

TRANSPORT FOR LONDON

BOARD

SUBJECT: STATUS OF THE JUBILEE LINE UPGRADE

DATE: 21 JULY 2010

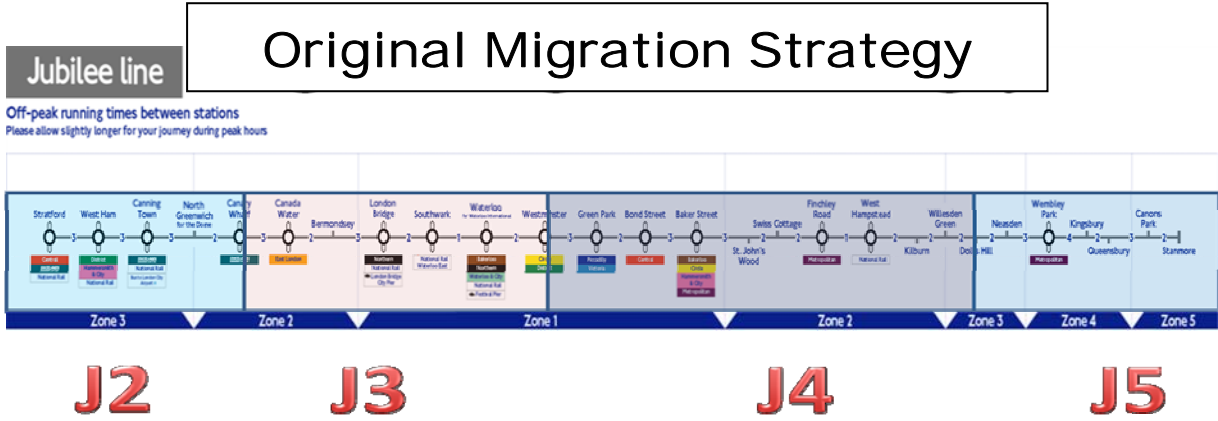
1 PURPOSE

- 1.1 The purpose of this report is to update the Board on:
- (a) the current status of the Jubilee Line Upgrade (JLU) as at June 2010 prior to the acquisition of Tube Lines (TLL) by TfL;
 - (b) the approach taken to design and testing;
 - (c) the proposed commissioning strategy; and
 - (d) the risks to completion and the potential impact on customers.
- 1.2 The key component of the upgrade is a new Transmission Based Train Control (TBTC) system being provided by Thales Signalling (formally Alcatel). In addition, there are train traction upgrade packages and some infrastructure modifications such as the introduction of a third platform at Stanmore. At the time of the PPP contract award this was the largest application of a TBTC system.
- 1.3 The assessment of the current state of the system has been independently reviewed by Serco Ltd (Serco) which, through its management of the DLR, has undertaken more Thales TBTC commissioning than any other railway. Serco's report, attached as Appendix 1, agrees with the key findings of this report.
- 1.4 The appendix to this report also presents an independent summary of the status of the Northern Line Upgrade (NLU) as at June 2010.
- 1.5 The Board is requested to note this report. TLL is now under TfL's direct control and direct engagement with Thales to deliver the upgrade in the most effective way is now underway.

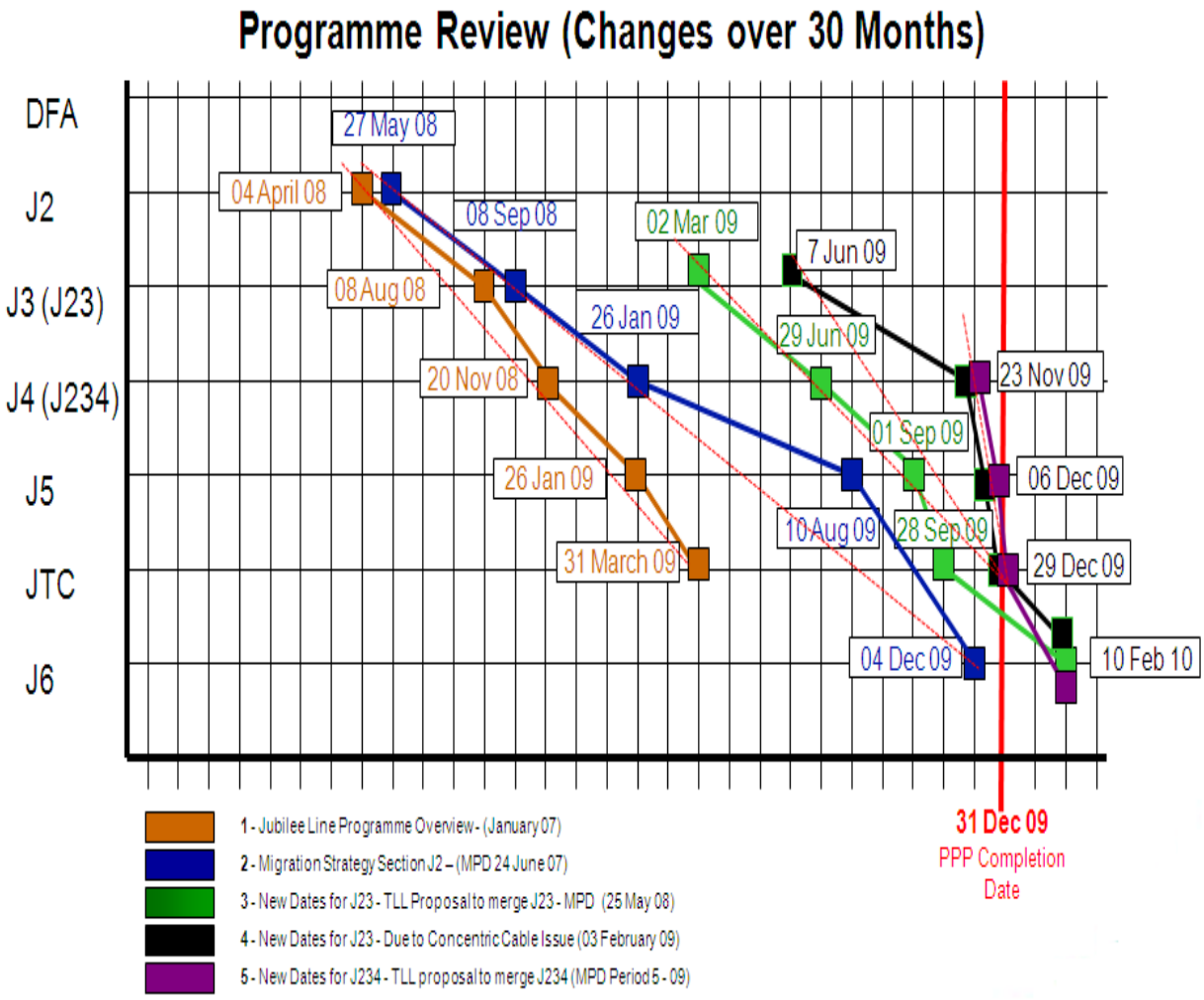
2 BACKGROUND

- 2.1 The JLU is the first upgrade required to be delivered by TLL as part of TLL's obligations in the PPP contract. TLL is contractually obliged to achieve the upgrade by delivering such new or enhanced assets as are necessary to meet a Journey Time Capability (JTC) score of 13.91 minutes by a latest implementation date of 31 December 2009.
- 2.2 The original TLL strategy was to deliver the new TBTC system on the line incrementally in an east to west direction, breaking the line into small sections (J2 through to J5, as shown in the figure on page 2) to minimise delivery risk

to the overall line. The final phase (J6) would see Automatic Train Operation delivered over the whole line.



2.3 TLL would have had to create system boundaries for each stage to allow the trains to move from TBTC signalling to conventional 'Tripcock' signalling mode as they progress. However, over time, as the project has fallen behind schedule, TLL has skipped stages of its original plan and combined these sections in an attempt to meet the required JLU delivery date (of 31 December 2009 under the PPP contract). This is illustrated on the following chart. The only system boundary that now exists is between J4 and J5 (at Dollis Hill).



- 2.4 A little over a year ago, TLL's assertion was that it would complete the JLU by the contractual date, despite the programme delays that had occurred. This was embedded in a Supplemental Agreement (known as the 'Additional Closures Agreement') dated 29 April 2009, in which, in return for certain considerations, London Underground (LU) granted 12 further short notice closures to TLL (often across other closures and events) on the basis that TLL would:
- (a) deliver TBTC in the J23 area (i.e. east of Waterloo) by 9 September 2009 at the latest; and
 - (b) deliver the full JLU by the contractual latest implementation date of 31 December 2009.
- 2.5 LU met its obligations under the Supplemental Agreement, but TLL's programme again slipped as it failed to make the required progress; by July 2009 it was again proposing to modify its plans, to deliver 'J234' (to Dollis Hill) as a single initial section and then the full upgrade by 31 December 2009. In doing so TLL requested six additional short notice weekend closures, on top of the 12 already granted in April, insisting at the most senior levels that this was all that was required to complete the upgrade despite LU's very grave doubts. (The TLL resulting timeline is indicated in the purple line in the chart on page 2).
- 2.6 Despite some further additional closures being provided, it soon became clear that there was no prospect of the upgrade completing by 31 December 2009. Finally, as the deadline approached, TLL offered a more realistic programme; in addition to the 113 weekend closures already granted, TLL asked for 19 further weekend closures and a further 14 "contingency" weekend closures up to the start of October 2010.
- 2.7 Based on this new, more credible, programme, LU issued a Corrective Action Notice to TLL on 5 January 2010 requiring it to deliver the upgrade by 11 October 2010, more than nine months late, in line with its revised programme.

3 CURRENT SITUATION

- 3.1 Since Christmas 2009, some progress has been made by TLL, although further issues have emerged as the system testing has progressed (TBTC is a dynamic system and as more trains are run, more issues emerge). During the four day line closure 25 to 28 December 2009, TLL was able to undertake some more significant multi train testing and ran a system-proving trial in the J23 area for the first time (although Stratford Market Depot was not at that time completed, this test was successful). Then, during a further four-day closure at Easter 2010, TLL 'cut over' the entire J234 TBTC system including Stratford Market Depot and carried out "final" testing to enable LU to run Trial Operations over two partial days, during which a handful of LU's Train Operators had a chance to use the TBTC system for the first time. The Easter closures were much less promising with further bugs and reliability problems exposed at Stratford Market Depot and Neasden Control Centre, as well as with train and system reliability. During the early May Bank Holiday TLL ran a further two days of testing and the system performance was poor, with additional bugs and reliability problems emerging.

- 3.2 Since then further trial operations have been undertaken and the system has still proved to be unreliable with approximately 750 to 1000 delay minutes per weekend which is many times worse than the current levels of service on the line. Hence the decision has been taken not to put the service into revenue service until the reliability issues have been addressed and further software fixes implemented.
- 3.3 Critically this poor reliability has impacted upon the number of train operators who are able to be trained and familiarised with the TBTC system. It is not possible to train drivers on a system that is not working.
- 3.4 Hence, even within the J234 area, there are still many challenges to overcome to ensure that the system has reached a level where it can be operated reliably at high capacity and without numerous 'workarounds' that would significantly impair performance.
- 3.5 For the J5 area, including Neasden Depot, the prognosis is not so good: while basic correspondence testing has commenced, the intense system level tests are only just commencing. The J5 area is the most challenging having:
- (a) the complex interface with Neasden depot;
 - (b) a 'Mixed Mode Area' where both Jubilee and Metropolitan trains operate; and
 - (c) a new third platform at Stanmore.
- 3.6 There are a large number of outstanding "system change requests"; (these are work orders to fix known defects with the system) and, in LU's view, which has been substantiated by independent reviews undertaken by Serco, substantial further work is required by TLL. LU believes that it will be some months before the system could be used in passenger service across the whole line, during peak periods.

4 DESIGN, TESTING AND MANAGEMENT APPROACH

- 4.1 The approach taken to design and testing of a signalling system, especially one involving extensive trackside and train fitment and a degree of automation of the operator function, has a major bearing on the overall programme and there are several key factors on the JLU that have had such an effect.

Requirements for closures

- 4.2 If a cardinal requirement of the system is that it minimises requirements for closures, then it affects the way design and testing is carried out. Metros such as Madrid take this approach for resignalling, and the end result is a system design which requires very few weekend or extended evening closures. This is achieved through various techniques such as "passive" testing (where equipment is installed but not connected to vital operational functions and it can then be tested in traffic hours), extensive investment in off-site simulation and testing, and in some cases, test tracks where the "real" railway is simulated as far as possible, with the objective of minimising the requirement to test on the operational railway.
- 4.3 In contrast, on the JLU, although there is a test track (Highgate Test Facility) and some simulation was done, this type of testing has been limited.

- 4.4 The other key element affecting closures was the decision not to design the TBTC system in “overlay” mode with the new system overlain on top of the existing one, such that the new trains can read the old signalling through the “overlay”. With an overlay approach, testing can be done without the need to switch “over” to the new system and “back” to the old system. On the JLU, this “over and backing” takes at least ten hours (and was much longer initially) meaning that even to do a one hour test, a full day closure is needed. In contrast, the Victoria Line Upgrade (VLU) has been designed as overlay, and a new VLU train (with its onboard signalling) can be tested at night; that is why the resignalling closure requirements on the VLU are far less than on the JLU, as estimated in the table below:

Estimated Signalling Closures (in equivalent 52 hour minor closures) at 10/2/2010	VLU (to March 2012)	JLU (to July 2010)
Route Km	21.25	37.80
Number of Closures	22 ^(a)	129
Closures per Route Km	1.04	3.40

(a) Including VLU Extended Engineering Hours equivalent.

Reliability

- 4.5 The lack of adequate simulation and off-site testing, combined with the revised commissioning strategy which TLL now proposes of putting a large section of the line into service in one go, has meant that the risks of poor reliability are harder to manage. This is evidenced in the actual performance of the system compared to that predicted. The total delay minutes for the Easter trial operations were 463 compared with a forecast 22 minutes, and in the May Day Bank Holiday trial operations the figures were 785 compared with 240 planned(+/-90 minutes). This poor level of reliability impacted significantly on the ability to familiarise drivers and signallers.

Depots and Terminal stations

- 4.6 Two of the key areas of difficulty facing the JLU are the terminal stations at Stratford and Stanmore, and the interfaces to the depots at Stratford and Neasden. At Stratford, the depot interface (where trains have to be accepted into the TBTC system before they come on to the line) is not yet complete. The “debugging” at Stratford has taken nearly a year, and it demonstrates how challenging it has been to design the TBTC to interface to a non-TBTC systems used for signalling the depot. At Neasden, where system testing has barely started, there will undoubtedly be similar issues although it is to be hoped that lessons have been learnt from the experiences at Stratford.
- 4.7 Stratford station also has debugging still to be completed, and the three platform layout is mirrored at the other end of the line at Stanmore. Again, it is hoped that lessons have been learnt in the design and testing such that the problems seen at Stratford are not replicated, although J5 (which includes Stanmore and Neasden) is unlikely to be completed before October this year at best.

Trains

- 4.8 The TBTC has to be installed and commissioned on all Jubilee line passenger and engineering trains. This has proved a great challenge and currently, of the 63 passenger trains (of which 57 should be available for full service); only

around 20 are sufficiently reliable for passenger service. This is just enough for a J23 service (Waterloo to Stratford at approximately 10 trains per hour).

- 4.9 One of the reasons for the train unreliability is the inability to put all trains in the fleet through TBTC testing due to the immaturity (until recently) of the TBTC system, and also the lack of a robust testing facility in the depot to check for “unhealthy” trains. As a result, trains have been put out to service with faults because running them on the railway is the only way of identifying if they are “healthy”.

Functionality

- 4.10 On a software-based system like TBTC, there is always likely to be a number of functions that are either not available or are incomplete during development. This “deferred functionality” is mitigated by “operational restrictions”, i.e. the operators are required to do things that make up for the lack of system functionality. Currently on the JLU there is a significant list of operational restrictions, and the judgement on readiness for passenger service includes an assessment of the workload/training requirement for operators, as well as the status of system reliability.

Schedule

- 4.11 Given the challenges described above, the realistic window for completion of J234 (i.e. reliable TBTC operation including trains, depots, control centres and signalling) is forecast at October 2010 if progress is good. J5 remains very high risk and could go through to Christmas or even later given current progress as confirmed by the reviews undertaken by Serco. Closures will be required in this period, including four track closures through Neasden (i.e. of the Metropolitan as well as Jubilee line).

5 TLL’S PROPOSED COMMISSIONING STRATEGY

- 5.1 The manner in which a new signalling system is commissioned and brought into service is of fundamental importance given the operational impact. As described earlier, the original TLL strategy was to bring in the first limited section (J2) east of North Greenwich into TBTC (manually-driven) mode, thus limiting the scale of the new system brought in and its potential impact on reliability. Such incremental commissioning is in line with good industry practice.
- 5.2 The next stages of commissioning would have extended to J23, then to J234, then to J2345 and eventually full Automatic Train Operation. As the schedule has slipped however, the commissioning strategy has changed and more has been put into the “first” commissioning such that, rather than a first small section, it had been proposed, last summer, that all of J234 be commissioned together.
- 5.3 LU had, from the start, expressed its concerns at such a major first step but under the PPP these were TLL decisions to take, although TLL has now re-thought its approach again. The most recent proposal from TLL, received in the last few months, is to revert to a J23 commissioning stage (although this is still a large section containing London Bridge, Canary Wharf and North Greenwich). However, because of earlier TLL decisions and design changes, there is now no system ‘boundary’ at Westminster; that is, no ability for a train to transfer from TBTC control to conventional signalling as was first proposed

three years ago. Instead there has to be a physical boundary, which means in effect a track closure between Green Park and Waterloo to separate J23 from J45.

- 5.4 TLL have proposed to introduce the system in a phased manner, which would help to grow the reliability of the assets, in effect splitting the railway into two halves at weekends, operating in passenger service but with no Jubilee line service to or through Westminster. TLL propose to offer the line in this configuration for multiple weekends. There would be three phases:

Phase 1

Initially TLL would introduce TBTC mode east of Waterloo, while a 'normal' service operates north from Green Park; this would mean a reduced frequency service on the eastern half, through Canary Wharf and North Greenwich (up to 10 trains per hour compared with the usual 18) at weekends, and no through service from north to south, disrupting longer journeys, but it would reduce the number of full weekend closures.

Phase 2

Once the J23 section is at an acceptable level of reliability, J4 would be added and TLL would 'swap over', with the section from Green Park to Stanmore then operating in TBTC signalling mode and the Waterloo to Stratford section under conventional signalling in tripcock mode. Once its reliability is proven J234 will be brought into full revenue service on weekdays as well as weekends. During this phase J5 would continue to operate under conventional signalling in tripcock mode.

Phase 3

Finally, once the J5 section has proven to be at an acceptable reliability level, the whole line can be commissioned in TBTC mode in full passenger service for the full weekday service, and the upgrade completed.

- 5.5 The advantage of a phased commissioning approach is that it would provide for the introduction of the TBTC based service on a limited geographical area at relatively quiet times, rather than the whole line switching to full TBTC service at one go.

6 INDEPENDENT REVIEWS

- 6.1 At the request of LU, independent reviews of the programme and progress for the Jubilee and Northern Line upgrades and Thales' proposal to reduce closures in order to deliver the latter have been undertaken by Serco. A summary of the reviews is included as Appendix 1 to this report.

7 RECOMMENDATION

- 7.1 The Board is asked to NOTE this report.

8 CONTACT

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VERSION 1.0

1 July 2010

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1. INTRODUCTION

This document summarises Serco's recent work reviewing the programme and progress of the Jubilee and Northern Line upgrades.

2. JUBILEE LINE

The Jubilee Line runs from Stratford in the East of London to Stanmore in the North West, and serves Canary Wharf, Westminster and a number of mainline commuter stations. The purpose of the planned upgrade to the signalling systems (supplied by Thales) which was to be delivered under the PPP, was to increase the capacity to the major commercial centre at Canary Wharf and other areas of London.

For the purpose of the upgrade the railway is divided into four sections, thus: from Stratford to North Greenwich (J2), from North Greenwich to Westminster (J3), from Westminster to Dollis Hill (J4) and from Dollis Hill to Stanmore (J5). The railway is serviced by two train depots at Stratford (East) and Neasden (West) and traverses an area known as the mixed mode area from Finchley Road to Wembley Park where it runs adjacent to and at Neasden interacts with the Metropolitan Line.

Tube Lines' (TLL) initial plan to achieve the upgrade was to convert each section in sequence from Stratford to Stanmore. Unfortunately TLL appears to have underestimated the difficulty in developing the software of the system which is both safety critical and complex. This had the result of delaying the programme and increasing the number of closures requested to complete the upgrade. In an effort to make up lost time and to meet the contractual completion date TLL adopted the approach of merging the upgrades of the individual sections by first combining J2 and J3 (J23) and later J2, J3 and J4 (J234). This approach goes against the experience of other 'brown field' upgrades (i.e. upgrades to an operational railway) where the strategy usually is to commission the railway in as many short sections as practical. The result of TLL's revised approach meant that the technical difficulty in commissioning these larger sections increased and has added further delays to the programme.

In May of this year TLL proposed that the railway be introduced into weekend revenue service over a reduced area (J23) of the line using software that had not seen the benefit of trial operations, and whose testing was proposed to be undertaken in an unreasonably short period. Serco was asked to comment on this approach and Serco's conclusions are outlined in the attachment entitled 'Commentary on the Jubilee Line Upgrade Programme'. In summary Serco recommended that this version of software, which was designed to rectify an unreasonably high number of errors, should not enter public service without further testing and a period of trial operations. LUL took the decision not to go ahead with TLL's proposed plan. This decision proved correct as in the event the testing of the software was not completed in the time available.

The plan for commissioning the last section of the railway (J5, the section from Neasden to Stanmore) appears embryonic and at this time it is difficult to predict when the full line will be completed with Serco concluding that it is likely to be commissioned some six months after J234 enters weekday revenue service. In coming to this conclusion Serco believe that up to three additional releases of software will be required resulting in this extension to the programme.

The plan for J5 and the number of closures that may be required is still open to significant doubt.

3. NORTHERN LINE

The Northern Line runs from Morden in the South via two routes through the city coming together at Camden Town and thence onto High Barnet and Mill Hill East on one branch and Edgware on the other. For the purposes of the upgrade the railway is divided into a number of sections, the first being from Morden to Clapham North (N2) then from Clapham North to Bank and Clapham North to Euston (N3) then from Bank up to and including Camden Town (N4), then Hampstead to Edgware (N5) and Tufnell Park to High Barnet (N6).

Serco was asked to review the Northern Line upgrade programme as recently published by TLL. The review of this programme shows significant slippage with it being forecast that the upgrade will not be complete until May 2012, some five months after the latest implementation date. Furthermore the programme appears to be both embryonic with dates continuing to slip and to be based on the JLU approach with a high dependency on closures. Furthermore a number of intermediate completion dates look very optimistic. With the majority of this programme still yet to run, it is difficult to provide an accurate forecast of likely completion date. However, the slippage experienced to date suggests that if this programme were to proceed then it is likely that the upgrade would not be complete until late 2013. This date is conditional to a large extent on the degree of access provided, and the amount of resource drawn off the project to complete and deal with problems that arise on the Jubilee Line. As a consequence it is felt that even this estimate may be optimistic.



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VERSION 1.5

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1. INTRODUCTION

This note summarises the findings of the Serco Team reviewing the Jubilee Line Upgrade Programme in the period 18-25th May 2010.

In conducting this short review Serco have met with personnel from LUL including Mike Harvey, Pat Williamson and Stuart McKay and other members of the project and have reviewed relevant documentation. This follows a review of the Upgrade by Mike Lockyear and Alexander Furber in October 2009, as requested by Dean Finch, CEO Tube Lines, and published to LUL in December 2009.

2. ASSESSMENT OF THE CURRENT STATE OF THE SYSTEM

The points given below address issues related to the state of readiness of the system to support weekend revenue service on J23 from 5th June 2010, using software release 2.42.40

- Release 2.42.40 is to be regression tested during the closure of 30th May with circa 80 faults scheduled to be rectified in this release; this is an unrealistically high number of faults to be rectified in a single release and an unrealistically short period to confirm if this high number of defects has been rectified. Furthermore, the experience shows that a number of these fixes will not have been successful and unexpected side effects are likely to become apparent. Therefore it is felt that this release may not be suitable to support revenue service
- Previous trial operations have only met with limited success; and none have been able to replicate the level of service to be expected during revenue, therefore the system has not yet been seen to operate with adequate reliability to support revenue service
- The number of operational restrictions that accompany 2.42.40 is higher than one could reasonably expect a relatively inexperienced control room team to manage; this is likely to lead to errors and consequent delays
- The reliability of the system has not been adequately demonstrated; during Easter trial operations 463 delay minutes were recorded, and in the May trial operations 785 delay minutes were recorded. The current level of delay minutes on the Jubilee Line is 20 minutes
- The entrance and exits to Stratford Maintenance depot are at this time not fully operational and there is no proof as yet that the forthcoming release will adequately address this issue. This will cause difficulties in trains entering and leaving service
- The Schedule Regulation System (SRS) of the SMC has proved unreliable during trial operations leading to significant failures to the system. It is quite likely that stressing the SMC further will lead to further failures of the SRS. There is no evidence in place that 2.42.40 adequately addresses this issue

The statement above is thought to be a realistic assessment of the current state of the system, as at the date of this review.

3. RESULTS OF THE INDEPENDENT REVIEW

The terms of reference under which this independent review was commissioned have been addressed as follows:-

1) State of Completion of the design of the system

Areas where the design of the system appears to be incomplete include:-

- Management of the mixed mode area in J5
- Interface to the Bakerloo line at Baker street
- Interface to Neasden depot
- The interface to the Metropolitan control system is yet to be confirmed as adequate

In addition there appears to be issues associated with interfaces with Stratford Market Depot that are yet to be addressed.

2) State of Completion of installation of the system

Essentially installation is complete

3) State of Completion of the testing and commissioning of the system

Essentially testing of J23 is well advanced; however it has been reported that a number of test cases are currently outstanding. It should be noted that when software defects are addressed in future releases many of these tests will be required to be repeated. J5 has seen no high level system tests.

4) State of Completion of the training of maintenance personnel

Maintenance personnel trained but have little experience of the system in service. In addition it would appear that training in a number of areas needs to be refreshed due to the length of time between the completion of the training programmes and the system going into service.

5) Proof of system reliability and capability

Results of three periods of trial operations have not demonstrated the system as being reliable. In particular it is noted that the SRS (Schedule Regulation System) appears not to have been exercised to its limits, and has shown itself to be unreliable in the limited use to date. This mirrors DLR's initial experience with this system.

6) State of Completion of documentation

It is understood that a number of items of documentation have yet to be formally signed off. This includes bookwiring and other technical items of documentation which are essential to the maintenance team to support the system.

7) Readiness of post commissioning support

It is understood that four weeks post commission support from Thales is in place. However it is unclear from what date this support begins.

8) State of Readiness of Rolling Stock

The vehicle fleet has not yet been adequately shaken down and proved reliable in service, risking delays and failures in service. The interface between Thales / TLL and Alstom does not seem to function well, which appears to be contributing to the general lack of readiness of the fleet.

Conclusions

- It is noted that a commissioning plan has been tabled that calls for J23 to go into revenue service over the weekend of 4th June 2010, less than one week after the delivery of 2.42.40. It is noted that this release will not have been subjected to any trial operations before this date. It is considered likely that initially the system will be unreliable and if so not likely to be suitable to support revenue service. A period of trial operations is essential in order to judge both the reliability of the system and the ability of the operator to manage the system with the operating restrictions in place.
- It is noted that closures to the system are now at a premium. A compromise way forward, in order to provide a minimal period of trial operations is therefore suggested although not recommended. During the first weekend scheduled for revenue service – on the Saturday of that weekend - trial operations using 2.42.40 take place. If satisfactory revenue services maybe considered to proceed on the Sunday of that weekend. If performance is not seen to be satisfactory an opportunity exists for corrective action to be implemented before exposing the system to revenue services. It should be noted however that this short period of trial operations is likely not to exercise the system sufficiently and as a consequence is **not recommended**.
- If this is not possible, for whatever reason, and the system has to enter revenue service without the benefit of trial operations, then a series of contingency measures must be put in place to minimise the effects of the likely disruption to the travelling public. These are discussed in our commentary on paragraph 5.5 in the Appendix to this document. However it should be noted that commissioning the system with no period of trial operations is strongly **not recommended**.

Subsequent Progress.

Subsequent to the production of this paper a number of weekend closures took place. Results from these closures are as follows:

- **31st May.** The purpose of this closure was to regression test release 2.42.40 and verify a number of errors were rectified. The results from this closure was disappointing with regression and SCR verification not completed within the time available due, at least in part, by the decision by Tube Lines to attempt a number of

JTC test runs. This effectively put paid to any chance that J23 weekend revenue services could commence on the 5th- 6th June.

- **12th-13th June.** Again performance over this weekend was disappointing. The closure was arranged thus:

J23 in Trip Cock Protection (Legacy).

J4 in TBTC for Trial Operations.

J5 for testing.

Again performance was disappointing with axle counter and train unreliability significantly disrupting the service. Sunday's performance improved but did still not achieve the levels of reliability required for service. It is planned that Release 2.42.40 will complete regression testing on 3rd July.