OLE Hot Weather Resilience

Targeted Assurance Review

31 August 2021

Contents

Acronyms and Abbreviations

AC	Alternating Current
AT	Auto-Tension
BWA	Balance Weight Anchor
CP	Control Period
DEAM	Director of Engineering and Asset Management
DU	Delivery Unit
E&P	Electrification and Plant
EM	East Midlands
FT	Fixed Termination
NW&C	North West and Central
OLE	Overhead Line Equipment
OLEMI	Overhead Line Equipment Master Index
ORR	Office of Rail and Road
QLM	Quarterly Liaison Meeting
RAG	Red, Yellow, Amber
RAM	Route Asset Manager
RFI	Request for Information
RPP	Railway Planning and Performance
RSD	Railway Safety Directorate
SM	Section Manager
STE	Safety Technical & Engineering
TA	Technical Authority

TME	Track Maintenance Engineer
TOC	Train Operating Company

Definitions

Auto-Tension (AT) – A tensioning system which has the ability to automatically re-adjust the tension in the system/wire in response to environmental effect such as heat and cold. Examples of auto-tensioning devices are: Balance Weights and spring tensioners.

Fixed Termination (FT) – A tensioning system where the catenary and contact wire are fixed to the structure with tension and wire sag varying with temperature. The wires contract and expand with temperature change.

Jumper – A conductor that provides electrical continuity.

Network Rail Technical Authority (TA) – This includes the national discipline professional heads and chief engineer.

OLEMI – OLE Master Index – It comprises the Mark 3, Mark3a, Mark 3b, Mark 3c, Mark 4, Mark 5, and UK1 overhead line design ranges. It also encompasses metric conversion assemblies for Mark 1. Some of these OLE design ranges go as far back as late 1960s and early 1970s.

Overhead Line Equipment (OLE) – A system that channels electrical energy to the train through the pantograph attached to the roof of the train. It is also known as Overhead Contact System (OCS).

1. Executive Summary

1.1 Purpose

Following a series of overhead line equipment (OLE) incidents in summer 2019, ORR carried out a TAR – Targeted Assurance Review to gain understanding of the impact of the incidents and what Network Rail is doing to make the OLE asset more resilient in hot-weather. By reviewing the OLE performance in summer 2020, this TAR also evaluated the effectiveness of follow up actions taken by Network Rail.

1.2 Background

25th July 2019 was the hottest day on record in the UK with temperature of 38.7 °C. This was above the upper operating temperature limit for the legacy OLE asset which are designed to operate from -18 °C to +38 °C. Although at the upper temperature limits, some level of tolerance were expected, thermal gains can make the OLE vulnerable to other factors such as wind speed, non-live or earthed parts in close proximity, pantograph passage and train dynamic effects among others. The hot weather increased the vulnerability of the OLE and resulted in numerous incidents on the railway network and disruption to services.

In summer 2020, the third highest temperature in the UK was recorded as 37.8 °C, which again got close to the upper temperature limits of legacy OLE asset and there were also notable disruptions on the network but not as bad as experienced in 2019. At the time of finalising this report in August 2021, the ORR have not seen or received any report of OLE hot weather incidents this year.

In an article published by Nature Communications in June 2020, researchers reported that there is increasing likelihood of temperatures above 30 to 40 °C in the United Kingdom[1]. The Met Office also projected that in 50 years' time, by 2070, summer will be between 1 to 6°C warmer and up to 60% drier[2]. This climate change trend and its consequential effect on the railway overhead line asset, make it necessary to intensify effort to improve asset resilience with commitments from Network Rail, ORR and railway network funders.

1.3 Findings

The failure of the OLE was mainly due to heat induced sagging of Fixed Termination (FT) conductors, Balance Weight defects, excessive differential along track movement of conductors and other secondary causes detailed in the main body of this report. Northwest

[1] https://www.nature.com/articles/s41467-020-16834-0

[2] https://www.metoffice.gov.uk/weather/climate-change/effects-of-climate-change

& Central (NW&C) and Eastern regions were the most affected by the hot weather with a report of 13 and 18 OLE incidents respectively, both culminating into a total of 69,560 minutes delay. In Scotland the temperature was not as high as experienced in England but there was a dewirement in an FT section. Wales and Western had no incidents relating to hot weather as most of the OLE in the region are relatively new with design (Series 1) characteristics which gives them higher resilience against hot weather. The Series 1 as well as the UK Master Series (UKMS) which is the current and only approved equipment for new overhead line electrification, are characterise with operating limits of -18 °C to 40 °C with the use tensorex systems which allows independent conductor tensioning. The region however has a 12-mile of older OLE, designed to operate at lower temperature tolerance and susceptible to hot weather but it's being managed. The Southern region is mainly a third-rail DC network with few overhead line AC electrification. In 2019 and 2020, there was no report of hot weather related OLE incidents in the region.

The third hottest day in the UK was in summer 2020 with a temperature of 37.8°C. Despite this, the general performance of the OLE was better than the previous year. This was because the regions majorly affected in 2019, which were NW&C and Eastern gained better oversight of their risks. They took proactive steps to prepare; by identifying the susceptible parts early through surveys, correcting defects and planning risks management ahead of summer. Some of the corrective works include: Balance Weight adjustments and wire re-tensioning works. There are more ongoing projects across the regions to improve OLE hot weather resilience and asset condition monitoring.

Asset age and inadequate maintenance were also found to have contributed to the vulnerability of the asset to hot weather. Continuous operation of lines with FT equipment, some of which have been installed for over 50 years without adequate maintenance, increased the vulnerability of the asset to harsh environmental effects such as unusually hot weather.

Network Rail is planning a risk-based renewal as a long term solutions to hot weather resilience issues. This is however hinged on the level of asset condition knowledge available. Presently, the level of asset knowledge is insufficient and this needs continuous improvement in CP6.

1.4 Conclusions and Recommendations

The hot-weather incidents of 2019 were mainly due to the unusually hot weather and inadequate visibility of risk to Network Rail. Deferred maintenance of fixed termination equipment and inherent defects in susceptible OLE parts were also contributory factors.

Following the incidents, Network Rail reviewed their assurance processes for hot-weather preparedness and updated their maintenance work specifications (NR/L2/ELP/21087) as well as other relevant standards. For example, assessment of residual tension in FT systems has now become a maintenance scheduled task in its own right but this was not explicitly referenced before 2019 incidents. They are also working towards improving asset condition knowledge using remote-monitoring technology, some of which are in the trialling stage. Regionally, Network Rail has committed to some weather resilience works such as Project Alpha in the Northwest, Balance weight condition assessment and dashboard visibility in Eastern, among others. Some of these works contributed towards the improved performance seen in 2020 summer. While maintaining these positive steps, Network Rail needs to become more proactive by improving on their hot-weather risk visibility and ensuring the risks are effectively managed. These should be done with the recognition of the wider context of risk such as critical defect management, public area prioritisation and vegetation control.

Network Rail needs to ensure their assurance process is more robust, consistent and visible to give confidence to all stakeholders on their readiness for summer annually.

In addition, Network Rail needs to recognise the wider context of risk such as critical defect management, public area priotitisation

For weather-susceptible OLE assets which are already approaching the end of their technical life, an immediate-fix solution such as FT re-tensioning, may not be economical. Network Rail is planning a risk-based renewal of wire-runs and anchors.

With the increasing risk of hotter summers, and asset already operating at the limits of their technical lives, targeted funding will be required in CP7 to ensure better asset performance in hot weather.

Below is a list of recommendations from this TAR:

1. Each Region should produce evidence of summer preparedness detailing level of risk oversight and planned controls. This should be made available at RQLMs preceding summer.
2. Each region should produce a survey report of all FT OLE asset to ascertain risk level and inform renewal decision. This should include plans and timelines for defect correction.
3. Each region should produce a survey report of all Balance Weights to ascertain risk level and inform renewal decisions. This should include plans and timelines for defect correction.
4. Each region should produce and share their OLE hot weather resilience plan and give updates on implementation at RQLMs.
5. Network Rail to improve on asset condition knowledge. ORR will assess progress as part of PR23 review.

6. Network Rail TA should conduct a deliverability assessment of the updates to maintenance standards on FT and inform ORR of their conclusions.
7. Network Rail to work with TOCs to resolve driver reporting issues with OLE condition in hot weather.
8. Network Rail to improve on regional interaction to share best practices and discuss key ongoing challenges.

1.5 Next Steps

The report will be distributed within Network Rail specifically DEAMs, Maintenance Directors, Route Asset Managers and E&P Network Leads. Network Rail will be required to produce a time bound plan to address the recommendations in this report. We are aware that Network Rail will be developing Regional WRCCA plans, which will form part of their submission to ORR for PR23. It may be possible to address some of the recommendations through this mechanism.

ORR will monitor progress at existing Quarterly Liaison Meetings and via e-mail correspondence. Site visits will also be carried out as required. Progress and capability of the regions to address the recommendations will be re-assessed early 2022. Unsatisfactory responses could lead to issues being placed on the regulatory escalator.

2. Introduction

2.1 Purpose

This report is based on a Targeted Assurance Review (TAR) conducted by ORR to understand the impact of the hot weather on the overhead line equipment (OLE) based on the performance of the asset in 2019 and 2020 summer. The TAR also assessed the corresponding reaction of Network Rail following the 2019 hot weather incidents and the effectiveness in OLE performance in summer 2020.

2.2 Background

The overhead line is susceptible to hot weather due to heat-induced expansion in the wire. This is usually managed by Network Rail through maintenance activities which include surveys, defect correction and monitoring of susceptible parts. On 25th July 2019, there was severe disruption to train services across the network due to a high number of OLE incidents with severity ranging from circuit breaker trips to dewirements. The incidents were mainly due to the hot ambient temperature, which in some part of the country, exceeded the upper operating temperature limit (38 °C) for legacy OLE.

25th July 2019 was the hottest day on record in the UK with a temperature of 38.7 °C in England[3]. Table 2.0 shows the highest daily maximum temperature records in countries within the UK.

Country	Temperature (°C)	Date	Location
England	38.7	25-Jul-19	Cambridge Botanic Garden
Wales	35.2	02-Aug-90	Hawarden Bridge (Flintshire)
Scotland	32.9	09-Aug-03	Greycrook (Scottish Borders)
Northern Ireland	30.8	12-Jul-83	Shaw's Bridge, Belfast (County Antrim)

Table 2.0 – Highest daily maximum temperature record in the UK[4]

Network Rail mitigates the risk of hot weather to the OLE by applying emergency speed restrictions, deployment of a watch-person to monitor sites of concern, and suspension of train services in extreme conditions. These however proved to be less effective in stopping

[3] https://www.netweather.tv/weather-forecasts/news/10394-what-is-the-highest-ever-uk-temperature

[4] https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-extremes

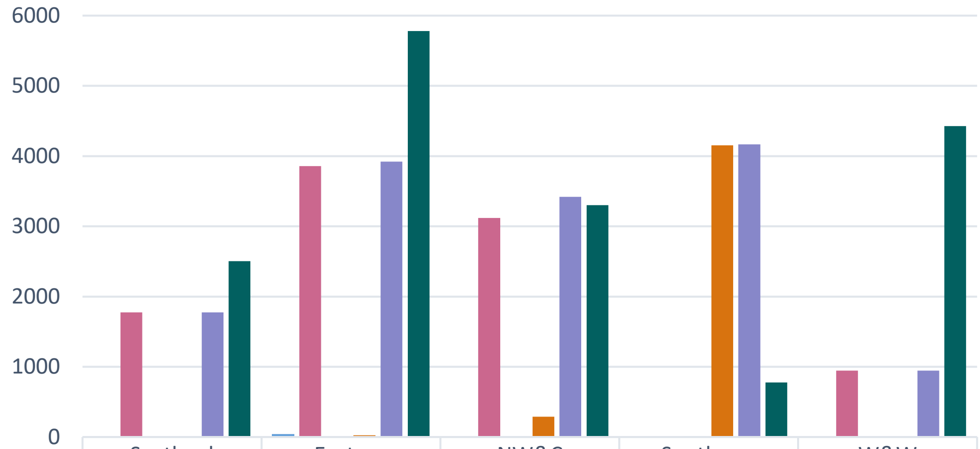
34 OLE incidents in 2019. This is because the effectiveness of the measures is much dependent on level of risk visibility, asset condition knowledge, and ability to make early and accurate weather forecast. This TAR also explores Network Rail's strengths in these dependencies.

In summer 2020, the third highest temperature (37.8 °C) in the UK was recorded, which is close to the upper operating temperature limit for legacy OLE asset. Again, there were OLE incidents due to the high temperature, but they were not as many as those of the previous year. At the time of finalising this report in August 2021, the ORR have not seen or received any report of OLE hot weather incidents this year.

With rising global temperature as a result of climate change and the associated impact on performance of the OLE asset, it is imperative to understand the challenges of OLE weather resilience and how Network Rail is dealing with them.

2.3 Scope

The scope of this review is limited to Network Rail regions where AC overhead line electrification is predominant. This includes: Scotland, NW&C, Eastern, and Wales & Western. Figure 2.0 below shows the regional electrification status.



	Scotland	Eastern	NW&C	Southern	W&W
1,500V DC OLE	0	37	1	0	0
25kV AC OLE	1773	3857	3121	2	945
Dual AC OLE/3rd Rail	0	2	8	14	0
3rd Rail 650V/750V	0	26	290	4152	0
Total Electrified	1773	3922	3420	4168	945
Non-Electrified	2505	5781	3301	776	4426

Figure 2.0 - 2019/20 Electrification status in (km). Excludes HS1. 2019/20 figures, excludes Core Valley Lines

Eastern and NW&C regions have the highest number of AC electrified tracks and were the most affected by the hot weather in 2019 with dewirements and other types of faults which resulted in significant delays in train services. This review focused more on these two regions.

In addition to regional reviews, the scope of the TAR also includes an assessment of ongoing OLE weather resilience works by Network Rail at regional level and by the central Technical Authority.

The other area of interest due to the high delays from the OLE hot weather incidents, is Network Rail's incident response capability. This is an assessment of the impact of incidents on customer journeys in terms of delay minutes. It also includes an evaluation of how Network Rail respond to incidents, and how it can be improved to ensure limited disruption to service. This assessment is not included in the scope of this TAR but covered in a separate TAR carried out by ORR.

2.4 Methodical Approach

Information required for this TAR was obtained through on-site and online meetings with Network Rail's Asset Managers, Regional Electrification and Plant (E&P) Engineers, and Technical Authority (TA). Information was also obtained via email in an RFI document which contained specific questions set related to the TAR. The questions set are included in Appendix A of this report. Copies of relevant strategies, processes, procedures, standards and incidents investigation reports were also requested. The findings from the review are detailed in this report with conclusions and recommendations.

3. Findings

A total of 34 hot weather related OLE incidents were recorded in 2019 in three regions while 17 was recorded in 2020 affecting only two regions. Both Eastern and Northwest & Central (NW&C) regions were mostly affected in 2019 and 2020. In 2019, the incidents culminated in delays of 38,994 minutes and 30,566 minutes in both regions respectively. Figure 3.0 shows the number of hot weather-related incidents per region in 2019 and 2020.

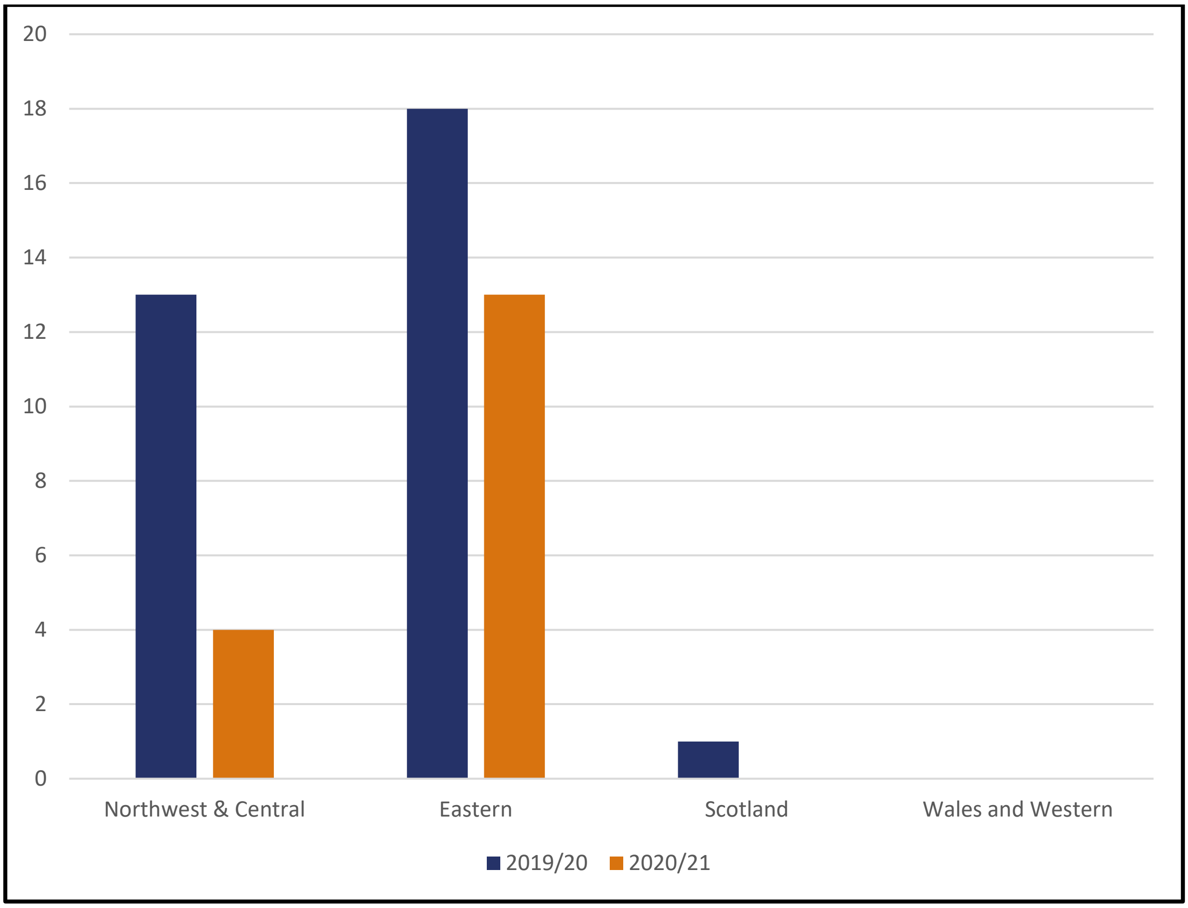


Figure 3.0 – OLE Hot weather-related incidents in summer 2019 and 2020

3.1 OLE Hot Weather Susceptibility

Several factors can affect the vulnerability of the OLE and lead to incident. These include changes in ambient temperature, thermal gain in the conductors, wind speed, humidity, train dynamic effects and proximity of other earthed or non-live parts among others. Increase in temperature beyond design limits, reduces the inherent resilience of the OLE and makes it more vulnerable to the effects of some of these factors.

The overhead line conductors expand due to heat and contract as the temperature drops. This conductive property is usually considered at the design stage of the OLE to ensure its resilience to hot weather. However, continuous global rise in temperature and other factors such as anchor system, age, and maintenance, which were identified in this TAR, are contributory towards the vulnerability of the OLE to hot weather as seen in summer 2019 incidents.

3.1.1 Heating effect on the OLE

Most legacy OLE asset are designed for temperature of -18 °C to 38 °C. The upper temperature limit was exceeded in 2019 summer. From the internal review conducted by the TA and other information obtained during this TAR, the key effects of the hot weather on the OLE which led to the failures are:

- Fixed Termination Conductor Sag – Unlike Auto Tension equipment, conductors in fixed termination arrangement are unable to automatically readjust their tension to temperature changes. Conductor expansion due to high temperature resulted in significant drop in the wire tension and excessive sag, causing the pantograph to hook over the wire and pull it down or brought the wire into contact with train roof or other non-live parts. These explained most of the incidents in FT areas in 2019. Figure 3.1 shows an example of sagged conductors at Aston, Birmingham. Figure 3.2 shows a detached pantograph head entangled within a fixed termination crossover near Partick viaduct, Scotland in summer 2019.

Figure 3.1 – Sagging conductors at Aston.

Figure 3.2 – Detached and entangled pantograph head at Partick Viaduct.

- Heat-induced excessive conductor expansion at overlaps – The hot temperature caused conductors at overlap to stretch beyond normal; resulting in excessive sag of outrunning wire and excessive differential movement of adjacent wire runs. This further led to pantograph hooking over sagged wire or overlap jumpers disconnecting after being overstretched. Figure 3.3 and Figure 3.4 shows some examples of incidents caused by broken jumpers.

Figure 3.3 – Stretched jumper at overlap hanging foul of vehicle gauge.

Figure 3.4 – Disconnected jumper wrapped around pantograph horn.

The high temperature experienced in summer 2019 did not affect all the FT on the network. Similarly, outrunning wire sag and jumper failures only occurred in some part of the network. These suggest that the risk of failure in hot weather is not applicable to all. It therefore implies that early identification of vulnerable sections of the network with adequate control measures could have prevented some of the incidents.

This TAR established that new OLE systems are designed with better resilience to hot weather. New designs such as Series1, Series2 and UK Master Series, have higher operating temperature limit of +40 °C and are set up with more resilient automatic spring tensioning system (Tensorex) instead of Balance Weights. Some of the advantages of Tensorex are independent tensioning of conductors, high precision performance, better reliability of operation, low maintenance, reduced risk of vandalism and low impact aesthetics. There is however the disadvantage that unlike Balance weights, failure signs in Tensorex are not apparent until catastrophic.

3.1.2 Asset Age

Some of the OLE on busy parts of the network are fast approaching the end of their technical lives based on years of continuous operation and exposure to environmental factors which have caused gradual degradation. Mark 1 (Mk 1) equipment dates back to 1960s while the Mark 3 (Mk 3) equipment varied from ’70s to ’90s. With years of stretching and wearing, resilience of these legacy asset has significantly decline, making them the most affected in Eastern and NW&C during the hot summer.

Aside Mk1 and Mk3 equipment, the 2019 hot weather also affected the ex-1500V dc OLE in NW&C, which was installed in 1954 and converted to 25kV system in mid ’80s. Though designed to cope with temperature up to 50 °C, years of conductor stretching, compounded by low bridges with no headroom puts this area in jeopardy in unusual hot weather.

These frail legacy assets are getting more difficult to manage. With some in busy sections of the network where accesses are difficult to get, maintenance interventions are limited, and the assets’ state of health continues to decline with increasing vulnerability to environmental factors such as hot weather. Some risk-based renewal intervention is therefore imperative.

3.1.3 Inadequate Maintenance

Inadequate maintenance of the fixed termination (FT) OLE was identified as a contributory factor to increased hot weather vulnerability of the asset. Maintenance of FT OLE include activities such as tension assessment and re-tensioning, which can be complex and time consuming. These tasks also require significant resource and disruptive access, which can be difficult to get. For these reasons, FT maintenance work are usually retained in maintenance backlog for long periods.

Another issue with FT OLE is lack of clarity in the maintenance frequency requirement. This made it an optional maintenance activity which was not viewed as mandatory. This perception has made the FT OLE remained in a poorly maintained state over the years.

Network Rail’s Technical Authority (TA) have now updated maintenance standards and added new standards to address the highlighted inadequacies. However, the condition of the FT OLE across the network need to be assessed, most especially sections that have not been re-tensioned or undergone any tension assessment for long periods.

3.1.4 Inadequate preparation for hot weather

Network Rail’s preparation for hot weather includes survey and defect correction, which should give good risk visibility and inform intervention plans. While this is the standard expectation, the level of commitment to pre-summer preparations do not give the expected confidence level. The preparations were found to be targeted only at known areas of previous failures rather than a detailed survey of all vulnerable asset which include FT and Balance Weights.

Resource limitation could be a reason for inability to extensively survey the full range of vulnerable asset. However, this could be managed through risk-based planning and prioritisation of vulnerable assets months before summer begins.

Network Rail needs to engage in early preparation for hot weather and this needs to be checked and assured by Asset Leads.

3.1.5 Pantograph damaging effect

This TAR could not establish if pantographs directly contribute to the vulnerability of the OLE to hot weather. However, the possibility exists. Defective pantograph carbon could damage or hook over the contact wire.

Further work needs to be done to establish if there is any industry standard which sets out the quality and tolerances of pantograph carbons which travel on the contact wire, and if there are documented carbon quality checks prior to running trains. This will be reviewed by the ORR and if necessary, a TAR will be carried out in this area.

There are ongoing works in Scotland region on pantograph monitoring using remote technology known as PanMon. As the work progresses, it should help better understand the risk posed by damaged pantograph carbon.

3.2 Network Rail Technical Authority (TA) Review

In an immediate response to the hot weather incidents of 2019, the TA showed commitment to addressing the problems by setting out short-, medium- and long-term response plan.

The short-term strategy was a “quick fix” approach aimed at restoring the network to normal operation. This includes activities such as re-prioritising defects and maintenance activities to address the heat related defects and vulnerabilities. ORR followed up with the implementation of this plan and confirmed that regions which were most affected in 2019 are really carrying out these activities as planned.

The medium-term strategy was aimed at investigating the possibility of new technologies and campaign changes to optimise the current system and improve resilience in susceptible sections of the network. This also includes updates of relevant standards to target known issues or omissions. Since 2019, there have been various new condition monitoring technologies which are being trialled and some are already yielding benefits to the regions.

The long-term strategy focuses on climate change risk assessment and long-term asset policy requirements to inform renewal decision or long-term risk management approach. As identified in previous section of this report, Network Rail is planning a risk-based renewal in the long term, but asset condition knowledge is crucial to this strategy. Network Rail needs to carry out detailed assessment of those legacy assets that are vulnerable to hot weather to decide if they definitely need to be renewed or they can still be maintained at acceptable performance level in CP7.

Below is a summary of some actions already taken by the TA:

- The TA organised a fixed termination management workshop to develop a detailed work instruction and to share best practices in tension management techniques and adjustments for all the regions.

- The TA updated some maintenance standards to improve the quality of maintenance delivered at DU level. This include NR/L2/ELP/21087 and NR/L3/ELP/27237. In addition, a new standard – NR/L2/ELP/21090, was released to provide a systematic and structured approach to preparing and responding to the threats of extreme weather conditions to the OLE. Although standards now exist which set out new aspirations, the TA will also need to undertake a review of the deliverability of the standard as it may impact resource, access time and available funding.
- In preparation for 2020 hot weather, Network Rail carried out seasonal preparedness activities which highlighted the key risks in each region and action plan to control them. This was an effective piece of work reflecting Network Rail's commitment to proactively identify and deal with weather related risks. This level of commitment and pre-summer assurance is expected to continue. ORR will follow up on this at QLMs.

3.3 Network Rail Regional Review

3.3.1 Wales and Western Region

In this region, there was no hot weather related OLE failures for the periods assessed. The bulk of the OLE in this region is relatively new and have been designed with resilience for hot weather. However, there is approximately 12 miles of Mk3 designs with Balance Weights which are susceptible to hot weather.

The susceptible section of the network will be continually maintained and monitored in accordance with Network Rail's maintenance standard. It was noted that the region will be focusing its CP7 renewal strategy on replacing OLE parts such as Balance Weights that could cause disparity in performance between the Mark 3 and Series 1 designs.

Wales and Western are committed to research and application of new technologies for remote condition monitoring. One of such is the Overhead Line Equipment in Real Time (OLERT), designed to obtain and transmit data from train roof-mounted camera equipment and provide core numbers in relation to wire height, stagger and force. When this is fully developed and rolled out, it is expected to improve asset condition knowledge, aid a risk-based approach to maintenance and better inform renewal intervention. Overall, asset performance and reliability are anticipated to improve.

3.3.2 Scotland Region

Scotland region reported an incident relating to hot weather in 2019 and none in 2020. The single incident was in a fixed termination OLE system which was recently reinstalled after being damaged by a tree during a high wind event. The affected area was not classed as a high-risk area in hot weather because there was no previous hot-weather-related issue, therefore additional precautions and monitoring were not deemed necessary.

Based on documented regional weather resilience strategy, the only FT area being monitored is between Hyndland and Finnieston. The OLE is being monitored by a weather station installed at Finnieston which sends alerts at specific temperature level, which is then followed up by defined actions. Other precautionary measures include deployment of watchman, and speed restrictions depending on the temperature level.

Aside from the only section being monitored, there are other parts of the Scotland region with fixed termination OLE but the preparation of these asset for hot weather is dependent on historical incident records rather than actual condition assessment. Due to the age of this asset and evidence that they are now likely to be more vulnerable to hot weather, Scotland region needs to carry out condition assessment of these asset and update their weather resilience strategy accordingly.

3.3.3 Eastern Region

The Eastern region comprises four routes which are Anglia, East Midlands, East Coast and North & East. 26% of the OLE defects in the region are hot weather related. In the North & East route, the OLE performed well in 2019 and 2020 with no heat related incidents recorded. However, the OLE in the other routes experienced some significant heat related problems. Figure 3.5 below shows a comparison of the number of OLE hot weather-related incidents per route in the Eastern region in 2019 and 2020.

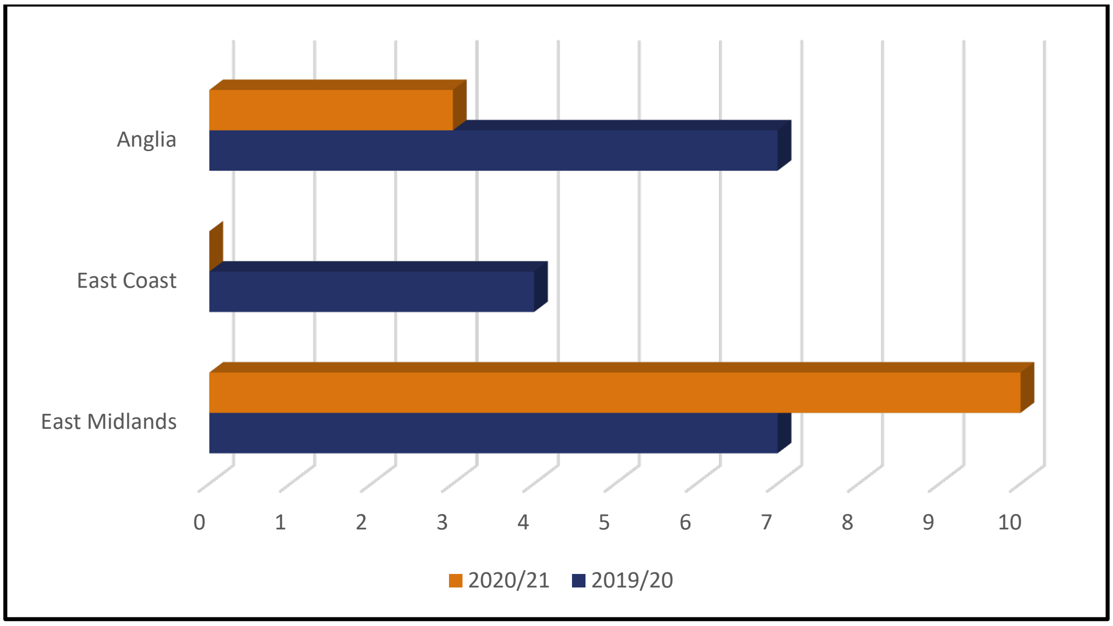


Figure 3.5 – Number of hot weather related incidents in Eastern region (2019 and 2020 excl. North & East route)

Figure 3.6 shows the contributions of each of the three affected routes to the total delay minutes recorded as a result of OLE hot weather-related incidents in 2019.

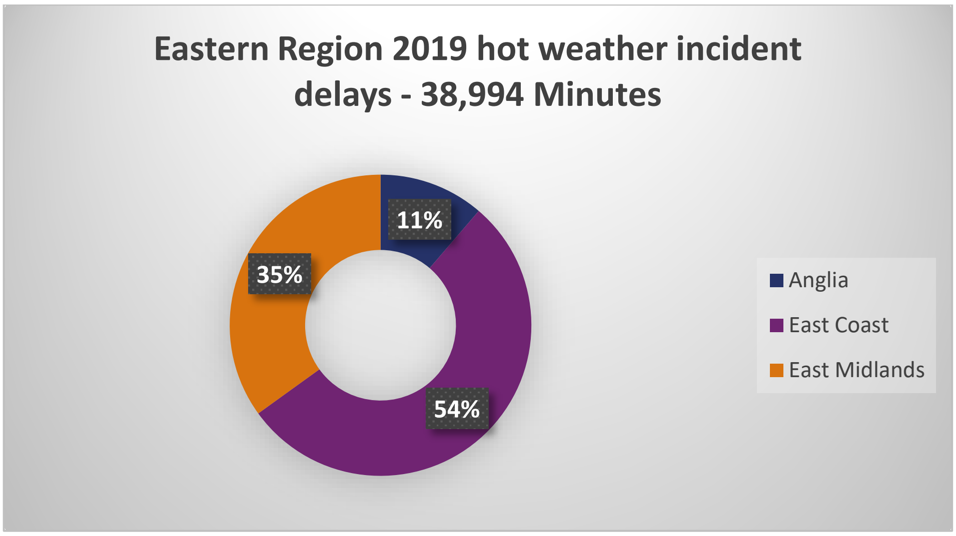


Figure 3.6 – Percentage contribution to delay minutes per route in Eastern region (excl. North & East route)

Despite having the lowest number of hot weather-related incidents in 2019, the East Coast route contributed 54% of the delay minutes. This is attributed to the severity of the incidents and the criticality of the route in terms of traffic. In summer 2020, however, the OLE in the route performed well with no record of weather-related incidents. On the other hand, incident report shows that East Midlands route performed worse in summer 2020 than it did in 2019 with more heat-related Balance Weight issues. However, comments from the route suggested that the increase in number may have been due to reporting issues with train drivers rather than actual incidents.

In Anglia route, there were reports of OLE hot weather-related incidents in 2019, and the tension in some wire-runs were found to be deficient in summer 2020 though there were lesser incidents.

Below are some of the steps taken by the region to improve the resilience of its OLE after the incidents of 2019:

- ***Balance Weight register***: The region reported that steps have been taken to improve the resilience of the asset by maintaining a Balance Weight register for auto-tensioned equipment. This register is monitored periodically at the Route Executive level via visualisation board. This was expected to improve Balance Weight condition knowledge, make failures predictable and inform maintenance and renewal interventions. This approach may have been effective in other routes in 2020 summer but clearly not the case at East Midlands where there were significant number of Balance Weight related problems. This poses a question on the effectiveness of the Balance Weight register on resilience improvement.
- ***New Monitoring Technology:*** The region is working to introduce train mounted technology for remote asset condition monitoring. Also, a remote Balance Weight

monitoring solution has been successfully trialled in the East Midlands route. This is awaiting product approval.

- ***Competence and Capability Improvement***: Staff upskilling is part of the long-term plan to improve asset performance in hot weather. The eastern region, with the support of the TA, organised a training masterclass to upskill their OLE maintenance staff. To further improve maintenance works, new Bluetooth live line cutters have been purchased to allow rapid removal of jumper tails that could put the OLE at risk in hot weather.
- ***Other Programs***: In Anglia route, Pfisterer auto-tension device have been installed to replace FT system in areas where the risk of hot weather failure is high. East Midland route has also done some work to identify defective Balance Weights and put a plan in place to correct the defects. Table 3.0 shows details of progress made on Balance Weights defects correction since 2019. The table shows there are now 17 risk sites when the temperature is from 34ºC to 36ºC, which is an improvement from what used to be 231 risk sites. Further improvement is expected where possible and risk management when temperature increases beyond 34ºC.

Balance Weights Out of Adjustment	Period	
	June 2019	November 2020
Lowest Site	23ºC	34ºC
<=26ºc Risk Sites	29	0
<=31ºc Risk Sites	63	0
<=36ºc Risk Sites	139	17
>36ºc	326	524

Table 3.0 – East Midlands Balance Weight position in 2019 vs 2020

3.3.4 North West and Central Region (NW&C)

In North West and Central, there were 13 OLE incidents in 2019 summer which resulted in a total of 30,566 delay minutes and delay cost of £4,369,757. Being one of the busiest regions in the UK, the incidents attracted a high volume of stakeholders' attention. However, the region responded well with immediate corrective actions and follow-up works aimed at building resilience into the OLE system. These works resulted in improved hot weather performance in 2020 with about 70% reduction in the number of incidents from the previous year.

A program of works was put together by the region to identify assets that are most susceptible to hot weather. A total of 133 wire runs which includes 86 fixed termination OLE and 47 auto-termination equipment were identified and resilience works are progressing. These works include high level survey, correction of defects, re-tensioning and future upgrade of fixed termination anchors.

To improve the quality of maintenance, site patrol, and to drive a consistent approach to pre-hot weather checks, the region has created a document titled "OLE Hot Weather Patrolling Guide". This document highlights samples of OLE conditions that are susceptible to hot weather, potential risks, details of checks required and follow up actions. This document is an example of best practice that should be adopted by other regions. It gives consistency to the quality of hot weather checks carried out.

For continuous improvement in 2021 and beyond, NW&C will reinforce its ability to carry out wire tension assessment by rolling out non-intrusive pole mounted tension meter. Further re-tensioning works of fixed termination OLE will be done and BWA will be remotely monitored until rectified. The season preparedness plans, and execution will also continue with proper management of hot-weather susceptible assets. These works will be monitored by ORR through reports from regional quarterly liaison meetings.

The region has also made some progress in the trailing of OLE remote condition monitoring technology but there's still much to be done. When the trials are completed and these technologies get fully rolled out, the region expects they will improve asset condition knowledge, help to predict and prevent and also reduce manual inspection while improving capacity for defect removal. ORR will assess the progress of these works in six month time with the region and the TA. Figure 3.8 below shows the details of technology programme and opportunities in the region.

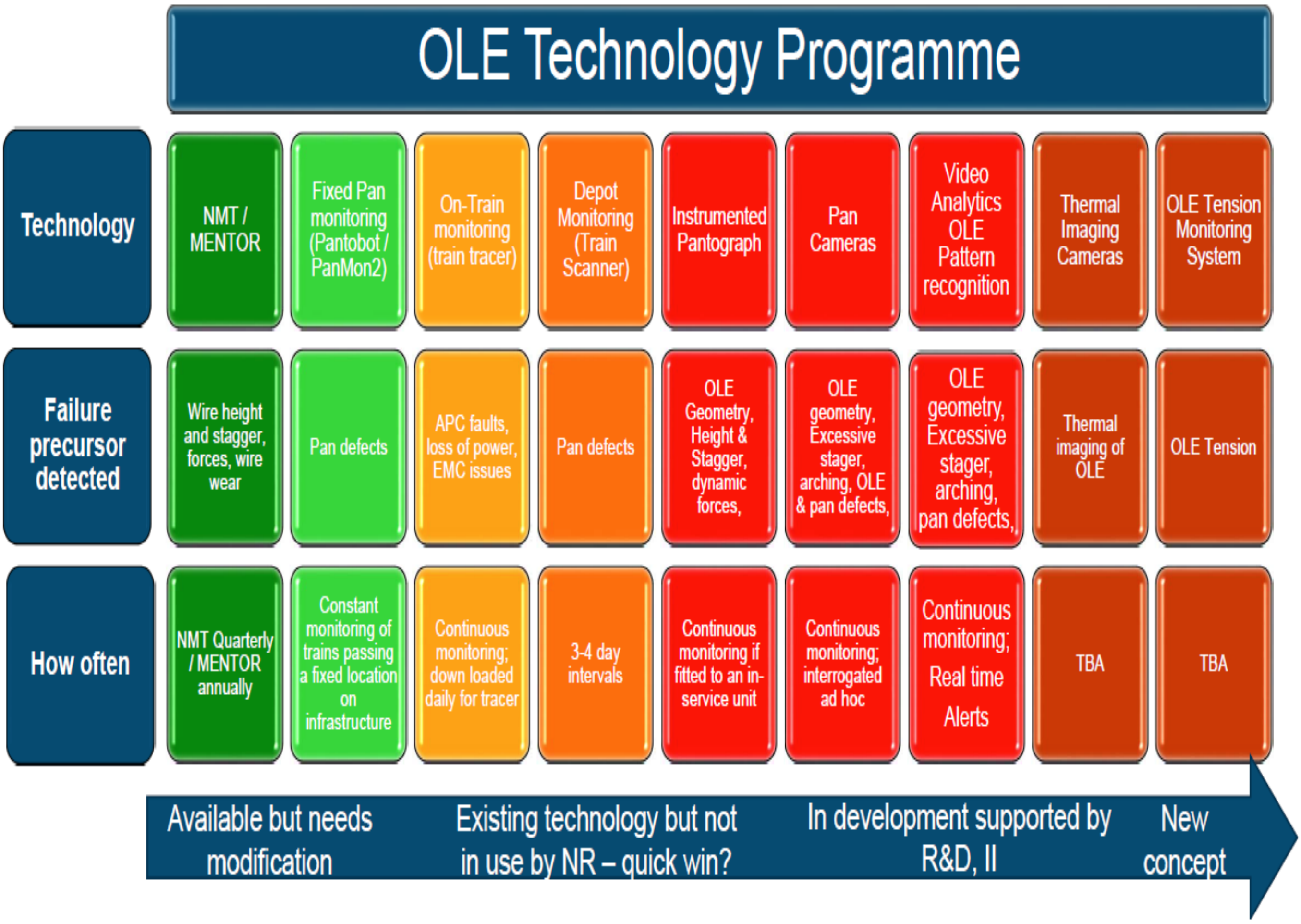


Figure 3.8 – NW&C OLE Technology Programme

Below is summarised list of some completed and ongoing works aimed at improving OLE hot weather resilience in North West and Central region:

- FT OLE wire runs prioritised and fixed termination tension survey programme in progress.
- OLE Re-tensioning work completed at previous failure sites, Camden, Stoke & Gorton
- Seasonal preparedness Balance Weight surveys completed. (Improvement required as only 90% complete by summer 2020, resulting in Balance Weight rectification lag).
- OLE Balance Weight remote condition monitoring successfully trialled at Preston, (self-powered, portable system).
- An illustrated OLE patroller's hot weather guide was issued to maintenance teams, to assist in identifying potential failures in advance of hot weather.
- Rollout of non-intrusive pole mounted tension meter to increase tension survey productivity.
- Further re-tensioning work of FT OLE in 2020-21 & 2021-22.
- Earlier progression of Balance Weight surveys.
- Rollout of portable Balance Weight remote condition monitoring at low Balance Weight sites, until rectified.

- Issue of local special inspection notice to measure jumper sag and rectify non-conformances.
- Project Alpha looking at dealing with critical defects and targeted resilience improvement in asset performance. ORR's investigation into poor train performance of NW&C published in May 2020, shows that OLE hot weather failures are also contributory. The ORR will continue to maintain detailed oversight of the asset management and operations across all regions.

4. Conclusion and Recommendations

4.1 Conclusion

OLE incidents relating to hot weather remain a high risk in summer. However, the severity and number of those experienced in 2019 were not repeated in 2020. Vulnerability of the OLE to hot weather is worsened by age, design operating temperature limits, and inadequate maintenance. Fixed termination equipment is highly susceptible to hot weather and if the tension is not properly monitored and maintained, there is a high risk of dewirement in hot weather.

Network Rail needs to be more proactive in their approach to asset management of OLE, as also identified in our NW&C investigation. Attention was only drawn to some key defects and pending maintenance actions after the 2019 incidents. However, in preparation for 2020 summer, Network Rail demonstrated better preparedness and awareness of the risks and vulnerabilities on the network. This was achieved through early site surveys, asset technical assessments and defect rectification works. This level of preparedness should be the least going forward. It is a good step towards being proactive.

The trialling and future installation of OLE remote condition monitoring technology is another proactive step in the right direction. This should help with better asset condition knowledge, good oversight of risk and intervention planning. It will also aid the ‘predict and prevent’ approach to asset management for better asset performance. There are ongoing trials of PANDAS, OLERT and PanMon, in NW&C, Wales & Western, and Scotland regions respectively. These trials have demonstrated some of the expected benefits. Works and research in this area need to be continuously supported by all stakeholders to hasten roll out. Updates on progress and benefits need to be shared across all regions to avoid duplicating works.

While it would be good to have all the fixed termination anchors on the entire network upgraded to auto-tension equipment, and all Balance Weights replaced with a more resilient AT equipment, the cost and disruption requirements would be untenable. Network Rail needs to take a risk-based renewal intervention in CP7 and beyond while continuously managing the hot weather-related risks.

Delay minutes accrued during incidents are dependent on the criticality of the route; the higher the route criticality, the higher the delay minutes. Unfortunately, most routes with higher criticality, have key assets which are either very close to the end of their technical life or exceeded. Continuous reliance on inadequately staffed maintenance team or asset managers with very tight budgets, will keep these assets continuously deteriorating in its vulnerable state. For improved future performance in hot weather, some key asset renewal decisions need to be made.

There are several of innovative and pragmatic steps being taken across all the regions to improve asset resilience to hot weather. However, each region appears to be working in isolation; dealing with their problems by themselves even if there is another region who has had a similar problem and found a solution. There is a need to improve regional interaction to share best practices and solutions to similar challenges.

4.2 Recommendations

The table below shows a list of recommendations from this TAR:

Recommendation ID	Category	Description	Action / Deliverable	Owner
1	Season Preparedness	Transparent and continuous commitment to early seasonal preparedness.	Each Region should produce evidence of summer preparedness detailing level of risk oversight and planned controls. This should be made available at RQLMs 3-6months in advance.	Regional / Route E&P Engineers
2	Fixed termination OLE	Complete survey of all FT assets to ascertain risk level and inform renewal decision.	Each region should produce a survey report of all FT OLE assets to ascertain risk level and inform renewal decision. This should include plans, timelines for defect correction and FT tension registers.	Regional / Route E&P Engineers
3	Balance Weight	Complete survey of all Balance Weight to ascertain risk level and inform renewal decision.	Each region should produce a survey report of all Balance Weights to ascertain risk level and inform renewal decision. This should include plans and timelines for defect correction. This could be	Regional / Route E&P Engineers

Recommendation ID	Category	Description	Action / Deliverable	Owner
			included in the deliverables for Recommendations 4.	
4	Weather Resilience	Each region is expected to have good oversight of their hot weather risks and have a long-term plan to address them from CP6 and beyond.	Each region should produce and share their OLE hot weather resilience plan and give updates on implementation at RQLMs.	Regional / Route E&P Engineers
5	Asset Condition Knowledge	In order to make informed risk-based renewal decision, it is important to have good asset condition knowledge. This is an area Network Rail needs to improve on.	Continuous improvement on asset condition knowledge with evidence of progress provided to the ORR. Evidence could include asset condition data improvement plan, programme, and updates.	Technical Authority Regional / Route E&P Engineers
6	OLE Maintenance Standards	The introduction of new standards and update of some existing standards will impact maintenance resource, access time and available funds. The TA in conjunction with the regional and route OLE maintenance team need to assess the possibility and challenges of delivering the new expectations as well as how to address them. The	TA to conduct a deliverability assessment of the updates to maintenance standards on FT and inform ORR of their conclusions. This may also be addressed in the regional or national OLE weather resilience strategy.	Technical Authority

Recommendation ID	Category	Description	Action / Deliverable	Owner
		challenges identified as well as the solutions may vary across the regions.		
7	Driver Reporting	The condition of the OLE in hot weather can sometimes generate concerns to train drivers who report them as potential incidents. An example is balance weights dropping very low. Technically, this is expected but some train drivers do not know this and they report them. This in turn generate delays and could also affect the performance rating of the affected region or route.	Network Rail to work with TOCs to resolve driver reporting issues with OLE condition in hot weather.	Technical Authority
8	Sharing best practices	There are some similar problems affecting different regions either at the same time or different times. Some regions have managed to work out a solution which has worked and others are trying to develop a solution.	Network Rail to improve on regional interaction to share best practices and discuss key ongoing challenges.	Technical Authority

5. Appendix A

Regional Request for Information
Outline how you manage the impact of hot weather on susceptible OLE assets. Your response should address the following points: 1. *Outline your strategy for OLE hot weather resilience and how this strategy is aligned to the relevant asset policy and standards;* 2. *Outline any mitigations in place to manage the impact of adverse hot weather on OLE assets;* 3. *Outline historical trends in OLE failures caused by adverse hot weather;* 4. *Outline any support you have received from STE in managing OLE weather resilience;* 5. *Highlight any OLE weather resilience projects being planned or delivered in CP6;*

6. Next Steps

The report will be distributed within Network Rail specifically DEAMs, Maintenance Directors, Route Asset Managers and E&P Network Leads. Network Rail will be required to produce a time bound plan to address the recommendations in this report. We are aware that Network Rail will be developing Regional WRCCA plans, which will form part of their submission to ORR for PR23. It may be possible to address some of the recommendations through this mechanism.

Early visibility of national plans and completion of high risk FT rectification works ahead of summer 2022 is expected. FT equipment tension registers should also be available by summer 2023 and critical sites planned where possible before the end of CP6 and the rest completed in CP7.

ORR will monitor progress at existing Quarterly Liaison Meetings and via e-mail correspondence. Site visits will also be carried out as required. Progress and capability of the regions to address the recommendations will be re-assessed early 2022. Unsatisfactory responses could lead to issues being placed on the regulatory escalator.

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