incidents resulting in collisions as a result of one or more driver involved being fatigued, depending on what information is recorded in STATS19, all could be attributed to fatigue, tailgating, both or a mixture. Additionally, fatigue can be especially subjective and is down to the judgement of the person(s) inputting the data.

C.20 Also, there are examples where hazards are similar but recorded separately, such as H67 - "Pedestrian in running lane - live traffic" and H147 – "Pedestrians walking in lane 1 (applies to ALR only)". As H147 is only considered an ALR-specific risk, it is therefore not included in the "After" analysis figures for comparison pre- and post-implementation of ALR (figure 13 of the *Smart Motorway Safety Evidence Stocktake and Action Plan*). So, whilst the hazard "Pedestrian in running lane - live traffic" may have increased by 67% in the after comparison, this does not include the additional risk of "Pedestrians walking in lane 1".

C.21 Highways England explained to us how it had debated fractionalisation and proliferation of hazards but ultimately taken a judgement on the most appropriate classifications for what it was seeking to achieve. It was clear in our review that the company's intent was to avoid fractionalisation and proliferation, but our opinion is that some fractionalisation has occurred over time. In any future update to the log Highways England should challenge itself on this.

Information gaps in the log

C.22 During our review of the hazard log we found that Highways England had not recorded information underpinning new hazards in the log. The missing information included a comprehensive description to articulate the hazard (besides the title), hazard causes and consequences. Highways England explained that this information does exist in underpinning technical notes. We were provided one of these notes late on in the review and found this to be the case.

C.23 We discussed this extensively with Highways England during our review and it has committed to inputting the information to the Generic Hazard Log as part of its periodic update.

C.24 We did not find any gaps in the scores for the top hazards which fed into the *Stocktake*.

Top hazards and risk tolerance

C.25 Highways England has determined that hazards should be managed on a proportional basis to the risk posed. This is a common approach across different sectors. This means that the hazards which have the highest risk scores will be categorised separately as "top hazards". This is aligned with guidance from HSE Reducing Risks, Protecting People and consistent with good practice observed within the rail industry.

C.26 Highways England determined that any hazard that is scored 8.0 before or after ALR introduction is deemed a "top hazard". The scoring mechanism designed by Highways England estimates that 92% of all the risk prior to ALR introduction was generated by these "top hazards". If hazards that scored 7.5 were included as well, this would equate to 95% of the risk. However, Highways England determined that the additional work in targeting hazards scoring 7.5 would require a disproportionate amount of effort for the three percent benefit to the risk profile.

C.27 The decision to consider as "top hazards" all hazards of 8.0 and above (leading to covering 92% of all risks) was made initially for the M42 ATM pilot based on multiple criteria such as higher scoring, different or increased risks, stakeholder concerns and risks to a particular group of users. Subsequently, these criteria were checked for possible weaknesses in both risk scoring and hazard selection. Based on the three-year monitoring results for the M42 these criteria were deemed suitable by Highways England and carried forward for new schemes. Whilst it is Highways England's responsibility to determine its own tolerance to risk, the tolerance judgement has not been reviewed since the original M42 ATM pilot and should be reviewed more often in a state of continuous improvement to achieve best practice.

Alternative and complementary tools

C.28 The Highways England's hazard identification process through facilitated workshops and the subsequently produced hazard log is one of a number of approaches available to model risk.

C.29 Highways England considered using other risk tools such as fault and event trees (which it did so for the one underlying assessment that we reviewed) but it did not for the Generic Hazard Log. Event Tree Analysis is a graphical technique for representing the mutually exclusive sequences of events following an initiating

event according to the functioning/not functioning of the various systems designed to mitigate its consequences. It can be applied both qualitatively and quantitatively.

C.30 Another example of a root cause analysis tool is a fishbone diagram which requires little (if any) data and therefore was available as an option to Highways England. A fishbone diagram is a visual representation of a process to understand contributing factors. This could have been done alongside workshops to provide a complementary tool.

C.31 **We recommend** that this is reviewed in line with current work that Highways England has planned to carry out. We also recommend that best practice tools and techniques (such as root cause analysis tools) should be adopted to provide confidence that the risks relating to ALR motorways are well- understood and that the right risk mitigation measures are in place.

Precursor data

C.32 The majority of the risk analysis carried out by Highways England has been generated by using data where harm has occurred. The risk analysis does not include road incidents where no physical harm has occurred, usually referred to as “Near Misses”.

C.33 One of the key weaknesses when only considering incidents where actual harm occurs is that it results in data sets which are limited in quantity. This means that the subsequent analysis and views are based on limited intelligence gathered.

C.34 Road accidents where harm occurs can be considered “Outcome” indicators as the event needs to have occurred to provide intelligence to inform the view and the risk is deemed to have materialised in these instances. However, whilst all accidents involving harm arise from an unsafe state or condition (creating a risk), not all unsafe states or conditions result in a road accident causing harm. Therefore, unsafe states or conditions can provide information and act as “Activity” indicators (sometimes referred to as “precursor” indicators; measures of whether a risk control system is in place and/or working effectively), which are usually greater in number and therefore a larger data set.

C.35 The *Smart Motorway All Lane Running Overarching Safety Report* notes that some of the “after periods” for post-implementation analysis of ALR schemes are based on around a year’s worth of data, in most cases mainly due to the length of time since implementation of the scheme and the report date. The *Smart Motorway All Lane Running Overarching Safety Report* acknowledges that a direct

comparison of before and after implementation on an individual scheme is difficult, due to the low number of accidents resulting in harm and therefore quantity of data or “data points”.

C.36 Highways England therefore decided to pool the data from the schemes to produce a holistic view of smart motorways, rather than seeking out additional data and, therefore, intelligence. Highways England has done some preliminary work in identifying additional data sources and concluded that disproportionate effort is required to capture this data. It has done this without conducting any trials.

C.37 Using additional data points aside from the outcome indicators could have assisted the intelligence and subsequent conclusions contained within the *Smart Motorway All Lane Running Overarching Safety Report*.

C.38 **We recommend** that Highways England conducts a trial of precursor indicator data, to determine the benefit to effort ratio, by establishing any restrictions or difficulties in the data and the value those data can add to Highways England’s understanding of risk. Highways England should also consider intelligence gained from the use of the additional risk tools in the previous recommendation to better understand what metrics could act as indicators. It would also be helpful if there were better data-sharing between organisations that hold relevant data. For example, Highways England should consider engaging with the Association of British Insurers (ABI) to understand what if any further information on no harm accidents might be shared.

Data held in STATS19

C.39 STATS19 acts as the key raw data analysis in the *Smart Motorway All Lane Running Overarching Safety Report* and *Smart Motorway Safety Evidence Stocktake and Action Plan*.

C.40 There is currently information held within STATS19 that is not visible to Highways England due to data protection policies. STATS19 records contains some sensitive data that is not released as open data. Access to the sensitive parts of STATS19 data is controlled through a licencing process. Highways England already has in place licencing agreements for some sensitive data but there is more that could be useful in understanding the risk profile of ALR motorways. An example of this is number plate information for vehicles which are involved in road accidents.

C.41 Number plate information and analysis of this data could provide further intelligence on the risk profile of ALR motorways. Number plate information would allow Highways England to know the vehicle type and possible country of origin or categorise non-UK based road users.

C.42 Trend analysis of vehicle type and country of origin before and after implementation of ALR motorways could allow a comparison of types of accidents that occur. Currently it is unclear whether the accidents and harm that occur after the implementation of ALR motorways are of a similar nature to those that occurred prior to implementation.

C.43 The additional data sources may allow Highways England to understand if non-domestic road users, or particular vehicle types, are exposed to greater risk on ALR motorways.

C.44 **We recommend that** the Department for Transport (DfT), in collaboration with Highways England, review what additional data within STATS19 could be made available to allow Highways England to better assess the risk exposure to specific users. For example, understanding country of origin and/or involvement of “high risk” vehicles in vehicle collisions on ALR.

Data and evidence available internationally

C.45 In the short time we had to do the review we found no published international data and evidence on ALR motorways. Hard Shoulder Running (HSR) has been implemented in some countries and HSR is used to describe two types of motorway; where the hard shoulder is used as a running lane during set times of the day (coincide with periods of high demand), and where the use of the hard shoulder is triggered by high levels of demand on the road (that is, Dynamic Hard Shoulder, DHS). The objective is to temporarily increase road capacity as a temporary traffic management measure.

C.46 Based on the studies we have found HSR has been deployed in a variety of different countries, and evidence has been gathered from Germany, the Netherlands, France, the USA and South Korea. Germany and the Netherlands appear to have been the first countries to adopt HSR, with HSR schemes in Germany dating from the mid-1990s.

C.47 In all countries, HSR is deployed on a minority of the network, and is reserved for sections of a highway with high traffic volumes. In Germany, HSR is regarded as an ‘interim solution’ to allow authorities to increase capacity until it is feasible to

widen the carriageway, although in practice many HSR roads have operated for over two decades.

C.48 The Conference of European Directors of Roads (CEDR) formed in 2016 to promote the excellence in the management of roads, of which Highways England is part along with 28 other members, with a strategy of benchmarking and sharing of knowledge and best practices. The CEDR creates a forum for countries and members to exchange and discuss experiences, to learn from each other, and to work towards a more harmonised approach.

C.49 In October 2018, a CEDR working group looked at HSR. The group comprised of 13 countries but the UK was not involved. The recommendations from the study proposed a KPI for reporting Hard Shoulder Running deployment and impact, with Safety Impact to be measured by number of accidents by type per vehicle, km of corridor.

C.50 During the continued program of upgrade works of existing conventional motorways to Smart Motorways, European National Authorities and Highways England had difficulties in the sharing of safety information due to differences with international comparisons of the definitions of casualty severity and road types (we have observed issues with making international comparisons through some of our benchmarking work). However, **we recommend** that given the limitations of the data available to assess the safety of ALR motorways there is an opportunity for Highways England to engage with CEDR to share lessons learnt from each National Authority's experience of defining hazards and modelling risk. This will allow Highways England to benchmark identified hazards and provide an opportunity to review controls in the spirit of continuous improvement.

Risk management – communication to road users

C.51 As part of the preparation for change it is good practice to examine the hazard log and where users are expected to take action to control a risk put in place a strategy to ensure that they are fully aware of this and will do it. In the case of ALR motorways, if this practice were followed we would expect to see communications with users notifying them of these requirements. This is of course hard to do in a road environment where it is an open system, as opposed to rail which is a closed system.

C.52 Between February 2015 and October 2021, Highways England conducted a number of campaigns aimed at road users (see Table C.1). In addition as part of its response to the *Stocktake* in March 2021 it launched the 'Go Left' campaign.

Table C.1 Highways England Communication Campaigns

Campaign	Dates
Smart motorways (Red X)	2 February - 1 March 2015
Smart motorways (4 features)	11 July – 8 August 2016
Smart motorways (3 features)	13 - 31 March 2017
Vehicle Checks (Second wave)	3 July - 13 August 2017
Smart motorways (Red X)	18 December 2017 - 7 January 2018
Vehicle Checks (Fourth wave)	17 July - 24 August 2018
Smart motorways (Red X)	19 March - 31 March 2018
Vehicle Checks (Third wave)	13 March - 2 April 2018
Vehicle Checks (Fourth wave)	17 July - 24 August 2018
Smart motorways (Red X, variable speed limits)	1 - 31 March 2019
Space Invaders (First wave)	17 September - 4 December 2018
Space Invaders (Second wave)	4 February - 3 March 2019
Vehicle Checks (Fifth wave)	3 April - 5 May 2019
Smart motorways (Red X, variable speed limits)	1 - 31 March 2019
Motorways (4 features)	21 June - 19 July 2019
Vehicle Checks (Sixth wave)	15 July - 2 September 2019
Motorways (4 features)	17 February - 23 March 2020
‘On the road again’ (vehicle checks)	15 - 17 May 2020
Space Invaders (Third wave)	7 September – 30 October 2020

C.53 Road users including pedestrians, cyclists and drivers are made aware of the mandatory rules by the Highway Code. Within the latest publication (paper copy dated June 2015 with an online update in July 2019), the Highway Code does not differentiate between conventional motorways and Smart motorways and contains all under the same section “Motorways”. Highways England has recently concluded a consultation into changes to the Highway Code to reflect the specific risks introduced by ALR motorways as part of its response to the *Stocktake*.

C.54 When changes to the UK road infrastructure are implemented, a gap exists on how updated mandatory rules and guidance are communicated to both domestic and international road users. We **recommend** that the DfT and Highways England consider how future changes to the infrastructure and road rules are communicated to both the domestic and international road user.

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