



## **Crossrail Project Representative**

Crossrail Joint Sponsor Team

## **Semi-Annual Construction Report 20**

**31 March 2018 – 15 September 2018**

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Note: This report relies on the information set out in CRL's Period 6 reports augmented by more current information received by PRep during the course of our routine discussions with CRL since the Period close on 15 September 2018. Note that information emerging after the close of Period 6 is subject to formal confirmation by CRL. This report is supplemented by our periodic and weekly reports to JST, and regular meetings with JST staff. The report is a reduced version of previous reports due to demobilisation of the PRep team; details in cover letter.

**Document history and status**

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## 1. Executive Summary

This report is our independent assessment of the issues that have arisen during the SACR20 period and our assessment of risks to the Staged Openings of the Crossrail project. Following the notification of an Adverse Event Notice on 30 August 2018, CRL submitted a Remedial Action Plan (RAP) which was then revised and reissued on 2 October 2018 (RAP2). We will comment on the achievability of CRL's revised proposals when we receive the new MOHS.

### Health and Safety:

H&S performance has been good during the period and all KPIs are well within target. CRL's 'Finish Safe' campaign commenced at the end of the SACR period.

### Financial:

For SACR20, CRL has reported P50 AFCDC at £13,679m, P80 at £13,752m and P95 at £13,831m in line with its RAP2 late dates. These replace the £13,293m P50 AFCDC reported at Period 6. The increase from SACR19 AFCDC of £12,723m is £956m at P50, £962m at P80 and £976m at P95. The predominant cause for these increases is due to cost pressures across the programme related to delays, prolongation and poor productivity. The P95 RAP2 late dates AFCDC of £13,831 exceeds IP2 by £1,318m. We await the results of the KPMG review.

The total NR On Network Works (ONW) forecast cost (AFC plus variations) is £2,584m, an increase of £54m on SACR19. This is in line with confirmed funding arrangements with Sponsors. Total Secured Funding for NR ONW at SACR20 was £2,885.7m. The CRL estimate for the ONW FFOC at £2,430m, is an increase of £54m on the previous SACR period due to additional Variation Notices being cash funded and therefore not constituting NR Programme Costs. This exceeds the CRL-NR Programme Protocol DfT Intervention Amount of £2.3bn by £130m. CRL has indicated that there are further cost pressures in a number of NR contracts.

### Schedule:

During SACR19 the refreshed Master Operational Handover Schedule (MOHS 2018) was signed off by CRL and its partners in February 2018, so this was the baseline plan for the SACR20 period. Although Stage 3, 4 and 5 Opening dates were retained, most activities and milestones were re-baselined. Our Period 11 FY17/18 report noted that this version was very optimistic and extremely challenging. Following its announcement in June that 'Trial Running' and 'Trial Operations' would be combined into 'Combined Trials' commencing 1 October 2018, CRL developed its strategy in more detail. Unfortunately, significant delays to 78% of all Anchor Milestones due to be delivered in the SACR period proved to be catastrophic for the schedule and the resulting opening dates.

Following issue of the RAP, CRL intend to issue a new MOHS. This will not be ready until 30 November 2018, and then will need approval at CRL Board meeting on 5 December 2018. It will reflect CRL's plans for completion of the project, taking into account its own QSRA and the independent schedule reviews. The MOHS will be based on the [REDACTED]

[REDACTED] We are already aware that some of these dates are under pressure and are likely to be adjusted in the new MOHS. We are also concerned that some Stations Shafts and Portals (SSP) may not be able to achieve completion before handover to the Infrastructure Managers.

The intention is to deliver Stage 3 Opening in Autumn 2019, with a new target date likely to be fixed during Spring 2019. New opening dates will also be confirmed for Stages 4 and 5.

**Progress:**

The combined effects in the SACR20 period of historical schedule pressure, outstanding workload, over-optimistic performance expectations, ongoing access and logistics challenges, and unplanned and unexpected incidents, caused CRL to concede that it is not possible for Stage 3 Opening to be achieved in December 2018.

The new delivery plan is predicated on the completion of all rail systems installation before the start of an intensive period of dynamic testing. The switch to the new regime will be subject to prescribed 'entry criteria', devised to determine the readiness of rolling stock, signalling software and infrastructure, being satisfied. Infrastructure installation is substantially complete, but challenges remain with connections into late-running Stations, Shafts and Portals works. Delays to rolling stock and signalling software development also must be overcome in order for the current Stage 3 Opening target of Autumn 2019 to be achieved.

Until the new regime is in place, dynamic testing will continue in 'windows'. Progress to date has been poor, but it is expected that significant improvements will be realised once 5/2 Dynamic Testing has started, using [redacted] software releases that are properly functionally aligned and fully pre-tested off-site. [redacted]

[redacted]  
[redacted]  
[redacted]  
[redacted]

**RSD & Operations:**

Progress of the Rolling Stock manufacture and software development has not met its forecasted deliverables in SACR20, which has delayed the planned opening of Stage 2-2, and contributed to the delay of Stage 3. However, the Old Oak Common Depot is now effectively operational.

Problems with TCMS and signalling integration have meant Stage 2-2<sup>1</sup>, planned during early SACR19 for the end of February 2019, is now forecast for May 2019. In our opinion, this date is unlikely to be met. For Stage 3, the train was expected to be approved for Dynamic testing (DT) in April 2018, but this is now forecast for November 2018. This is dependent upon both [redacted] resolving issues that affect key technical criteria for entering DT, so this date is at significant risk, which would result in consequential delays to the DT programme.

The IMs are generally in a good position to receive the railway for Staged Completion and Trial Operations. They must now ensure that staff morale, competencies and behaviours do not regress as a result of the enforced delay to Stage opening. [redacted]

[redacted]  
[redacted]  
[redacted]  
[redacted]

**Assurance:**

Progress in completing the assurance evidence during SACR20 has been behind schedule, with safety submissions to CRL's assurance body RAB-C averaging 5 per period, when 10 per period were required.

CRL's NoBo and AsBo have been similarly affected, as the testing and commissioning activities required to show evidence that construction and installation complies with the design has not

<sup>1</sup> See PRep SACR19 for an explanation of why Stage 2 was separated into two parts.

been carried out. This is consistent with the delay to the programme, because if the asset is not finished then the evidence cannot be produced.

The material for the assurance evidence is generated by the Contractors. We have highlighted in our Period reports the importance of Contractors completing this evidence as well as the physical works; without that evidence, the railway cannot be put into service. This must now be in accordance with the submission schedule (to be produced as part of the MOHS process) to the AsBo, NoBo and ORR.

## 2. Overview of Costs

### 2.1. AFDCD and Intervention Points

At SACR20, CRL is reporting that the [REDACTED] £13,831m P95 AFDCD from the Remedial Action Plan, dated 2 October 2018, (RAP2) replaces the £13,293m P50 AFDCD reported at Period 6. This is a £1,108m increase from £12,723m at SACR19. However, the methodology of ascertaining the RAP2 P95 estimate has used a different approach from previous P95 assessments and cannot be regarded as like for like. The uncertainty of the schedule to completion is causing significant confusion in establishing a tangible and credible AFDCD. The progression and inconsistent development of the AFDCD since the submission of the initial Remedial Action Plan up to SACR20 is tabled in Figure 2 - 1.

Probability Level	AFDCD					
	RAP1 18 September 2018 £m	[REDACTED] 2 October 2018 £m	[REDACTED] 2 October 2018 £m	Period 6 Board 8 October 2018 £m	Period 7 Board 2 November 2018 £m	SACR 20 Board 3 November 2018 £m
P50	£13,279	£13,279	£13,679	£13,293	£13,499	-
P80*	£13,309	£13,310	£13,752	-	-	-
P95*	£13,335	£13,335	£13,831	-	-	£13,831

Figure 2 - 1~ AFDCD Progression from RAP to SACR20

The values for both P80\* and P95\* tabulated above have been estimated by CRL assessing the latest progress position on site, recent contractor performance and the underlying assumptions upon which the CRL Remedial Action Plan was based. Time allowances were considered and each key period has been reviewed to provide an [REDACTED] completion date for each project.

The [REDACTED]

[REDACTED] dates take into account further risks other than those included in the quantified risk analysis, a Force Majeure type event or a fundamental system failure between train and signalling. The [REDACTED] dates provide a more prudent position for outturn time and cost, although the [REDACTED] dates are not guaranteed.

The Intervention Points IP0, IP1 and IP2 have increased by £1m during the SACR20 period to £11,673m, £11,913m and £12,513m respectively.

CRL has previously reported SACR AFDCD in line with the contemporaneous periodic results; Period 6 in this case. However, for SACR20, CRL has reported P50 AFDCD at £13,679m, P80 at £13,752m and P95 at £13,831m in line with its RAP2 [REDACTED] dates. This represents an overall increase from SACR19 of £956m at P50, £962m at P80 and £976m at P95. In addition, although CRL has expressed the £13,831m P95 AFDCD as the replacement to the Period 6 AFDCD, it has reported the Period 7 P50 AFDCD at £13,499m ahead of issuing SACR20. Presently, the RAP is not substantiated by an accepted programme. Once this becomes available, further analysis is essential in order to provide the necessary confidence that the AFDCD is credible to completion.

During the SACR20 period, Sponsors made available an additional £300m funding above IP2. The SACR20 AFDCDC has consumed all of this increased funding and has imposed commitment on Sponsors for further additional funding. As an interim measure, DfT announced on 26 October 2018 that £350m of short term repayable financing will be made available to the Mayor of London and TfL in the current financial year to ensure that full momentum is maintained behind Crossrail. Further funding will need to be put into place to prevent the Sponsor Funding Account (SFA) falling into deficit, which CRL is currently forecasting to occur in Period 10 2018/19.

**2.2. Risk & Contingency**

At SACR20, the Finance Current Control Budget (FCCB) has increased by £303m from £12,507m at SACR19 to £12,810m. The £13,293m P50 AFDCDC at Period 6 exceeds the financial budget by £483m, and exceeds the RP4.2 Baseline funding of £12,136m by £1.16bn. However, the P95 £13,831m AFDCDC CRL report at SACR 20 as replacing the Period 6 AFDCDC, exceeds the FCCB by £1.02bn and the baseline funding by £1.7bn.

The total contingency available to CRL was £84m at Period 6, which is insufficient to cover the risk exposure of £574m by £490m. The centrally controlled Delivery contingency and Board contingency are £38m and £23m respectively.

During the same period, the corresponding P50 risk exposure has increased by £99m, an increase of 21% over the SACR19 period. CRL ceased to report P95 risk exposure from Period 1. CRL has reported a P95 AFDCDC for SACR20 but, as noted above, this has been ascertained under different and unconnected principles from previous P95 estimates. CRL report that the SACR20 P95 Late Dates AFDCDC includes a risk exposure of £1,113m. The comparison and significant 83% increase of P95 risk exposure is shown in Figure 2 - 2, but this may be regarded as unreliable.

Description	£ million	
	P50 Risk Exposure	P95 Risk Exposure
SACR 19 Period 13	475	607
SACR 20 Period 6	574	1113
SACR Period Increase	99	506
% Increase	21%	83%

**Figure 2 - 2 ~ Increase in P50 and P95 Risk Exposure<sup>2</sup>**

The latest RAP includes allowances based on the latest forecast dates for an homologated train and associated software. No allowance has been made for further delays, and the costs assume a reliable and integrated train for the start of dynamic testing. The omission of associated risk provisions compromises the credibility of the AFDCDC to completion and could create further future AFDCDC growth creep.

<sup>2</sup> The SACR20 P95 risk exposure is based on RAP2 [redacted] dates.

### 2.3. Stage Opening Delays – Cost Implications

The issue of the Adverse Event Notice by CRL, and the related revised Stage 3 opening plan, have very significant implications for forecast costs which has contributed to the increase to the AFCDC at SACR20 and into Period 7. CRL is reporting that further AFCDC increases are expected to be added following the review of the RAP. CRL is ensuring that additional funding requests are supported by a realistic assessment of the schedule and risks. This will require examination at a detailed level to ascertain if they are credible, to ensure all costs are covered, including Stages 4 and 5, and sustainable to fund to completion. Sponsors commissioned KPMG to undertake two independent reviews of the project: one on governance and the other on financial and commercial management. An outcome from these reviews may be the determination of the costs to completion.

### 2.4. ONW Costs

At SACR20, the total AFC and Variations funding for NR ONW was £2,584m, an increase of £54m on SACR19 (£2,530m). This is in line with confirmed funding arrangements with Sponsors. Total Secured Funding for NR ONW at SACR20 was £2,885.7m, as a consequence of NR securing recoveries in respect of other NR projects etc., as shown in Figure 2 - 3.

The ONW funding is still expected to increase in future periods, as NR is currently discussing a further application for funding from the Portfolio Board to cover cost pressures relating to [REDACTED]

Description	SACR 20 Source of Funding				SACR 19
	DfT £m	CRL £m	NR £m	Total £m	Total £m
KD1A - OTP	2,049.0	-	-	2,049.0	2,049.0
CRL Managed Risk	110.0	-	-	110.0	110.0
Portfolio Board Funding	271.0	-	-	271.0	217.0
Approved £154m VNs	112.0	22.0	20.0	154.0	154.0
<b>NR Current Funding</b>	<b>2,542.0</b>	<b>22.0</b>	<b>20.0</b>	<b>2,584.0</b>	<b>2,530.0</b>
[REDACTED]					
<b>Sub Total</b>	<b>-</b>	<b>118.9</b>	<b>182.8</b>	<b>301.7</b>	<b>305.4</b>
<b>TOTAL SECURED FUNDING</b>	<b>2,542.0</b>	<b>140.9</b>	<b>202.8</b>	<b>2,885.7</b>	<b>2,835.4</b>

Figure 2 - 3 ~ NR ONW Secured Funding

At SACR20, the base NR Total Cost was £2,885.7m, as shown in Figure 2 - 4. CRL has applied a cost sensitivity analysis resulting in a range of £2,929m to £3,071m for potential NR costs as at SACR20.

Description	SACR19 £m	SACR 20 £m	Delta £m	SACR 20 Cost Sensitivity		
				Low £m	Mid £m	High £m
SPOT AFC - Gross excluding Risk	2,901.6	2,907.7	6.1	2,943.1	3,010.0	3,070.9
Risk	0.0	0.0	0.0	0.0	0.0	0.0
Efficiencies	-24.3	0.0	24.3	0.0	0.0	0.0
Recoveries (Residual)	-18.1	-7.1	11.0	-2.1	-1.9	0.0
Targeted Savings	-23.8	-14.9	8.9	-11.9	-7.5	0.0
<b>Cost Grand Total</b>	<b>2,835.4</b>	<b>2,885.7</b>	<b>50.3</b>	<b>2,929.1</b>	<b>3,000.6</b>	<b>3,070.9</b>
Total Secured Funding	2,835.4	2,885.7	50.3	2,885.7	2,885.7	2,885.7
Funding Gap	0.0	0.0	0.0	43.4	114.9	185.2

Figure 2 - 4 ~ NR ONW Cost Summary

The NR Forecast Final Outturn Cost (FFOC) at SACR20 is £2,430m, which reflects reported NR total funding of £2,584m, less £154m NR cash funding.

The CRL estimate for the ONW FFOC at £2,430m, is an increase of £54m on the previous SACR period due to additional Variation Notices being cash funded and therefore not constituting NR Programme Costs. This exceeds the CRL-NR Programme Protocol DfT Intervention Amount of £2.3bn by £130m. The FFOC is subject to estimated pain share adjustment of £70m, which results in a Forecast to the RAB of £2,360m, which exceeds the DfT Intervention Price of £2.3bn by £60m, as shown in Figure 2 - 5. CRL has indicated that there are further cost pressures in a number of NR contracts.

Description	SACR 19 Period 13 £m	SACR 20 Period 6 £m
AFC plus VN Allowance	£2,376	£2,886
Pain/gain share	-£70	-£70
Cash/CRL/NR Funding	£0	-£456
Total Forecast to RAB	£2,306	£2,360
DfT Intervention Price	£2,300	£2,300
Headroom to DfT Intervention Price	-£6	-£60

Figure 2 - 5 ~ FFOC Headroom for DfT Intervention Price

## 3. SACR20 Overview (up to 15 September 2018)

### 3.1. Health and Safety

The RIDDOR AFR remained at 0.09 and the Lost Time Case AFR fell from 0.17 to 0.15. The leading indicator HSPI reduced slightly from 2.59 to 2.57, with all contractors beating the target of 2.00. All KPIs remained well within target, which is to be applauded during a period when most systems were energised and the number of fit-out contractors, with visiting or part time workers, increased substantially. CRL's 'Finish Safe' campaign commenced at the end of the SACR period.

### 3.2. Milestones and Strategic Achievements

The refreshed Master Operational Handover Schedule (MOHS) was signed off by CRL and its partners in February 2018, so this was the baseline plan for the SACR period. Although Stage 3, 4 and 5 Opening dates were retained, most activities and milestones were re-baselined. Our Period 11 report noted that this version was very optimistic and extremely challenging. Our following periodic reports described the continuing delays as they occurred.

Following its announcement in June that 'Trial Running' and 'Trial Operations' would be combined into 'Combined Trials' commencing 1 October 2018, CRL developed its strategy in more detail. Twenty five Anchor Milestones (AM) were adjusted and a further eleven were deleted so that the revised MOHS reflected the new approach. The changes were carried out within the Systemwide, Operations and Integration elements of the schedule.

All 83 Anchor Milestones (AMs) scheduled for the SACR20 period are listed in Appendix D.1. 22% were delivered earlier than the late date base line and 20% were delivered late. However, the remaining 58% were not delivered and were forecast to be delivered late at the end of the SACR period (Period 6). These facts neatly summarise the status of progress during the SACR period i.e. there were significant delays across almost all parts of the Programme. Details regarding missed milestones are given elsewhere in this report.

In spite of the delays, a number of strategic achievements are worthy of note:

- Completion of Traction Power energisation from Pudding Mill Lane and Kensal Green, including securing all final LONO's from neighbouring railways;
- Completion and commissioning of permanent HV power systems on the Central Section;
- End-to-end test train runs at line speed between Abbey Wood and Westbourne Park;
- Initial dynamic test train runs across the NR GEML and GWML interfaces;
- Some Stations ready for OSD;
- Stage 2 partially started on 20 May 2018, with 4 RLU's operating between Paddington high level and Hayes & Harlington;
- The Old Oak Common depot was effectively completed for operational service.

The principal ONW achievements in the SACR20 period were:

- Ticket offices at Forest Gate and Gidea Park stations were handed to MTR-C;
- High voltage cables IC1 and IC2 were completed and energised at Kensal Green;
- Permanent Gauging Certificate obtained for the Class 345 (BXR14) rolling stock between Paddington and Reading;
- Integration of Crossrail into the Paddington to Reading (P2R) delivery unit;

- 100 Driver Only Operation (DOO) cameras and associated systems were successfully installed and commissioned;
- Pudding Mill Lane portal signals were installed and commissioned;
- Abbey Wood station and four public lifts were formally handed over to the NR Route and MTR-C;
- Royal Oak OLE was Entered into Service;
- Signalling works associated with the Hayes & Harlington station bay platform were completed;
- The Platform 2 extension at Romford was handed over to RfL.

NR completed all its planned Key Dates and Outputs in the SACR20 period, notably:

- KO2 – Infrastructure Capability from Abbey Wood to the Central Core Area at Plumstead Portal, from Stratford to the Central Core Area at Pudding Mill Lane and from Old Oak Common to Westbourne Park;
- KO5a - Full Infrastructure Capability in accordance with the ONFR from Shenfield to the Central Core Area at Pudding Mill Lane;
- KD22 - Route clearance and all other infrastructure, including stabling & sidings updates, complete to support Stage 4 Dynamic Testing;
- KO5b - Full Infrastructure Capability in accordance with the ONFR from Maidenhead to Westbourne Park Central Core Area
- KD24 - Infrastructure complete to support Stage 5 Dynamic Testing;
- KD33 – infrastructure complete to allow access to OOC Depot.

All of NR’s original Key Dates and Key Outputs have now been achieved. During the SACR20 period, CRL and NR established two new Key Outputs, KO6a and KO6b, to cover the residual works required for Stages 4 and 5 respectively: see Section 4.4.

### **3.3. Key concerns (April 2018 to September 2018)**

#### **3.3.1. Anchor Milestones not achieved in Period**

Forty eight AMs (58%) were not delivered in the Central Operating Section during the period and seventeen (20%) were delivered late; these are listed in Appendix D.1. The Baseline Dates shown are from MOHS 2018 (adjusted in June 2018) and the Actual/Forecast dates are as at Period 6 (end of SACR20).

It is of little benefit to describe in detail here why 65 AMs were delayed, although we do give summary explanations in the following text; details are provided elsewhere in CRL’s and our periodic reports. Suffice to say that significant delays to 78% of all AMs due to be delivered in the SACR period proved to be catastrophic for the schedule and the resulting opening dates. Our SACR19 report noted that “CRL face a number of significant challenges during the remainder of 2018, and there remains a high risk that Stage 3 Opening may be delayed or the opening will be sub-optimal”. Unfortunately, the high risk has become a reality.

All Baseline Early and Late dates will be reset in the new MOHS; see Section 4.

#### **3.3.2. On Network Works**

During the SACR20 period, ONW works progressed to 96% completion, based on expenditure; however, this reduced to 91% at SACR20 due to an increase in the FFOC. At the end of the SACR20 period, NR reported that all works are on schedule to achieve the remaining Key Dates

and Key Outputs. The remaining stations work is being procured, with works programmed by NR to complete late 2019.

The cost of the Enhanced Stations (West) continues to remain uncertain. NR reports that Package 3 (Southall, Hayes & Harlington, West Drayton) tender returns have been assessed and tender recommendation made, although clarity is now being sought with respect to staging options, so final recommendation is scheduled during Period 7 and Contract award expected in October 2018. Package 2 Tender returns (Acton, Ealing, West Ealing) have been received and are under review. [REDACTED]

**3.3.3. Rolling Stock and Depot (RSD)**

[REDACTED] planned activities for Rolling Stock in SACR20 were as follows:

- For Stage 3 develop TCMS v7.2 so that it would be approved for DT in early April 2018, Trail Running in late June and be authorised for passenger service in early August 2018. In addition, it would continue to supply trains for acceptance by RfL and MTR-C to allow 22 trains to be ready for Trial Running.
- For Stage 2-2<sup>3</sup> develop TCMS v7.3<sup>4</sup> to a point where it could be used for integration testing at Melton, followed by the undertaking of the formal ETCS testing (known colloquially as the 39 tests) on the Heathrow spur. Approvals for driver training were forecast to be achieved for mid-October 2018, and for passenger service by mid November 2018. Passenger service would start once the driver training programme was completed, and was not confirmed at the start of SACR20.

The development of the train software for Stage 3 did not maintain the forecast dates. There have been issues with the integration of the [REDACTED] During SACR20, transition testing has been carried out but it has been problematic, and multi train testing has yet to start.

So far, 18 Full Length Units (FLUs) have been accepted by RfL. The number has not increased to 22 as planned [REDACTED] BT has manufactured 40 FLUs as of early November 2018.

[REDACTED] did not make sufficient progress with TCMS v7.3 during SACR20 to enable formal ETCS testing to start as planned in mid-August. As of early October 2018 it is expected to start in December 2018, but this is provisional and unconfirmed by BT. [REDACTED]

[REDACTED] It is likely that TCMS v7.2 will need to be significantly complete before momentum can be applied to TCMS v7.3. We therefore expect further slippage to the provisional date. [REDACTED]

The depot was effectively completed during SACR20. The remaining outstanding works of note comprise the connection of the Back Line, and these Works are the responsibility of NR.

<sup>3</sup> In this report we have described Stage 3 before Stage 2-2, as during SACR20 CRL made a decision to prioritise Stage 3 and implement it before Stage 2-2.

<sup>4</sup> TCMS v7.2 has full CBTC functionality, TCMS v7.3 has in addition full ETCS functionality.

**3.3.4. Regulatory Approvals & Assurance**

The change in status of regulatory approvals during SACR20 is shown in Figure 3 - 1.

Stage	Status						Comment
	P1	P2	P3	P4	P5	P6	
2-2	Yellow	Yellow	Yellow	Yellow	Red	Yellow	During the first 4 periods the target date for opening, was late February 2019. Over the course of the SACR period, the delays to the TCMS v7.3 software, and consequential impact upon the driver training programme, made a February opening increasingly untenable, hence the change to 'red'. The amber rating reflects the proposed May opening <sup>5</sup> .
3	Yellow	Yellow	Red	Red	Red	Yellow	The first two periods reflected CRL's belief that the September submission date to the ORR for the COS APIS was possible. The change to 'red' in P3 was due to the slow rate of progress in safety evidence being produced by the Contractors and submissions to RAB-C. It was clear indication that an ORR submission in September 2018 would not be possible <sup>6</sup> . The Change to amber in P6 reflects the re-baselining exercise.
4	Green	Green	Green	Green	Green	Green	The Green rating reflects the status of the regulatory approvals as they relate to Stage 4, not the rating of Stage 4 itself. Implementing Stage 4 has been rated 'red' since Period 2.
5	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	The amber status is due to the delay to ETCS being implemented between Paddington and Stockley Junction as planned by start of Stage 5 (December 2019). The delay to Stage 5, possibly to December 2020, is unlikely to affect the rating.

Figure 3 - 1 ~ Regulatory Approvals during SACR20

**3.3.5. Infrastructure Completion and Systems Integration**

CRL retained Blockade Working (alternating 11 days of construction with 3 days of dynamic testing in two-weekly cycles) as the most efficient and cost effective means of progressing infrastructure installation and dynamic testing. It was implemented in late April 2018 to address the problem that Systemwide delivery and dynamic testing activities had effectively 'saturated' the tunnel environment, with little scope for gaining performance improvement in one workstream without significant impact upon the other. It also overcame the fundamental inefficiencies of the previous delivery philosophy of alternating between dynamic testing and construction (on days and nights, respectively). However, despite the availability of longer construction periods, the logistical difficulties of servicing multiple sites in an extremely constrained tunnel environment, combined with unrealistic delivery targets, has meant that many MOHS milestones were missed. Prioritisation of critical rail systems installations has allowed dynamic testing to start, but completion of ventilation systems, walkways, fire mains, drainage and lighting remains outstanding. CRL's plans to achieve completion are summarised in Section 4.3.

<sup>5</sup> In our opinion this is unlikely to be achieved.

<sup>6</sup> We had recommended a 'red' status during SACR19.



The following commentary refers to the refreshed MOHS 2018 (as adjusted in June 2018)<sup>7</sup>. New SSP target dates for Tier One Substantial Demobilisation (TOSD) commencement and Staged Completion (SC), through to Stage 3 Opening, will be included in the new MOHS. These are referred to in Section 4.3.5.

██████████  
 CRL's forecast for Handover to the IM slipped by 11 weeks during the period to 26 November 2018. The delay was mainly caused by poor management and coordination of MEP design and installation, and poor progress with fitout works.

**Bond** ██████████  
 CRL's forecast for Handover to the IM remained at 28 November 2018 during the period but the Contractor's programme did not support this date, and significant issues, such as installation and testing of tunnel ventilation at the eastern end, continued at this station.

██████████ ██████████  
 CRL's forecast for Handover to the IM slipped by 15 weeks during the period to 26 November 2018. The delay was mainly caused by poor management and coordination of MEP design and installation, especially the fire alarm system.

██████████ :  
 CRL's forecast for Handover to the IM slipped by 14 weeks during the period to 26 November 2018. The delay was mainly caused by poor management and coordination of MEP design and installation, especially the mechanical air handling and fire systems.

██████████  
 CRL's forecast for Handover to the IM slipped by 4 weeks during the period to 23 November 2018. The Contractor experienced delays on the Northern Line link and in the central concourse.

██████████ i:  
 CRL's forecast for Handover to the IM slipped by 6 weeks during the period to 16 November 2018. The Contractor had problems with the central concourse cladding, MEP and communication systems.

██████████  
 CRL's forecast for Handover to the IM slipped by 22 weeks during the period to 7 December 2018. CRL were aiming at two staged completion dates on 28 September and 16 November, but all target dates became at risk due to the additional 'Project 3' works identified. CRL are currently reviewing potential additional works known as 'Project 4'.

██████████  
 CRL's forecast for Handover to the IM slipped by 9 weeks during the period to 1 October 2018 due to difficulties completing all MEP works and related testing. Although the work is substantially complete, communications systems were not finished so this target was not achieved.

██████████ :  
 CRL's forecast for Handover to the IM slipped by 2 weeks during the period to 14 November 2018. Problems with production of cladding installation continued as well as delays to final MEP installation and testing.

<sup>7</sup> With additional information from meeting with Delivery Director 18 October 2018.

**Shafts and Portals:**

Completion of work at [REDACTED] was the biggest problem, caused by delays with the removal of temporary tunnel ventilation and completion of MEP systems. To enable early Handover to RfL, all parties considered staged completion for [REDACTED] but this was not implemented due to the new opening strategy. All other shafts and portals were targeted to be ready for handover during August and September, with full Handover targeted for 1 October 2018, although these were challenging targets. CRL had ambitious plans for Phase 3 testing which did not prove achievable due to insufficient resources in the systemwide contractors, so Handover on 1 October 2018 was not met.

**3.3.8. Operations**

Current Operations by MTR-C for Stage 1 and 2-1 are of a high standard, and are regularly at or near the top of the national Operators Passenger Performance Measurement table. [REDACTED]

[REDACTED]

In broad terms, the IMs and MTR-C have been meeting their programmed activities with regard to recruitment and training of staff. [REDACTED]

[REDACTED]

[REDACTED]

<sup>8</sup> During the latter stage of SACR19 Trial Running and Trial Operations were combined into a 9 week trial period.

## 4. Forward Look (from 16 September 2018)

### 4.1. Schedule

#### 4.1.1. MOHS Refresh

Further to the Adverse Event Notice (AEN) issued by CRL on 30 August 2018, and following Sponsors request, CRL presented its Remedial Action Plan (RAP) to the Sponsor Board meeting on 20 September 2018. Sponsors informed CRL that the RAP was not adequate and requested additional information. The updated RAP was discussed at the CRL Board meeting on 11 October 2018 and the Sponsor Board meeting on 15 October 2018.

The new MOHS will not be ready until 30 November 2018, and then will need approval at CRL Board meeting on 5 December 2018. It will reflect CRLs plans for completion of the project, taking into account its own QSRA and the independent schedule reviews<sup>9</sup>. The MOHS will be based on the [REDACTED] strategy presented to Sponsors on 15 October 2018. [REDACTED]

[REDACTED] The intention is to deliver Stage 3 Opening in Autumn 2019, with a new target date likely to be fixed during Spring 2019. New opening dates will also be confirmed for Stages 4 and 5.

The RAP sets out the following strategy:

- Finish Routeway installation – December 2018;
- Complete [REDACTED] Integrated testing – May 2019;
- Commence Interim Dynamic testing – December 2018;
- Commence 5/2 Dynamic testing – January 2019;
- Complete Dynamic testing – May 2019;
- Commence Trial Running – June 2019;
- Stage 3 Opening – Autumn 2019 TBA.

All of these are subject to change and confirmation in the new MOHS.

#### 4.1.2. Anchor Milestones for SACR21 period

The new MOHS will include new Anchor Milestones. Further details will be included in our periodic reports.

### 4.2. Stage 2 Phase 2 Opening – target start date May 2019.

The project teams understand that they should be planning to start services by May 2019, and are currently seeking to resolve the train's software, the key impediment to that objective.

### Rolling Stock

#### *Interim stage*

We understand RfL is targeting implementing the FLUs in time for the new timetable introduction on 9 December 2018. There would be no detrimental impact upon passengers if that does not succeed, as RLUs could continue to operate. If this happens, then RfL does not

<sup>9</sup> Schedule Reviews by Ian Rannachan and by John Boss Consulting.

need to wait until the next timetable change to make the swap. The negative impact of the delay would be to defer the opportunity to build reliability<sup>10</sup>.

*Stage 2-2*

Looking forward, RfL is expecting [redacted] to have completed TCMS 7.3 type testing and the formal Heathrow tests (known colloquially as the 39 tests), culminating in Approval to Operate ETCS for driver training by February 2019 and Approval to Operate C345 in passenger service by early March 2019<sup>11</sup>.

However, we however have little certainty as to whether these dates will be met by [redacted] due to the on-going demands of completing Stage 3 software development. Forecasting dates for completing TCMS v7.3 with a greater degree of confidence will be in doubt until that work is significantly complete. This is not likely to be until some point in or beyond November 2018.

The uncertainty surrounding the software means that we think it unlikely that the current target date for opening, May 2019, will be met. [redacted]

[redacted] RfL is considering a contingency plan by entering talks to extend the lease of the existing C360s, which currently ends in May 2019. This is prudent, but problematic due to the fleet's changing maintenance requirements and logistics<sup>13</sup>.

CRL/RfL have been considering mitigations such as using another test track, but availability is likely to be limited. It may also consider reducing the functionality of the TCMS software. This particular initiative, if implemented, is likely to disrupt the current plan for completing the TCMS software that will be required to operate for all Stages.

**Operations**

The key operational issue affecting the start of Stage 2-2 is the driver training programme, currently estimated by MTR-C to have a duration of 10 weeks, at the end of which 140 drivers will be trained. The current programme<sup>14</sup> assumes a start date at the end of February, but as we said in the Rolling Stock section there is little clarity as to whether the train software will be developed and tested in time to support this date. [redacted]

A further complication is that MTR-C does not wish to implement Stage 2-2 during the implementation phases of Stage 3. If the May date is missed, and we believe there is a high risk of that, then it is unclear whether Stage 2-2 can be implemented until after Stage 3 opening.

**Regulatory Approvals**

There is one remaining key approval for Stage 2-2, APIS ETCS On-board to be issued by ORR to BT, which was forecast for early March 2019. There are other approvals to obtain from the industry safety panels:

- NR's Wales and West SRP will approve putting ETCS wayside into use;

<sup>10</sup> The first provisional date for implementation was 12 August 2018. See PRep Period 2 status report.

<sup>11</sup> Dates provided by RSD Period 6 Dashboard.

<sup>12</sup> [redacted]

<sup>14</sup> Stage 2 Phase 2 Period 6 PDB dashboard.

- MTR-C SVP will approve driver training and then passenger service;
- HALARP will approve reliability running, driver training and passenger service.

These approvals are dependent upon successful completion of the train’s software and subsequent provision of assurance evidence.

### 4.3. Stage 3 Opening

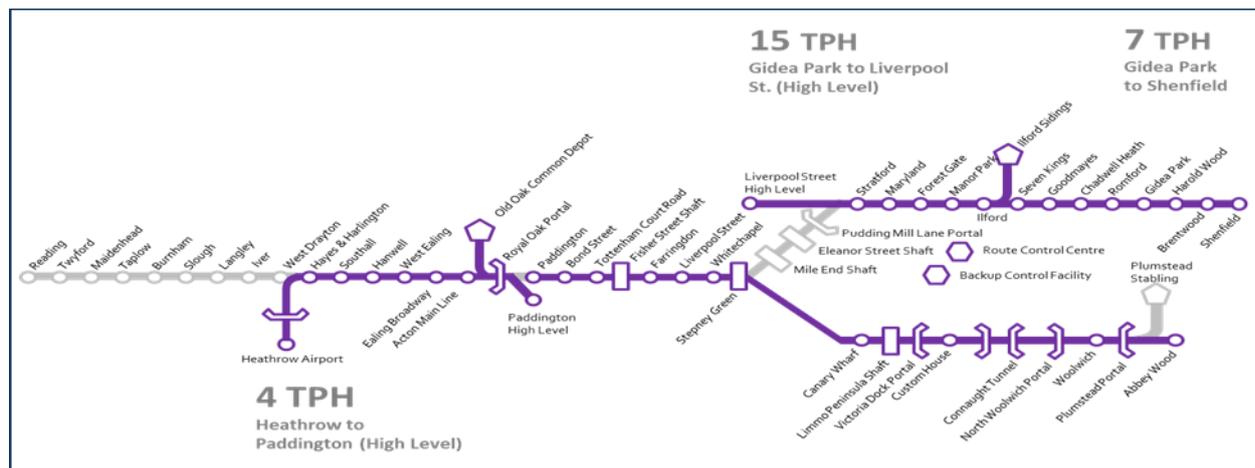


Figure 4 - 1 ~ Stage 3 Opening

#### 4.3.1. Infrastructure Completion and Systems Integration

CRL will continue with Blockade Working for the early part of SACR21. CRL then intends to switch to a new delivery regime known as ‘5/2 Dynamic Testing’, which forms part of CRL’s wider strategy for the delivery of an integrated railway fit for Handover to the IMs, Trial Running and Trial Operations (see Section 4.1.1). The new regime effectively reverses the balance in schedule opportunity between construction and dynamic testing, and is based upon the assumption that reduced access only will be necessary for any remaining construction-related works. It is possible that the content of CRL’s final plans will be influenced by the outcome of a review being carried out by PA Consulting.

Fitness to switch will be assessed at an independently-chaired Readiness Review at least 4 weeks ahead of the target date, and will consider pre-requisites for Construction, Fixed Infrastructure Systems, Rolling Stock and Dynamic Testing Operational Planning Governance Arrangements. The target date is driven by actual progress, and the decision to commit will consider the extent to which any outstanding work inhibits ongoing strategic delivery progress. Further objectives are to minimise construction-related costs, and to remove the reliance upon the works trains and rail plant which currently drive the retention of the temporary tunnel ventilation arrangements.

Elements of outstanding works remain with linear rail systems, signalling, tunnel ventilation, radio, traction and HV non-traction power, SCADA and communications, stations, shafts and portals. Current forecasts indicate that the entry criteria for these are able to be satisfied to meet the Interim Dynamic Testing date in Section 4.1.1.

Thereafter, and in parallel with dynamic testing, the outstanding SSP mechanical and electrical installations will need to be completed to allow Phase 3 Static Integration Testing back to the Romford RCC. Phase 3 testing remains a significant critical workload, requiring a large number

of C660 specialist testing resources which have yet to be secured, and which must be completed to allow Trial Running to start. The current Early Start Date for Trial Running is 17 June 2018.

While the new MOHS has yet to be formalised, we urge CRL to be realistic rather than over-optimistic about what can be achieved, and to adhere to the entry criteria so far as possible. The setting of challenging schedule milestones can bring benefits, but we feel that CRL has spent a disproportionate amount of time and energy in the past on mitigation measures for delays which might have been avoided had a realistic schedule been developed in the first place. It is imperative that CRL produces a new MOHS which provides schedule confidence and delivery certainty.

#### 4.3.2. Dynamic Testing

The setting of appropriate entry criteria and the application of a rigorous process for checking readiness to switch to 5/2 Dynamic Testing (see Section 4.3.1) are designed to ensure that the pitfalls of previous delivery approaches are avoided. Experience to date has shown that many failures have arisen from seeking to integrate fundamental but incomplete elements of the programme (i.e. incomplete or unreliable trains/infrastructure). It is essential that rolling stock and fixed infrastructure integration is progressed without being impeded or distracted by issues unrelated to the tests themselves. We therefore support CRL's intention to establish known and stable completion baselines before embarking upon an uninterrupted Phase 4 Dynamic Testing period.

CRL will continue to carry out dynamic testing in windows until the switch to 5/2 Dynamic Testing is made. CRL has split the introduction of 5/2 Dynamic Testing into two stages. (Note that the dates identified below are 'Early' and are subject to confirmation in the new MOHS):

- Interim Dynamic Testing (IDT) (1x shift / 5 days per week) : 10/12/2018 – 11/1/2019
- Main Dynamic Testing (MDT) (2x shifts / 5 days per week) : 14/1/2019 – 20/5/2019

The introduction of an interim stage allows CRL to manage a 'soft' migration from construction into an intensive 4 month period of dynamic testing. The interim stage provides for a single 8 hour dynamic testing shift and a double 8 hour shift of installation and static testing each weekday. It will allow handover processes to be perfected and provide a final opportunity for construction completion.

CRL has recently proposed an alternative Interim Dynamic Testing arrangement comprising three or four 48 hour 'schedule blocks' between 10 December 2018 and 14 January 2019. This will be subject to independent assessment and then CRL Board review<sup>15</sup> before implementation.

CRL has extended the original series of windows ahead of 5/2 Dynamic Testing to make use of the schedule available while the infrastructure and rolling stock are completed to Entry Criteria standards. Windows 13 and 14 are planned to be carried out in November 2018 for a range of systems interface tests in all Zones.

Thereafter, we are aware<sup>16</sup> that CRL has made applications to NR for further interface possessions of the GEML and GWML from February through to May 2019, for signalling transition testing. The additional time now being requested at these interfaces (over 100 hours at each) more realistically reflects the workload necessary to prove their correct operation.

<sup>15</sup> CRL Board Meeting scheduled for 8 November 2018.

<sup>16</sup> CRL Testing, Commissioning & Handover Steering Group meeting held on 18 October 2018.

**4.3.3. Rolling Stock**

RfL will have sufficient number of trains available to support all parts of Dynamic Testing, Trial Running and Trial Operations and Stage 3 services, as 40 have been manufactured so far. [REDACTED]

[REDACTED] have produced a programme that manages the integration between the parties during the Dynamic Testing phase. The programme addresses the 29 tests, considered a pre-requisite by CRL in September 2018, to the start of Dynamic Testing.

The train will require various upgrades to its TCMS, CBTC, ETCS, TPWS and brakes software prior to it being placed into passenger service. The changes to software have been coordinated into different configurations as Dynamic Testing proceeds, and are as follows:

Configuration	Authorised for use <sup>17</sup>	Comment
Y 0.220 <sup>18</sup>	16/11/18	Necessary for Multi Train Testing, allowing TW14 & Interim Dynamic Testing to proceed.
Y 0.230	02/01/19 <sup>19</sup>	Necessary for Main Dynamic Testing to start, includes fixes to some of the failed 17 tests.
Y 0.240	18/02/19	Fixes to failed 17 tests effectively complete, essential entry criteria met <sup>20</sup> .

Figure 4 - 2 ~ Dynamic Testing Proceeds

During IDT and MDT, there are likely to be a significant number of faults found on the train, as well as with the infrastructure. This is to expected, but any delays to starting IDT or MDT is likely to delay the start of Trial Running<sup>21</sup>.

[REDACTED]

**4.3.4. Assurance**

RAB(C)

During SACR21, RAB(C) will continue to review formal submissions in line with CRL and RfL requirements, but CRL will need to begin meeting its own submission deadlines. A total of 52 submissions at Period 6 remain to be reviewed and approved before Stage 3 Opening, at a rate of approximately 5 per month. There should be some confidence in meeting this target, as this is the average submission rate for approximately the last 6 months.

<sup>17</sup> Rolling Stock dashboard – PDB 24 October 2018.

<sup>18</sup> E.g. Y 0.220 will have TCMS 7.2.2.5, TPWS 2.5.2, ETCS PVI 5.6, CBTCA03-003, brakes 6.0 and propulsion 1.2.5.0. All these elements will be revised in later configurations.

<sup>19</sup> Assurance evidence is currently planned to be assessed between 19 December 2018 and 2 January 2019.

<sup>20</sup> One test relating to CBTC and PSD remaining until June 2019.

<sup>21</sup> Scheduled to start mid-June 2019 – CRL Period 7 Board report.

New key dates for Engineering Safety Management submissions for the Stage 3 Safety Case will be provided as part of the MOHS refresh.

Technical File submission to ORR

The delivery of interoperability compliance will need to improve during SACR21.

Completion of design evidence (circa 95% complete) has stalled for CRL design and NR deliverables. What should then complement the design evidence is the DT evidence showing the design has been achieved. Very little of this evidence has been completed due the delays in the build.

A similar state exists with the production of the evidence required for the Safety Assurance Report.

Therefore the key issues for CRL to address in SACR20 are:

- Project Wide Hazard Record closure are at 21%. The remaining open items require Test & Commissioning evidence from the Contractors before they can be closed, and CRL should ensure Contractors comply;
- C631 (Platform doors) Engineering Safety Management must be in place, allowing closure of interface hazards;
- C660 must improve its closure of open hazards allocated to it;
- C620 interface design with other signalling systems needs to be completed;
- O&M manuals (see Section 4.3.6) must be produced to allow closure of system hazards<sup>22</sup>.

We note the importance of Contractors completing the assurance evidence as well as the physical works. This must in accordance with the submission schedule (to be produced as part of the MOHS process) to the AsBo, NoBo and ORR.

The Railway's Elements will not be deemed finished until the evidence is produced and accepted.

**4.3.5. Stations, Shafts and Portals (SSP)**

The new MOHS will include target [REDACTED] dates for all SSPs<sup>23</sup>. The dates that follow are taken from the RAP and are subject to confirmation when the new MOHS is issued. [REDACTED] [REDACTED] [REDACTED] dates for TOSD commencement are challenging and are unlikely to be achieved in all cases. Any delays to SCADA or other [REDACTED] systems will impact on SC dates, which are under review. [REDACTED] dates are at 95% probability, but some may not be achieved. The key targets at each location are:

- Tier 1 Substantial Demobilisation (TOSD) starts;
- Critical SCADA and [REDACTED] systems complete;
- Staged Completion (SC) also defined as Take Over under NEC contract;
- Handover (HO).

Definitions for each are to be clarified by CRL when the new MOHS is issued.

Most Shafts and Portals are targeted [REDACTED] for TOSD by the end of 2018, with Handover (no SC required) during March and April 2019. The exception is [REDACTED] which will aim for TOSD in May and Handover in August 2019. In many cases, Handover will occur

<sup>22</sup> This is because the mitigating action against many of the hazards is 'IM to follow the O&M manual'.

<sup>23</sup> Details included in CRL presentation for Sponsor Board 15 October 2018.

before dynamic testing is complete and before RfL have 'stood up' as IM of the Trace under ROGS.

LUL stations [REDACTED] have target [REDACTED] TOSD dates between December 2018 and March 2019, with SC approximately 4 to 5 months later, and Handover 2 to 3 months later. The last SC is [REDACTED] in August 2019.

RfL stations [REDACTED] have target [REDACTED] TOSD dates by the end of 2018, with SC between May and July 2019.

Stations will be Taken Over (TO) under the NEC contract by CRL and then passed on to RfL or LUL as a Staged Completion (SC). In most cases, by agreement, the contractors will have outstanding work to complete after SC. With the possible exception of [REDACTED] Station, SC of a station Element needs to be finished before dynamic testing completes.

Handover of the Assets may occur at the same time that Contractors achieve Completion under the NEC contract; i.e. all works and paperwork are 100% complete. Details at each location will be agreed nearer the time.

Specific key dates across all SSPs will be extracted from the MOHS and monitored in our future periodic reports. We are already aware<sup>24</sup> that some of these dates are under pressure and are likely to be adjusted in the new MOHS.

**4.3.6. Handover and Operations**

The poor progress of accepted O&M manuals, acceptance of asset information by IMs and delay of HMDL material, continues to remain a matter of concern. These items are an integral part of Handover to the IMs, and the delay to the overall programme does not necessarily mean there is now adequate time to complete the work.

- **Training Courses**

Training of the IMs has progressed sufficiently to the point where we believe the remaining issues are manageable, and likely to be completed during SACR21. These issues are:

- [REDACTED] [REDACTED] [REDACTED] [REDACTED] stations training due to their late running programmes, and
- [REDACTED] due in some cases to the lack of fitted equipment.

The one outstanding issue is likely to be whether the IMs have received all completed test materials before service opening. This is an important activity, but is unlikely to impede opening.

- **O&M Manuals**

We stated in our SACR19 report that there were approximately 750 O&M manuals, of which half were critical to the IMs, and that 4 had been completed. A further 30 were completed in SACR20, bringing the total to 34. The poor delivery is due to a combination of behaviours from all involved parties, quality issues and an overly extended review process. Providing these manuals is a large task and CRL must quickly improve by addressing the causes of poor performance described above.

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<sup>24</sup> See PRep Periodic Report for Period 7.



This delay has the potential to impact how the Yellow Plant will be used to maintain the railway from the start of Trial Running, provisionally forecast for June 2019, as well as support CRL prior to that. There will also be issues with bringing the C345 sidings into service within a working depot. RfL is investigating stabling the Yellow Plant in other depots that are in close proximity to Plumstead. A revised BIU strategy for the depot needs to be developed.

We have a concern as to whether the signalling functionality matches the operational concepts that were developed. Parties within CRL and RfL are identifying if there are areas of risk concerning the time taken to prepare the trains and if there are unplanned limitations to depot movements. Due to the late stage of the build it would be easier to adjust the operating concepts rather than the design. The issue will be whether there are cases where the change would be too operationally restrictive, necessitating a design change that potentially causes delay.

#### **NR works for Stage 4:**

NR will be progressing the works incorporated into Key Output 6a, Full Infrastructure Capability to support Crossrail Stage 4 operations with sufficient time for testing and trials. At SACR 20, this is reported as on schedule for 1 May 2019 forecast completion. We have the following comments:

##### *Power upgrades*

The risks to NR completing its partial upgrade to the Auto Transformer (PML - Gidea Park) are:

- Access agreed with the NR route, but not yet with the primary NR timetable function;
- No agreed schedule between the NR project team and its contractor.

Discussions are underway between all parties, but this situation needs to be resolved shortly in order to meet an important possession at Christmas 2018.

The above was predicated upon Stage 4 starting in May 2019. That is now not the case. However there are very few access periods from May 2019 to December 2019, so the delay has a limited benefit.

##### *DOO CCTV*

Installation of DOO CCTV on platforms 5 and 8 at Stratford. Access has been identified at Christmas 2018 for installation, but there remains uncertainty that this will proceed until the contractor confirms its plan and resource.

##### *Station Information & Security System (SISS) stations and RCC*

This element of work is behind schedule due to delayed works and a lack of integration between NR's contractor and [REDACTED]. What is required is a programme from the contractor for completing its station works and for [REDACTED] to accelerate its own works. The delay to the Crossrail Programme is likely to alleviate schedule pressure.

#### **NR works for Stage 5:**

NR ONW for Stage 5 is included under NR Key Output 6b, Full Infrastructure Capability to support Crossrail Stage 5 operations (including Ilford and Romford Enhanced Stations) with sufficient time for testing and trials. NR is reporting that progress for Key Output 6b is on schedule for 1 December 2019 forecast completion.

##### *West outer stations*

At SACR20 NR reported that Package 3 (Southall, Hayes & Harlington, West Drayton) tender returns had been assessed, and Contract award is expected in October 2018; although we have been recently advised this will be delayed. Package 2 Tender returns (Acton, Ealing, West Ealing) are under review. [REDACTED]

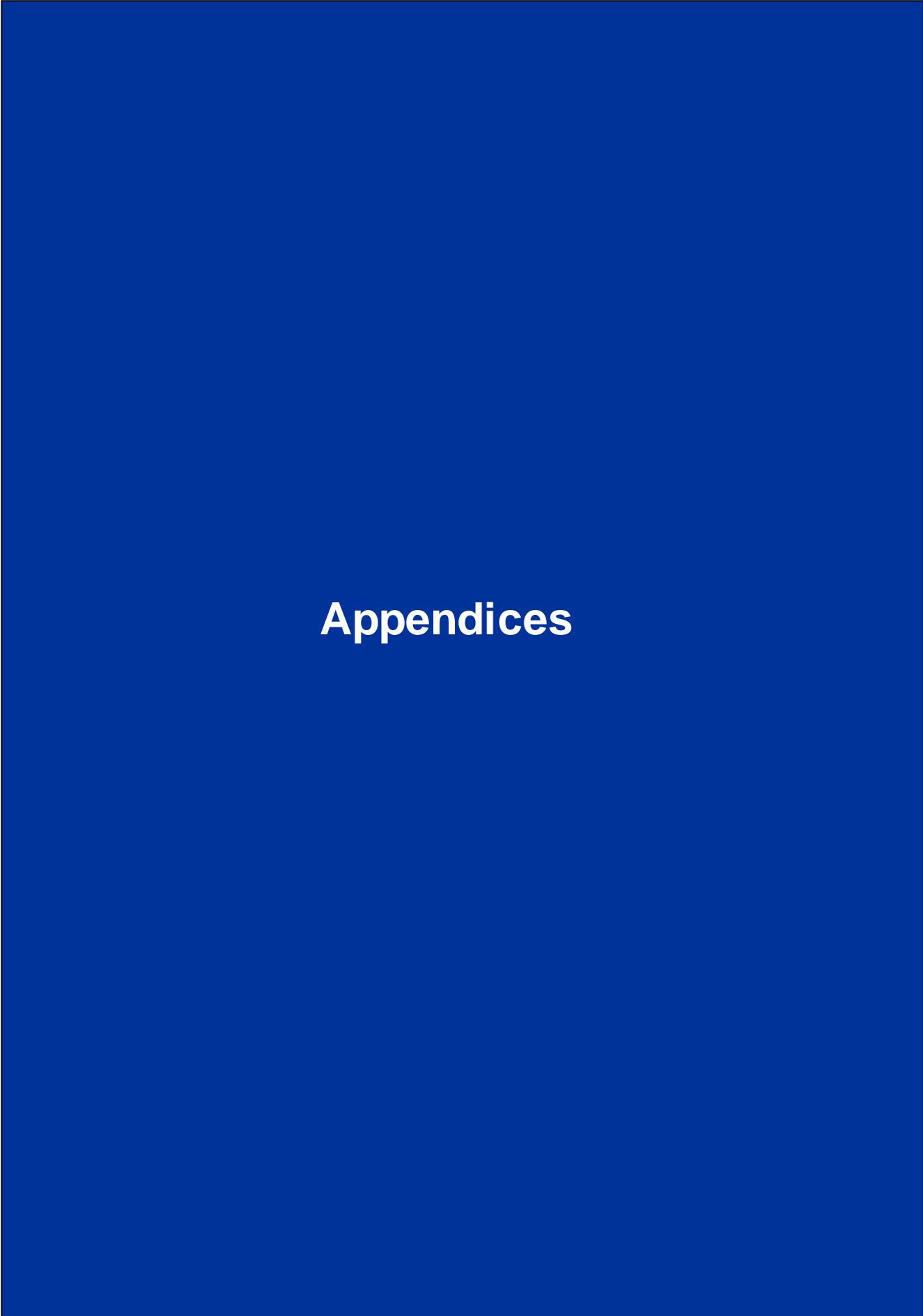
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Stage 5a proposes to introduce a 4TPH service between Paddington and Maidenhead/Reading, building on the existing Stage 2-2 between Paddington and Heathrow. The target date for this service is December 2019. The areas of risk to this date are as follows:

- Stage 2-2 will need to have been implemented, see Section 4.2;
- There is an overlap in the implementation of Stage 3 and this service, which could affect management focus;
- There are a number of industry regulatory issues to resolve, such as route capacity and the adjustment of platform workings at Paddington. These need to be agreed by 1 March 2019 for a formal submission to NR;
- The exemption certificate for enhanced TPWS will need to be extended, (although this is already being actioned).

On a general point, we reiterate from our last SACR report that management of the train service across the operating interfaces will be key between the COS and the GE; and for Stage 5 between the COS and the GW. We believe the major issue will be the interface with the GW, as it is a significantly lower performing railway when compared to the GE, and the forecast performance of the COS. Activities during Trial Running and Trial Operations should stress-test these interfaces to ensure disruption to initial service performance can be mitigated.



**Appendices**

## Appendix A    **CIM**

### **A.1 Crossrail Investment Model**

A review of the Crossrail Investment Model has not been undertaken at this SACR as this has been done as part of the independent financial and commercial review.

**Appendix B Commentary on CRL’s SACR20 Report<sup>30</sup>**

Appendix B contains comments on CRL’s SACR20 report where we feel they are necessary, but this should not be regarded as a detailed critique.

**CRL Section 2: Chairman and Chief Executive’s Overview:**

This Section, and page 9, indicates that the revised MOHS is being finalised. It was due at the end of October but is now delayed to 30 November 2018, subject to approval at CRL Board meeting on 5 December 2018.

**CRL Section 3.4: Cost Status, Sponsor Funding**

CRL has described unfunded scope, here and elsewhere in its report, as a contributor to the causes of change and increased costs. This item was also described in its SACR15, 16, 17, 18 and 19 reports. We reviewed these items of scope as part of our review of SACR15, and provided a briefing note to Sponsor Board<sup>31</sup>.

**CRL Section 4: Plans for the Next Six Months:**

Section 4.2 contains planned key events and milestones. These are based on MOHS 2018 and as noted in our report they are significantly delayed and should not be used. New milestones will be issued in the new MOHS. Section 4.3 contains information regarding critical paths. This is also subject to confirmation in the new MOHS. We are particularly concerned about the prospect of Stations Shafts and Portals becoming critical. This Section also contains [REDACTED] dates extracted from the RAP. These are currently under review and some are likely to be delayed in the new MOHS. We also highlight the 21 schedule risks and 11 Stage 3 assumptions listed in this Section. We will review these when the new MOHS is issued.

**Information regarding Affirmations not included within CRL SACR20 report:**

There is no description of Affirmations in CRL’s SACR20 report. For completeness we have repeated the outstanding actions from previous affirmations, described in our SACR19. These are:

Description	Position
Affirmation 0020 Crossrail Resilience	The resilience plan can be proved at the conclusion of the FDO process. The evidence will be provided to Sponsors.
Staff Accommodation (SR 3.1.1.7)	‘Facilities are provided in the Surface Sections for training facilities, train crew, cleaning and maintenance staff to support 30 TPH utilising 240m trains in the Central Section.’  CRL states it cannot confirm that it has met the requirement until the FDO process has been completed. If it is found that the requirement has not been met in full then CRL must Affirm what it has provided.
Affirmation 026 Supporting Communication Distribution	CRL must demonstrate that it has complied with the requirements described in the Sponsors review of its affirmation.

**Figure B - 1 ~ Affirmation Status**

<sup>30</sup> Based on CRL Board Version of SACR20 received 3 November 2018.

<sup>31</sup> Unfunded Change Briefing note: Factors influencing Crossrail AF CDC, 9 March 2016.

## **Appendix C Undertakings and Assurances (U&As)**

In accordance with the PRep demobilisation plan, the assurance of Undertakings and Assurances (U&As) is now carried out by JST.

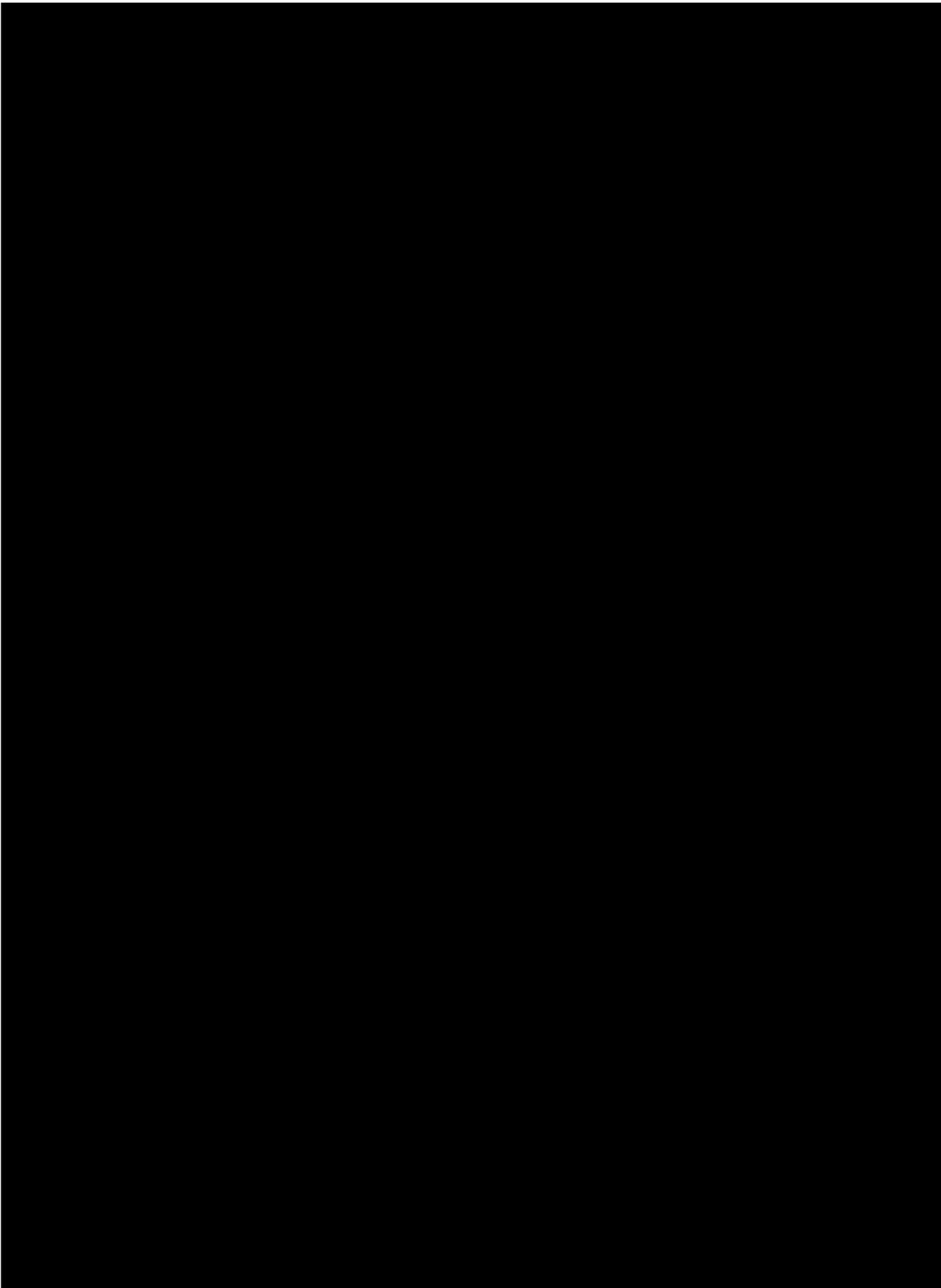
## Appendix D SACR20 and SACR21 Milestones



ID	Anchor Milestone	Baseline Early Date	Baseline Late Date	Actual / Forecast
A177	ONW - NE Spur - KD20 Signalling updated & commissioning compl. on the GE route	31-Aug-18	31-Aug-18	05-Feb-18
A176	ONW - NESpur - KD21 Update of GE Control Centre at Liverpool Street compl.	31-Aug-18	31-Aug-18	05-Feb-18
A630	C530-WOO-A630 Woolwich Handover East End to OSD	27-Apr-18	08-Dec-18	23-Apr-18
A695	CBTC Auto Reverse and Isolated ETCS Testing	06-Apr-18	06-Apr-18	27-Apr-18
A746	Draft COS Safety Case + results from Dynamic Testing zones 1 and 2	30-Apr-18	30-Apr-18	10-May-18
A726	C610- A726 Traction E&B complete in Zones 3 & 4	13-Apr-18	13-Apr-18	11-May-18
A715	C660 -A715 OFN re-configuration for All Zones complete	15-Apr-18	07-May-18	15-May-18
A557	C660 - A557 Dark Fibre Handover to C6XX (Zones 3 & 4)	07-May-18	07-May-18	15-May-18
A693	C644 -A693 WBP ATFS energised	31-Mar-18	31-Mar-18	17-May-18
A168	Stage 2 Implementation (Mixed CI.345 / 360 Service)	20-May-18	20-May-18	20-May-18
A564	C660 -A564 Linewide SCADA available in Zones 3 & 4	30-May-18	30-May-18	30-May-18
A625	Provide all Trains to Systemwide for Dynamic Testing (3rd & 4th FLUs)	07-Jun-18	07-Jun-18	07-Jun-18
A701	C610 -A701 Permanen ly energise OHLE Zones 3 & 4	10-Jun-18	10-Jun-18	08-Jun-18
A710	C650 -A710 All 11 kV S,S&P locations energized	15-Apr-18	15-Apr-18	09-Jun-18
A698	Sys - A698 Start PSD Platform Train Interface Test (DT) in Zone 1	10-Apr-18	10-Apr-18	10-Jun-18
A725	C610 -A725 Start Dynamic Testing in Zones 3 & 4	11-Jun-18	11-Jun-18	11-Jun-18
A711	C631-A711 PSD Ready for Dynamic Tes ing in Zone 1	31-Mar-18	09-Apr-18	16-Jun-18
A719	C620 -A719 Signalling infrastructure ready for DT in Zones 3 & 4	23-Jul-18	23-Jul-18	20-Jun-18
A278	C435-A278 PDA Milestone 13 - Site available to commence FAR Western Ticket Hall OSD	30-Jun-18	08-Dec-18	30-Jun-18
A620	C696 - A620 Construc ion Works Commence	02-Jul-18	02-Jul-18	03-Jul-18
A660	SS&P Provision of DOO and Platform Finishes for Dynamic Testing in Zones 1, 2, 3, 4	15-May-18	10-Jun-18	15-Jul-18
A160	ONW - RW - KO2 Infra.Capability Abbey Wood-Cent. Core Area at Plumstead Portal, etc	30-Jun-18	30-Jun-18	31-Jul-18
A721	C610 -A721 Partial access to C696 PLU provided	31-Jul-18	31-Jul-18	31-Jul-18
A696	CBTC Authorised for Pre-Trial Ops (CBTC Intergrated)	26-Jun-18	05-Aug-18	10-Aug-18
A621	C620 - A621 Ready to Commence Transition Tes ing @ GEML	12-Aug-18	12-Aug-18	12-Aug-18
A174	ONW - West - KD24 Infrastructure compl. to support Stage 5 Dynamic Testing	10-Sep-18	10-Sep-18	16-Aug-18
A134	C360 - ESS - Eleanor Street Shaft External Works Complete (A134)	24-May-18	03-Aug-18	31-Aug-18
A276	C412-A276 PDA Milestone 11 Site available to commence BOS Eastern Ticket Hall OSD	11-Jun-18	12-Jul-18	31-Aug-18
A179	ONW - NE Spur - KD22 Route clearance & all infrastructure compl.	31-Aug-18	31-Aug-18	31-Aug-18
A622	C620 - A622 Ready to Commence Transition Tes ing @ GWML	10-Sep-18	10-Sep-18	08-Sep-18
A713	C660- A713 Train GSM-R Radio available to support Combined Trials	09-Sep-18	30-Sep-18	09-Sep-18
A178	ONW - NE Spur - KO5A Full Infra.Capability from Shenfield to Central Core Area at PML	10-Sep-18	10-Sep-18	10-Sep-18
A169	ONW - West - KO5B Full Infra.Capability Maidenhead to Central Core Area at WB Park	10-Sep-18	10-Sep-18	10-Sep-18
A684	SS&P Fire Mains Ready for Integration Zones 3&4	05-Jul-18	15-Jul-18	14-Sep-18
A700	C631 -A700 PSD Ready for Dynamic Testing in Zones 3 & 4 (4 Platforms)	27-Jul-18	27-Jul-18	17-Sep-18
A752	C631 -A752 PSD Ready for Dynamic Testing in Zones 3 & 4 (2 Platforms)	10-Aug-18	10-Aug-18	01-Oct-18
A709	C650-A709 All 22 kV S,S&P loca ions energized	30-Jun-18	30-Jun-18	06-Oct-18
A753	C631 -A753 PSD Ready for Dynamic Testing in Zones 3 & 4 (3 Platforms)	24-Aug-18	24-Aug-18	12-Oct-18

Key				
Milestone achieved early or on ime				
Milestone achieved later han EDBL				
Milestone forecast to be delivered later than EDBL				





**D.2 SACR21 Milestones**

The Anchor Milestone baselines for SACR21 (from 15 September 2018) will all be revised as a consequence of the new Master Operational Handover Schedule (MOHS).

These have not been issued to us at this time. However, we will report on these in our periodic reports.

## Appendix E Glossary of Terms

Abbr.	Description	Abbr.	Description
A&M	Access & Maintenance	LBTH	London Borough of Tower Hamlets
ABB	ASEA Brown Boveri	LDBL	Late Date Baseline
ABW	Abbey Wood	LFB	London Fire Brigade
ACBs	Air Circuit Breakers	LIS	Liverpool Street
ACJV	Alstom Costain Joint Venture	LMU	London Metropolitan University
ACWP	Actual Cost of Work Performed	LO	London Over ground
AEA	Abellio East Anglia	LoNo	Letter of No Objection
AEN	Adverse Event Notice	LoR	Line of Route
AFC	Anticipated Final Cost	LTC	Lost Time Case
AFC	Approved for Construction status	LTIFR	Lost Time Incident Frequency Rate
AFCDC	Anticipated Final Crossrail Direct Cost	LU	London Underground
AFR	Accident Frequency Rate	LUL	London Underground Limited
AGA	Abellio Greater Anglia (now known as 'GA')	LV	Low Voltage
AHU	Air Handling Units	M&E	Mechanical & Electrical
AIP	Approved in Principle	MAID	Mandatory Asset Information Deliverables
AIP	Approval in Principal	MCR	Material Control Requirement
AM	Anchor Milestones	MCS	Master Control Schedule
AMS	Agreements Management System	MDTR	Main Dynamic Testing Regime
APIS	Authorisation to Place into Service	MENTOR	Mobile Electrical Network Testing, Observation and Recording
ARS	Automatic Route Setting	MEP	Mechanical Electrical & Public Health
AsBo	Assurance Body - Ricardo Rail	MEPA	Mechanical, Electrical, Public Health, Architecture
ASLEF	Associated Society of Locomotive Engineers and Firemen	MES	Mile End Shaft
AT	Autotransformer	MFF	Multi-Functional Framework
ATC	Automatic Train Control	MIRP	Maintenance Integration Review Panel
ATF	Auto Transformer	MML	Mott MacDonald Ltd
ATFS	Autotransformer Feeder System	MOHS	Master Operational Handover Schedule
ATO	Automatic Train Operation	MOS	Member of Staff
ATP	Automatic Train Protection	MPS	Master Plan Shaft
ATS	Automatic Train Supervision	MTIN	Miles Per Technical Incident Number
ATS	Auto Transformer Station	MTIN	Miles Technical Incident Number
AWS	Automatic Warning System	MTR SMS	MTR Safety Management System
B&PC	Board & Programme Contingency	MTR-C	Mass Transit Railway - Crossrail
BBM	Balfour Beatty Morgan Vinci	MV	Medium Voltage
BCA	Bilateral Connection Agreement	NCE	Notified Compensation Event
BCWP	Budgeted Cost of Work Performed (Earned Value)	NCR	Non Conformance Report
BCWS	Budgeted Cost of Work Scheduled (Planned Value)	NEC	New Engineering Contract
BFK	Bam Ferrovial Kier	NG	National Grid
BH	Berkeley Homes	NGET	National Grid Electricity Transmission
BIU	Bringing Into Use	NKL	North Kent Line
BLL	Bakerloo Line Link	NoBo	Notified Body
BMS	Building Management Systems	NOW	North Woolwich
BOS	Bond Street Station	NR	Network Rail
BP	Business Plan	NR PDB	Network Rail Programme Delivery Board
BREEAM	Building Research Establishment Environmental Assessment Methodology	NSACS	New Sector Area Cost Summary
BSP	Bulk Power Supply Point	O&M	Operations and Maintenance
BT	Bombardier Transportation	OCS	Overhead Catenary Systems

BT / PC	Bombardier Transportation/ Prime Contractor	OLE	Overhead Line Equipment
BTH	Blomfield Ticket Hall	OMC Building	Operations Maintenance Centre
BUCF	S	OME	Order of Magnitude Estimate
BUF	Bottom Up Forecast	ONFR	On Network Functional Requirements
C&CSC	Commercial and Change Sub-committee	ONSIP	On Network Station Improvements Programme
CAR	Corrective Action Report	ONW	On Network Works
CARE	Crossrail Assurance Reporting Environment	OOC	Old Oak Common
CBTC	Communications Based Train Control	OOCPA	Old Oak Common Paddington Approaches
CCB	Current Control Budget	OPEX	Operational Expenditure
CCP	Commitments Compliance Plans	Ops	Operations
CCR	Consolidated Cost Report	ORAT	Operational Readiness & Transfer Group
CCRB	Construction and Commissioning Rulebook	ORR	Office of Rail & Road
CCRRB	Crossrail Construction Railway Rule Book	ORSG	Operational Readiness Steering Group
CCSA	Contract Commercial Status Analysis	OSD	Over Site Development
CCSC	Commercial & Change Sub-Committee	OSP	Operations Safety Procedures
CCTV	Closed Circuit Television	OTIS	OTIS escalators (company)
CD/RA	Closed Door / Right Away	OTP	Overall Target Price
CDG	Competence Design Group	P2R	Paddington to Reading
CDL	Central Door Locking	PA	Public Address
CDM	Construction Design & Management Regulations	PAD	Paddington station
CDN	Crossrail Data Network	PC	Principal Contractors
CDT	Commitments Delivery Tracker	PDA	Project Development Agreement
CE	Compensation Events	PDB	Programme Delivery Board
CEC	Chief Engineer's Communications	PES	Platform Edge Screen
CEEQUAL	Civil Engineering Environmental Quality Assessment Scheme	PES	Permanent Earthed Sections
CEG	Central Engineering Group	Ph3C	Phase 3 Complete
CEO	Chief Executive Officer	PIP	Paddington Integration Project
CER	Communications Equipment Room	PIR	Potential Incident Report
CFCCB	Contingency Finance Current Control Budget	PLU	Plumstead
CFO	Chief Financial Officer	PM	Project Manager
CIF	Crossrail Integration Facility	PMI	Project Manager Instruction
CIS	Customer Information System	PML	Pudding Mill Lane
CMR	Crossrail Managed Risk	PMO	Project Management Office NR
CMS	Central Management System	PNY	Paddington New Yard
CoL	City of London	PPE	Personal Protective Equipment
COS	Central Operating Section	PPF	Property Partnership Framework
COS	Central Operating Section	PPM	Passenger Performance Measurement
COWD	Cost of Work Done	PRep	Project Representative
CPFR	Crossrail Programme Functional Requirements	PRISM	Cost Management Software
CPI	Cost Performance Index	PRM	Persons of Reduced Mobility
CPO	Compulsory Purchase Order	PSD	Platform Screen Door
CRAF	Completion Readiness Assessment Framework	PSG	Performance Steering Group
CRL	Crossrail Limited	PSR	Project Status Report
CRV	Crossrail Requirements Variation	PTYSC	Property Sub-Committee
CSCS	Construction Skills Certification Scheme	PWay	Permanent Way
CSDE	Correct Side Door Enabling	QBR	Quarterly Baseline Review
CSJV	Costain Skanska Joint Venture	QCRA	Quantified Cost Risk Assessment
CSM	Construction Safety Management	QRA	Quantified Risk Assessment
CSM-RA	Common Safety Method – Risk Assessment	QSRA	Quantified Schedule Risk Assessment
CT	Computerized Tomography	RAB	Regulatory Asset Base
CTOC	Crossrail Train Operating Concession	RAB (C)	RfL Assurance Board for Crossrail
CUH / CHS	Custom House Station	RAG	Red, Amber, Green Matrix
CW	Canary Wharf	RAM	Route Asset Manage.
CWG	Canary Wharf Group	RAP	Remedial Action Plan
CWS	Canary Wharf Station	RBC	Remote Block Computer

D&A	Drugs and Alcohol	RCA	Risk Control Actions
DA	Development Agreement	RCC	Route Control Centre
DeBo	Designated body	RfL	Rail for London
DESJs	Design Engineering Safety Justifications	RfL-I	Rail for London - Infrastructure
DfT	Department for Transport	RFT	Right First Time
DLO	Direct Labour Organisation	RIA	Railway Integration Authority
DLR	Docklands Light Railway	RIBA	Royal Institute of British Architects (Structure of Construction Stages)
DOO	Driver Only Operation	RIDDOR	Reporting of Injuries Diseases & Dangerous Occurrences Regulations 1995
DPS	Depot Protection System	RIRP	Railway Integration Review Point
DT	Dynamic Testing	RLU	Restricted Length Unit
Dwall	Diaphragm wall	ROC	Rigid Overhead Conductor
DWWP	Delivery of Works Within Possession	ROC	Regional Operational Centre
E&B	Earthing & Bonding	ROGS	The Railways and Other Guided Transport Systems (Safety) Regulations 2006
EA	Environment Agency	ROP	Royal Oak Portal
EAC	Estimate at Completion	RP4.2	Review Point 4.2
EB	Eastbound	RR	Ricardo Rail
ECHR	Element Completion Handover Report	RRV	Road / Rail Vehicles
ECI	Early Contractor Involvement	RS	Rolling Stock
ECP	Employers Completion Process	RSC	Return Screen Conductor
ECS	Empty Coach Stock	RSD	Rolling Stock & Depot
EDBL	Early Date Baseline	RSSB	Rail Safety & Standards Board
EDORs	ETCS Data Only Radio	RTU	Remote Telemetry Unit
EDT	Early Dynamic Testing	S&C	Switches & Crossings
EED	Emergency Exit Door	SA	Supplementary Agreement
EFC	Estimated Final Cost	SACR	Semi Annual Construction Report
EFC	Economic and Financial Committee	SAP	System Applications Products
EIS	Entry into Service	SAR	Safety Assessment Report
ELCBT	Elizabeth Line Countdown Board Tracker	SAT	Site Acceptance Test
ELRSG	Elizabeth Line Readiness Steering Group	SC	Staged Completion
EMC	Electromagnetic Compatibility	SCADA	Supervisory Control and Data Acquisition
EMU	Electrical Multiple Unit	SCL	Sprayed Concrete Lining
ERTMS	European Rail Traffic Management Systems	SCN	Sponsor Change Notice
ESJ	Engineering Safety Justification	SDG	Signalling Design Group
ESM	Engineering Safety Management	SDO	Selective Door Operation
ESS	Eleanor Street Shaft	SDS	Scheme Design Specification
ETCS	European Train Control System	SEJ	Safety Engineering Justification
ETH	Eastern Ticket Hall	SER	Signalling Equipment Room
EVM	Earned Value Management	SES	South East Service
ExCom	Executive Committee	SESR	South East Signalling Room
FAR	Farringdon	SFA	Sponsor Funding Account
FCCB	Finance Current Control Budget	SGS	Stepney Green Shaft
FDC	Framework Design Consultant	SHELT	Safety and Health Leadership Team
FDO	Final Design Overview	SIM	Simulation Room
FDS	Final Design Statements	SIRP	Systems Integration Review Panel
FFOC	Final Forecast Outturn Cost	SISS	Station Information and Security System
FGW	First Great Western	SJR	Safety Justification Report
FHO	Full Handover	SLD	Single Line Diagrams
FIS	Fisher Street Shaft	SMS	Safety Management System
FLU	Full Length Unit	SMTA	Smithfield Market Traders Association
FoI	Freedom of Information	SOC	Statement of Compatibility
FRAG	Fraud Risk Assurance Group	SONIA	Sterling Overnight Index Average
FTS	Floating Track Slab	SOR	Systems Operation Room
GAF	Greater Anglia Franchisee	SORBA	Shaping Architecture Company (sub cladding contractor)
GE	Great Eastern	SPI	Schedule Performance Index

GEBR	Guaranteed Emergency Brake Rate	SPS	Secondary Part Steel
GEFF	Great Eastern Furrer & Frey	SR	Sponsors Requirement
GEML	Great Eastern Main Line	SRP	Safety Review Panel
GFRC	Glassfibre Reinforced Concrete	SSE	Scottish & Southern Electricity
GLA	Greater London Authority	SSP	Stations, Shafts, Portals
GPE	Great Portland Estates	STG	Stepney Green
GRC	Glass Reinforced Concrete	STS	Standard Track Slab
GRIP	Governance for Railway Investment Projects	SVP	Safety Verification Panel
GSM-R	Global System for Mobile Communication - Railway	T&C	Testing & Commissioning
GW	Great Western	TAP	Technical Assurance Plan
GWML	Great Western Main Line	TBM	Tunnel Boring Machine
GWR	Great Western Railway	TC&HSG	Testing, Commissioning and Handover Steering Group
H&S	Health & Safety	TCMS	Train Control Management System
HAL	Heathrow Airport Limited	TCR	Tottenham Court Road
HALARP	Heathrow Airport Limited Assurance Review Panel	TCRW	Tottenham Court Road West
HAS	High Attenuation Sleeper	TDR	Technical Director's Report
HAVS	Hand Arm Vibration Syndrome	TDY	Tunnel Drive Y
HEP	Handover Execution Plans	TfL	Transport for London
HEX	Heathrow Express	TO	Taken Over
HIA	Heathrow Implementation Agreement	TOC	Train Operating Company
HM	Her Majesty	TOSD	Tier One Substantially Complete
HMDL	Handover Master Deliverable List	TPA	Tunnel Planning Authority
HO	Handover	TPH	Trains Per Hour
HPNM	High Performance Near Misses	TPS	Train Protection System
HRW	Heathrow Airport	TPWS	Train Protection & Warning System
HSPI	Health & Safety Performance Indicator	TRAIL	Transport Reliability Availability Integrated Logistics
HV	High Voltage	TRH	Temporary Rehousing
HVAC	Heating Ventilation & Air Conditioning	TSI	Technical Standard for Interoperability
IO	Input / Output	TTO	Temporary Ticket Office
IA	Interim Acceptance	TTVS	Temporary Tunnel Ventilation System
ICD	Interface Control Document	TUCA	Tunnelling & Underground Construction Academy
IDT	Interim Dynamic Testing	TWAO	Transport & Works Act Order
IECC	Integrated Electronic Control Centre	TXM	TXM Plant
IEP	Intercity Express Programme	U&A	Undertakings & Assurances
IFC	Issued For Construction	UKPN	UK Power Networks
IFD	Ilford Yard	UR	Urban Realm
IM	Infrastructure Manager	URT	Unresolved Trends
IOSH	Institution of Occupational Safety and Health	UTX	Under Track Crossings
IP	Intervention Point (0, 1, & 2)	VAP	Verification Assurance Procedure
IR35	Inland Revenue Taxation Regulation 35	VDP	Victoria Dock Portal
IRM	Incident Response Management	VERP	Value Engineering Review Panel
IRN	Installation Release Note	VFL	Voker Fitz Patrick
IRSG	International Regulatory Strategy Group	VN	Variation Notice
ISA	Independent Safety Assessment	VT	Voltage Transformer
ISJ	Interim Safety Justification	W&W	Wales & West Utilities
ISV	Intermediate Statements of Verification	WAD	Works Authorisation Document
ITP	Inspection & Test Plan	WBP	Westbourne Park
ITT	Invitation to Tender	WBS	Work Breakdown Structure
JST	Joint Sponsor Team	WC	World Class
KBR	Knorr-Bremse Rail	WCC	Westminster City Council
KD	Key Deliverable	WCCC	Whole Contract Construction Certificate
KE	Kinematic Envelope	WHI	Whitechapel
KG	Kensal Green	WiFi	Wireless Fidelity
KO	Key Output	WITI	Western Inner Track Infrastructure

KPI	Key Performance Indicator	WOE	Western Outer Electrification
KPMG	Klynveld Peat Marwick Goerdeler	WOO	Woolwich Station
L&P	Land and Property	WOTI	Western Outer Track Infrastructure
LB	London Borough	WTH	Western Ticket Hall
		YC	Yard Control