

# The Piccadilly Line Upgrade

Presentation to the  
Permanent Way  
Institution

12<sup>th</sup> June 2024

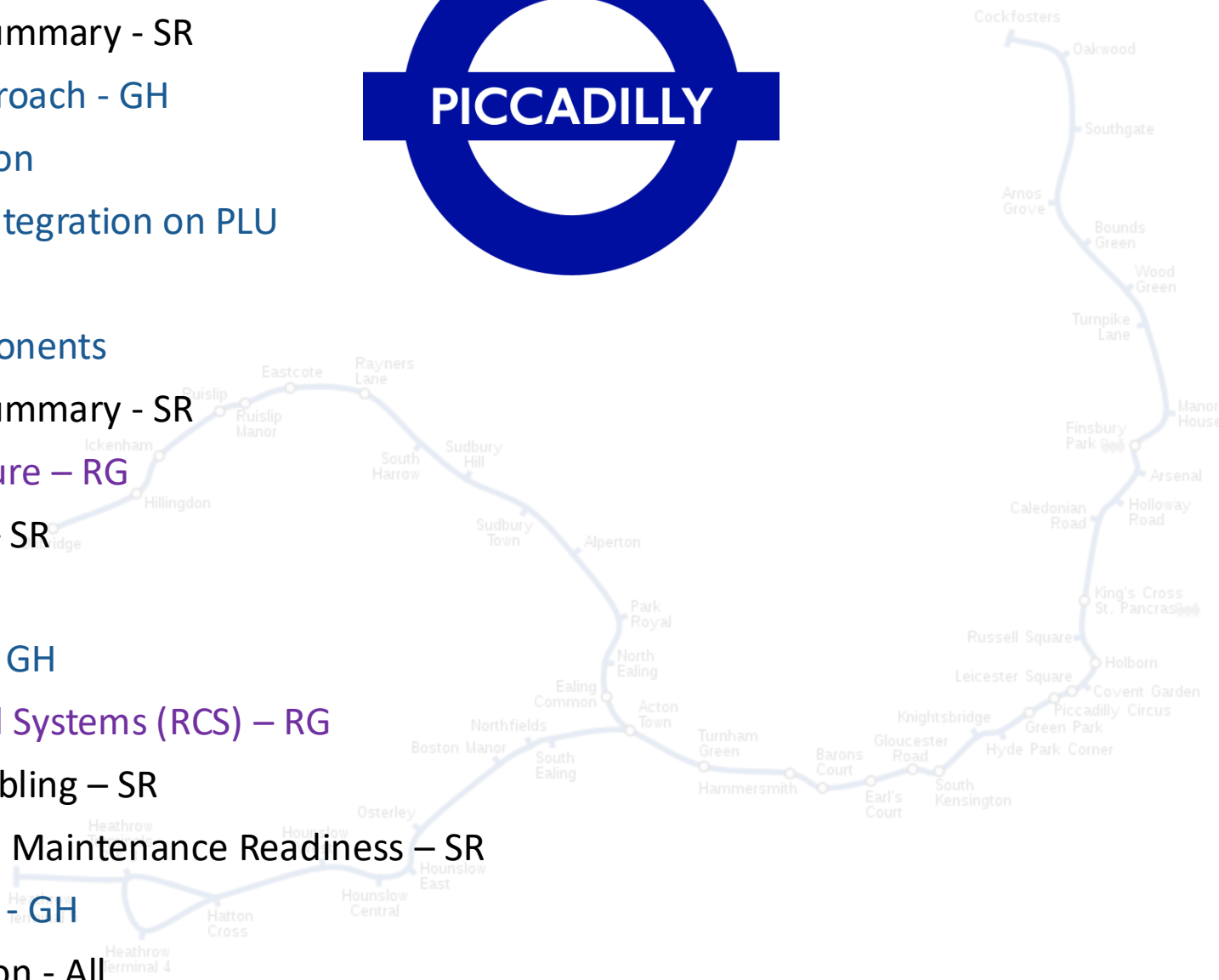
Steve Ristow  
Gareth Hood  
Rakesh Gaur



# Agenda

Presenters:  
Steve Ristow  
Gareth Hood  
Rakesh Gaur

- Introduction - SR
- PLU Benefits Summary - SR
- Integrated Approach - GH
  - Introduction
  - Systems Integration on PLU
  - Benefits
  - Key Components
- PLU Delivery Summary - SR
- **Train Architecture – RG**
- Train Systems – SR
- Power – SR
- Infrastructure - GH
- **Railway Control Systems (RCS) – RG**
- Depots and Stabling – SR
- Operations and Maintenance Readiness – SR
- **Key Milestones -GH**
- Q&A / Discussion - All



# PICCADILLY LINE UPGRADE – BENEFITS SUMMARY

## Stage 1 – New trains and enabling works (funded)

23% capacity increase

27 trains / hour

Improved accessibility (train / platform)

Replaces life expired assets

## Stage 2 – New signalling (unfunded)

64% capacity increase

Up to 36 trains / hour

Highly Reliable Automatic Operation

Contributes to 80% mode shift-2041

### Piccadilly Line (PL) Benefits



94 air cooled trains

- more capacity
- walk through cars
- improved accessibility and customer information
- enabling decarbonisation through regenerative braking



Improves access to the UK / World via Heathrow, plus rail services via Kings Cross St Pancras.

### Holborn Station – Key enabler to 33tph (unfunded)



Station at capacity

140% capacity increase

Enhanced access to central / west end areas

### London wide Benefits



#### New Homes

Stage 1 supports more than 8,000 new homes around PL stations

Stage 2 supports more than 61,000 new homes around PL stations and 40,000 additional passengers in AM peak



#### New Residents

23% of central London and 10% of inner London population growth will occur near a PL station



#### New Jobs

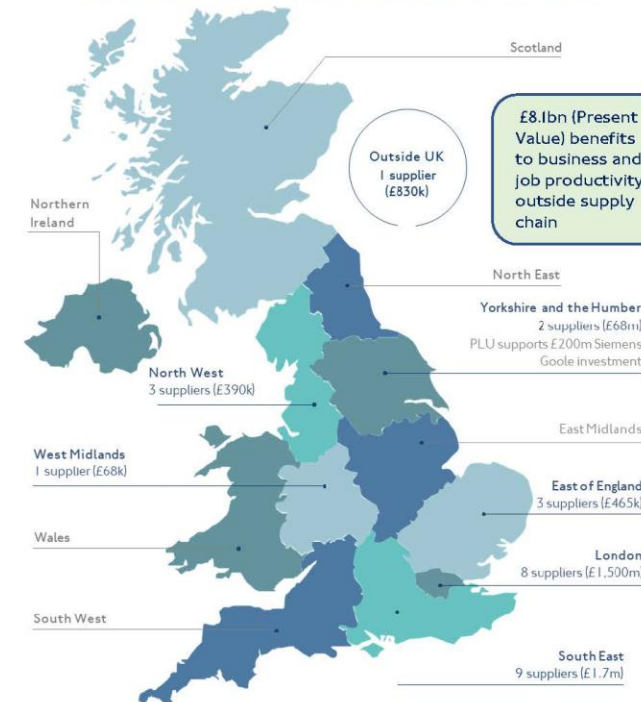
Directly supports more than 25,000 jobs across the capital

33% of central London and 10% of inner London employment growth will occur near a Piccadilly Line station

### UK Wide Economic Benefits

Version P4 Jul 2022

Number of, and Value of, Tier I suppliers by region from PLU Contracts Register as at 14/02/22



£8.1bn (Present Value) benefits to business and job productivity outside supply chain

### Job Creation & Innovation

Supports Siemens Mobility Limited's new £200m rail facility at Google driving innovation and providing employment opportunities with up to 700 skilled jobs in engineering and manufacturing, 250 in the construction phase and 1,700 in the broader supply chain. Includes Innovation Campus and supports 80 graduates and apprentices

## What is Systems Integration

Systems Integration (SI) for the infrastructure industry is the **integration of systems within a project**, not just the electrical, mechanical, architectural and civil systems, but also all technical and human elements.

**SI emphasizes a holistic view**, focusing on projects and the systems they are delivering as a whole. SI includes technical (functional, operational, logical, physical, geographical) interfaces as well as schedule-related and organizational interfaces.

It is necessary to ensure an **integrated solution from conception, through design, construction, testing and into service**. It ensures changes during construction consider the impact on the designed solution and facilitates required modifications.

## Why is Systems Integration Important on PLU

- Upgrading the Piccadilly Line whilst maintaining an operational railway is **highly complex**
- Implements change in **People, Process, and Technology** and considers physical, procedural and digital constraints
- Calls for an **integrated whole system approach** to enable successful realisation of benefits
- Fundamental that we learn the lessons from other programmes including Crossrail<sup>1</sup> in particular:

### Own the whole

*“To complete the railway we needed to move beyond a conventional mindset of the individual parts working in collaboration with each other and more towards every leader and team owning the whole of the system. Genuinely standing in the shoes of others.”*

### Co-ordinating complexity

*“As complexity increased within Crossrail so I observed the need for the client organisation to coordinate and sequence the work.”*



How the Sponsor explained it



How the Project Manager understood it



How the Engineers designed it



How the CAD Team drew it



What the testing and commissioning team received



What we told the Customer they were getting



How the project was documented



What the Contractor installed



How the customer was billed

<sup>1</sup> - Crossrail CEO: 6 Lessons Learned From Leading Crossrail | Institution of Civil Engineers (ICE)

## What are the benefits of Systems Integration

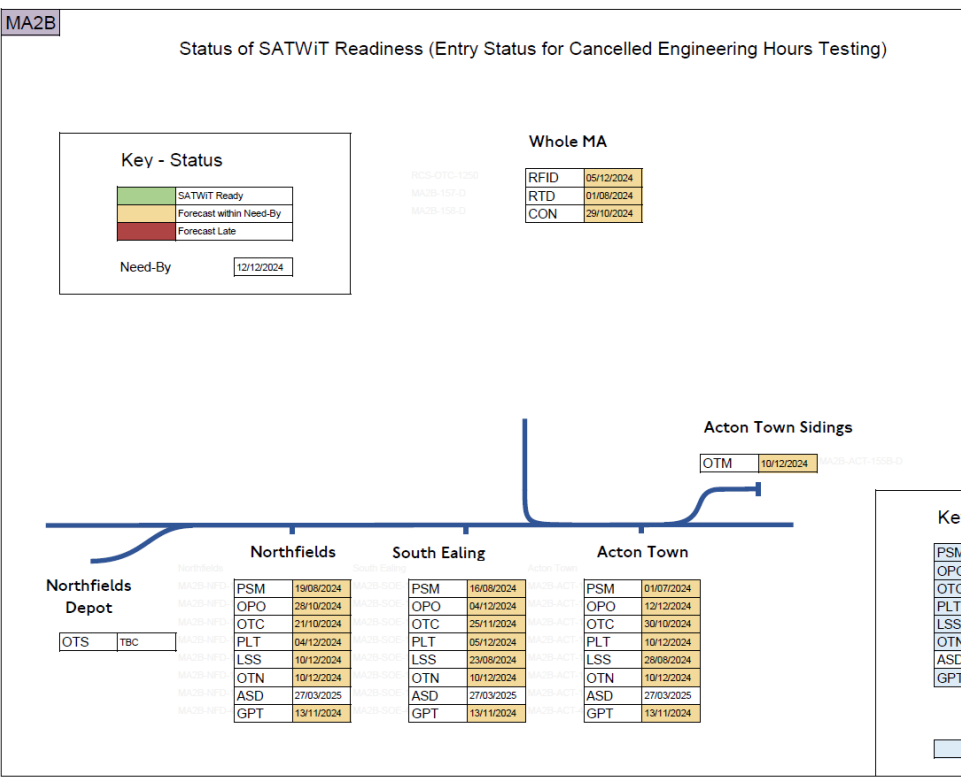
- ✓ Certainty of outcome
- ✓ A structured way of dealing with complexity
- ✓ Provides a holistic view of programme and interfaces
  - ✓ Often interfaces are not identified or specified until late in the project creating challenges
- ✓ Critical to the effective management of project risk / avoiding typical design and construction errors
  - ✓ Mitigates project risks through a systematic, fully documented process to deal with changing configuration
  - ✓ Mitigates against failure to properly define requirements
  - ✓ Mitigates against failure to manage change
- ✓ It complements good project management including
  - ✓ Full understanding off all stakeholders throughout lifecycle
- ✓ Maximises efficiency on pan programme activities including
  - ✓ Assurance
  - ✓ Testing and Commissioning
  - ✓ Access and Closures
  - ✓ EMC / HF / RAM / Cyber / Performance

# Integrated Approach

# Key Components - Clear Vision and Priorities

- Ensure the vision is clear and understood by all
- Use visuals, plans on a page to summarise
- Focus on current top delivery priorities
- Constant communication with team and stakeholders

## Key Components – Clear Vision and Priorities



Piccadilly line upgrade

## Our goal, mission and charter

**Our goal:** To transform the Piccadilly line and enhance our customers' lives. Together we are building a cleaner, greener legacy

**Our mission:** By working with integrity, and developing a united and thriving Piccadilly line upgrade team with a 'right first time' delivery mindset, we will deliver new trains for our customers and colleagues

**Safety**  
An embedded value that runs through the core of everything we do, ensuring everyone gets home safe and healthy, every day.

**Ownership and accountability**  
We are clear about what we own, including the decisions we make and the outcomes. We acknowledge realities, celebrate successes, share issues and face them together. We reflect and learn.

**Resilience**  
We enable a culture of resilience, realistic optimism and bravery by taking psychological safety seriously. This means people feel safe to speak up and share ideas without fear of being ignored, blamed or embarrassed.

**Open, caring and adaptable**  
These are our TFL values. We will talk about and role model them. When our actions are not in line with these values, we will give and be open to feedback delivered in a considerate, kind and thoughtful way.

**Community**  
We are building an inclusive and diverse Piccadilly line upgrade community, enabling everyone in our team to reach their ambitions, achieve industry recognition, grow and enjoy their work. We are creating an environment where everybody can lead in their own right.

**Quality**  
Quality and value are at the heart of all we do. We take pride in ourselves and each other, continuously improving so we can be better tomorrow than we are today. We seek win-win conversations and outcomes, ensuring we make 'best for TFL' decisions and deliver on our promises to London.

**Recognition**  
We celebrate effort as well as outcomes and build an environment where recognition is the norm.

EVERY JOURNEY MATTERS

As at: 20/05/2024

Key - Platform Works		Key - Works (Whole MA)	
PSM	Platform Stopping Mark	OTS	OTC - Depots / SH / Amos
OPO	OPO	OTM	OTC - Mainline Sidings *
OTC	OTC - Stations	CRA	Con Rail
PLT	Platform Enabling - SI	ARR	Arrestors
LSS	Legacy Sig / Op Signage	RFID	Rx Base
OTN	OTC NW Connections	RTD	Real Time Disrupt. Mess.
ASD	Assisted Dispatch	CON	CONNECT Radio
GPT	Gauging / PTI - Stations	ETM	Ealing Common TMD

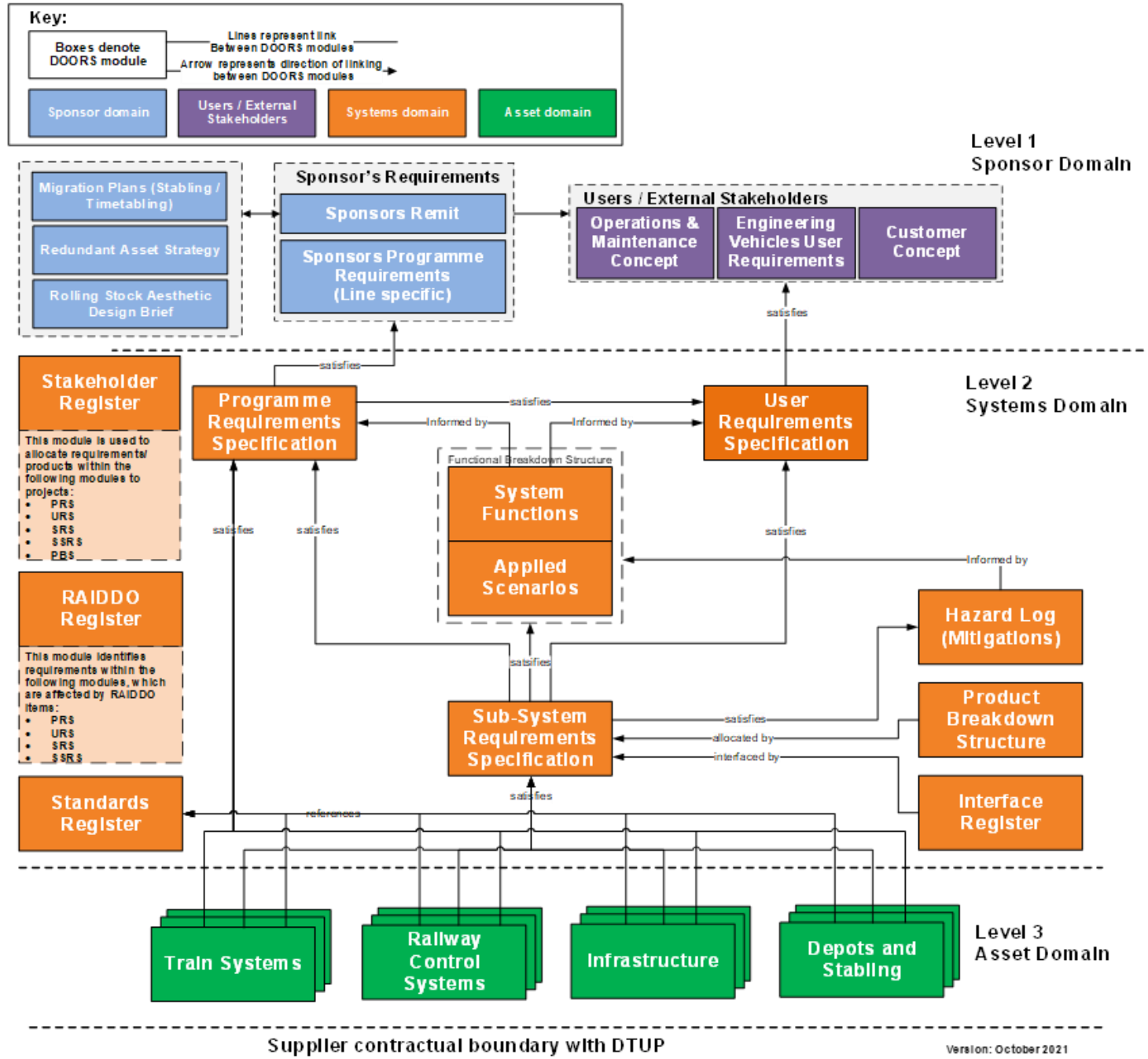
\* On map where present, not in 'Whole MA' table. Includes Rx Bases and OTC NW Connections

Version	Primavera Data:	20/05/2024
	Period:	Period 2
	Year:	2024/25
	Test Plan Version:	TBC
		T.P



# Integrated Approach

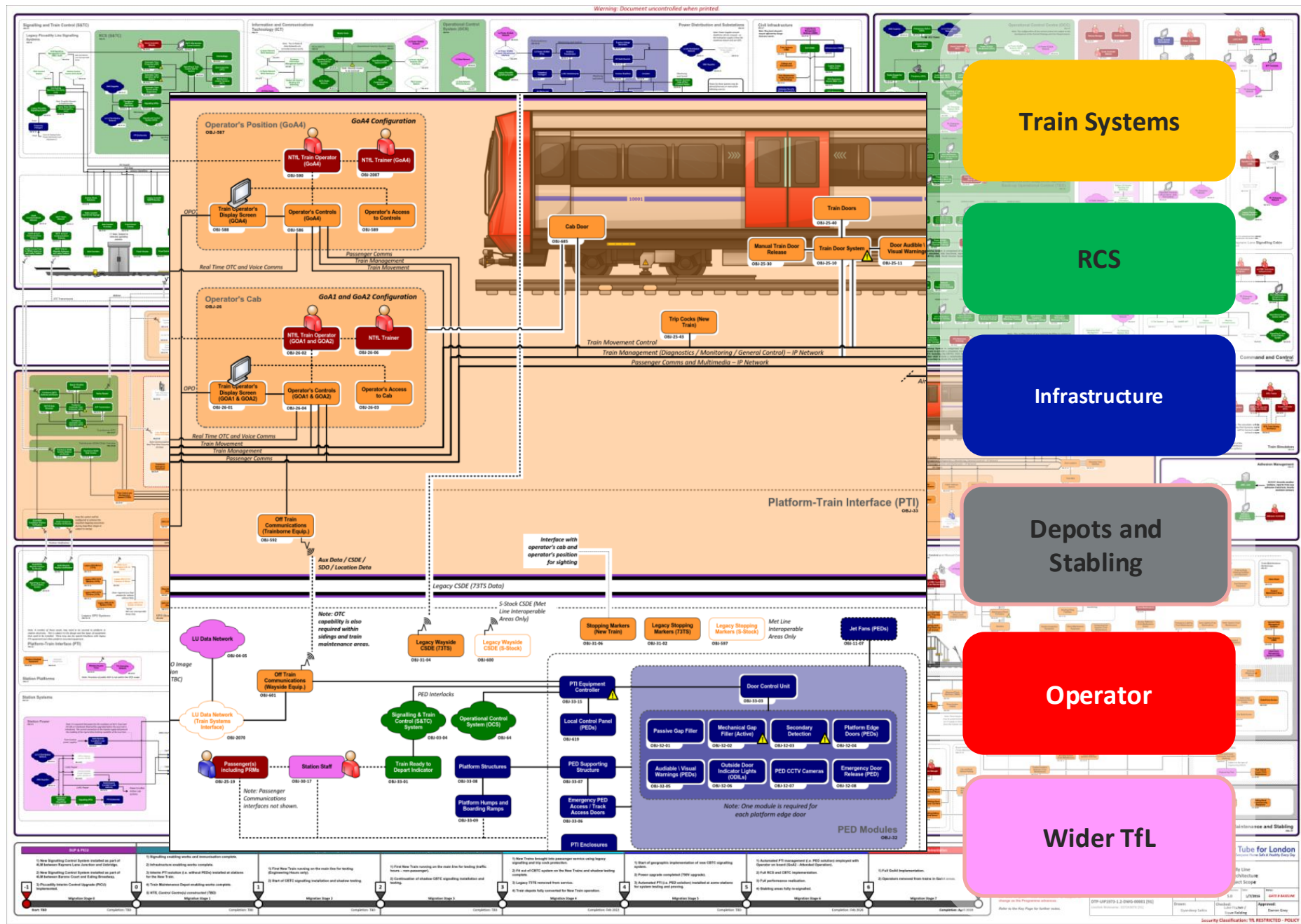
## Key Components – Scope Clarity / Requirements





# Integrated Approach

## Key Components – Interface Management / Physical Architecture



Train Systems

RCS

Infrastructure

Depots and Stabling

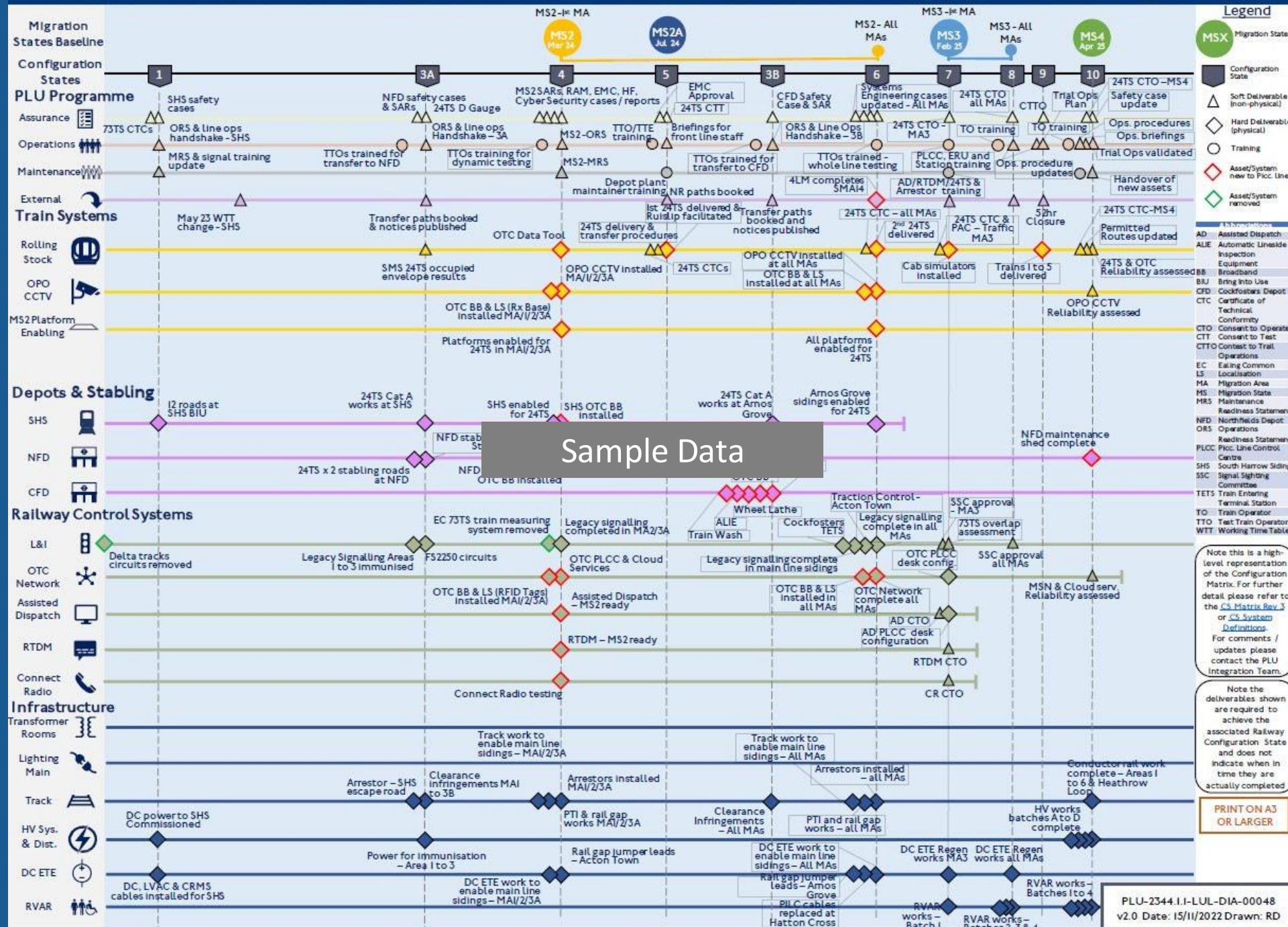
Operator

Wider TfL

# PICCADILLY LINE UPGRADE – CONFIGURATION STATE SUMMARY (STAGE I) 1 of 2

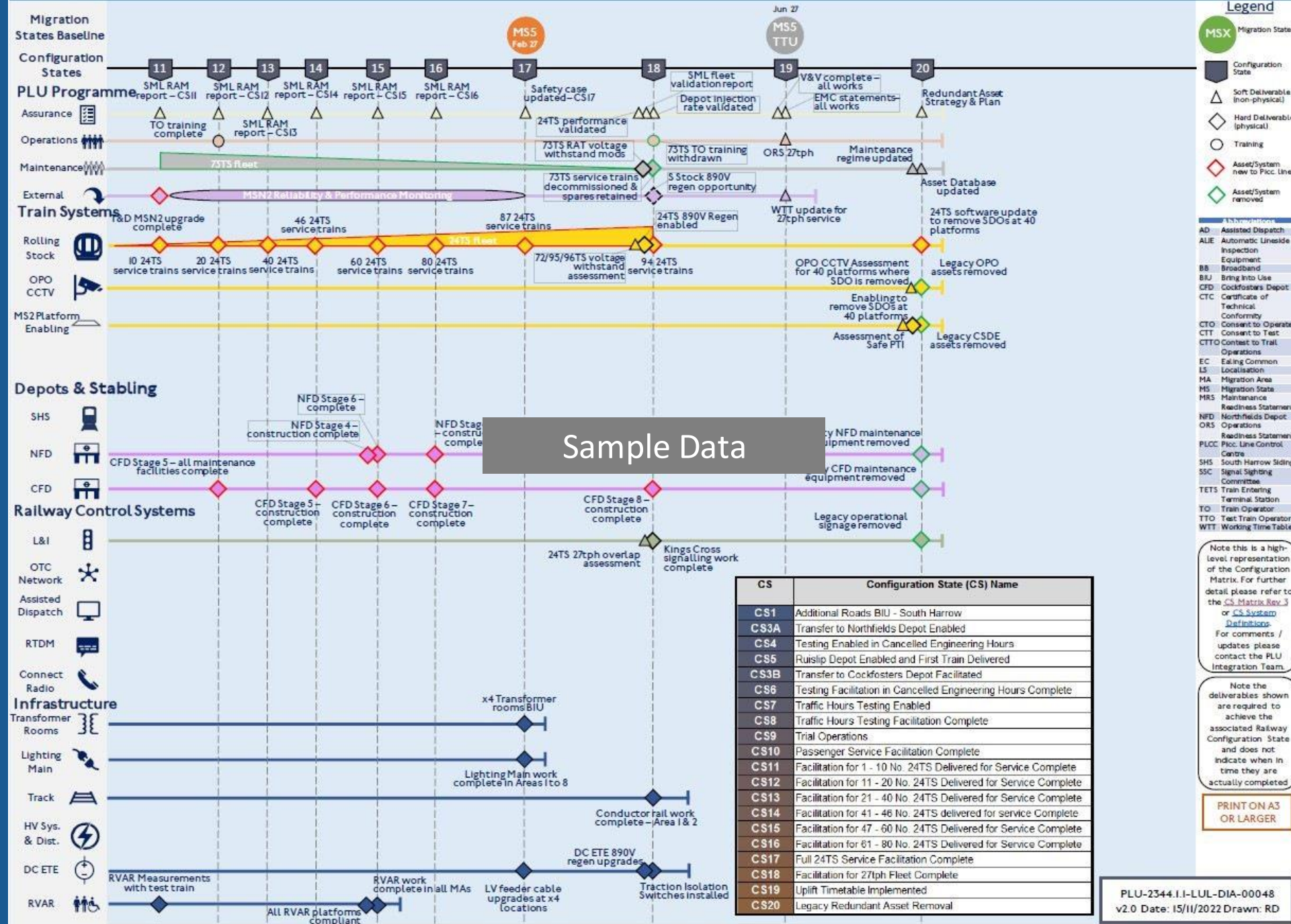
## Integrated Approach

## Key Components – Configuration State Summary



## Integrated Approach

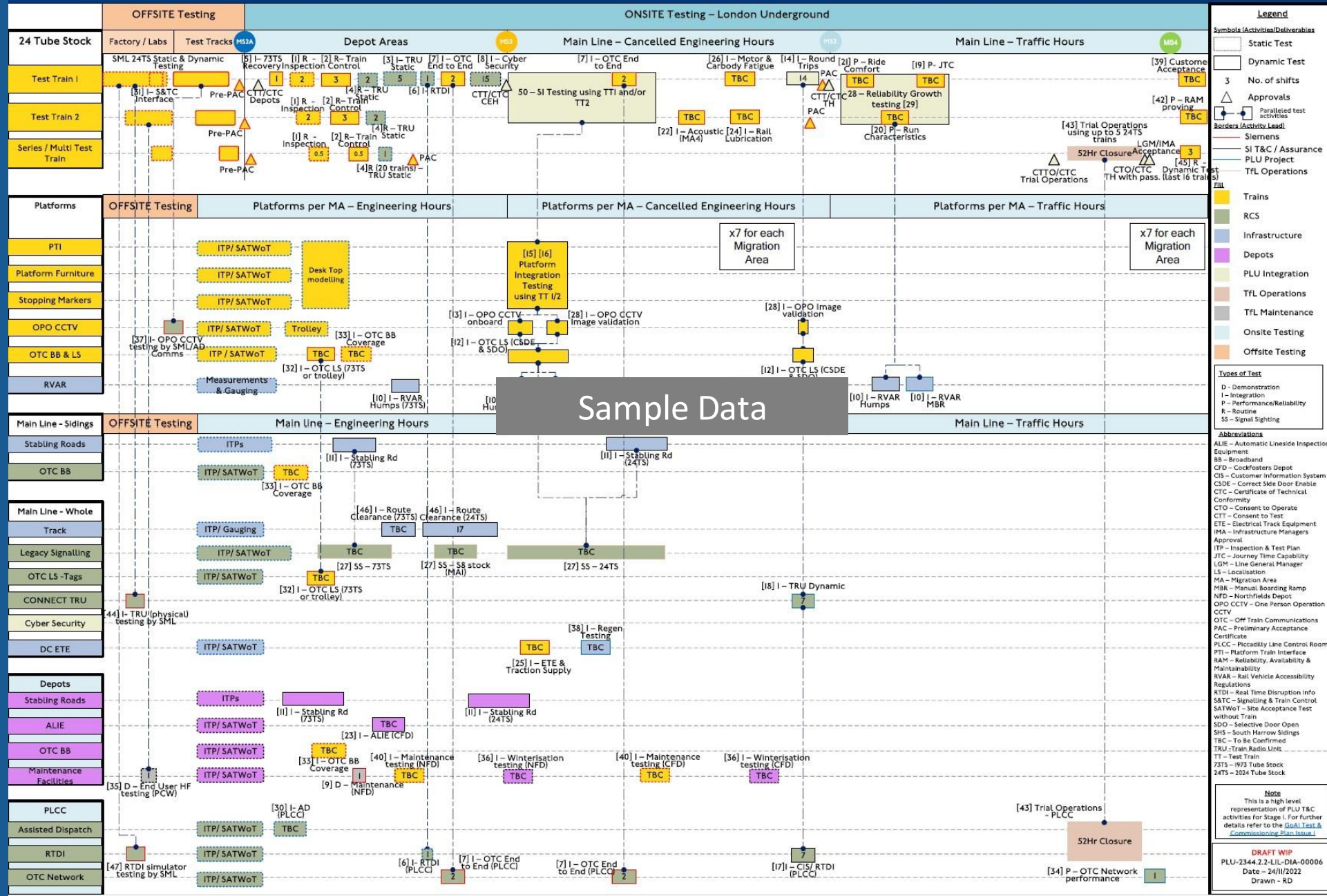
## Key Components – Configuration State Summary



# PICCADILLY LINE UPGRADE – TEST AND COMMISSIONING SUMMARY (STAGE I)

## Integrated Approach

## Key Components – Testing and Commissioning Summary



**Legend**

Symbols/Activities/Deliverables

- Static Test
- Dynamic Test
- No. of shifts
- Approvals
- Paralleled test activities

**Borders/Activity Lead**

- Siemens
- SI T&C / Assurance
- PLU Project
- TFL Operations

**Types of Test**

- D - Demonstration
- I - Integration
- P - Performance/Reliability
- R - Routine
- SS - Signal Sighting

**Abbreviations**

- ALIE - Automatic Lineside Inspection Equipment
- BB - Broadband
- CFD - Cockfosters Depot
- CIS - Customer Information System
- CSDE - Correct Side Door Enable
- CTC - Certificate of Technical Conformity
- CTO - Consent to Operate
- CTI - Consent to Test
- ETE - Electrical Track Equipment
- IMA - Infrastructure Managers Approval
- ITP - Inspection & Test Plan
- JTC - Journey Time Capability
- LGM - Line General Manager
- LS - Localisation
- MA - Migration Area
- MBR - Manual Boarding Ramp
- NFD - Northfields Depot
- OPO CCTV - One Person Operation CCTV
- OTC - Off Train Communications
- PAC - Preliminary Acceptance Certificate
- PLCC - Piccadilly Line Control Room
- PTI - Platform Train Interface
- SATWoT - Site Acceptance Test without Train
- SDO - Selective Door Open
- SHS - South Harrow Sidings
- TBC - To Be Confirmed
- TRU - Train Radio Unit
- TT - Test Train
- 73TS - 1913 Tube Stock
- 24TS - 2024 Tube Stock

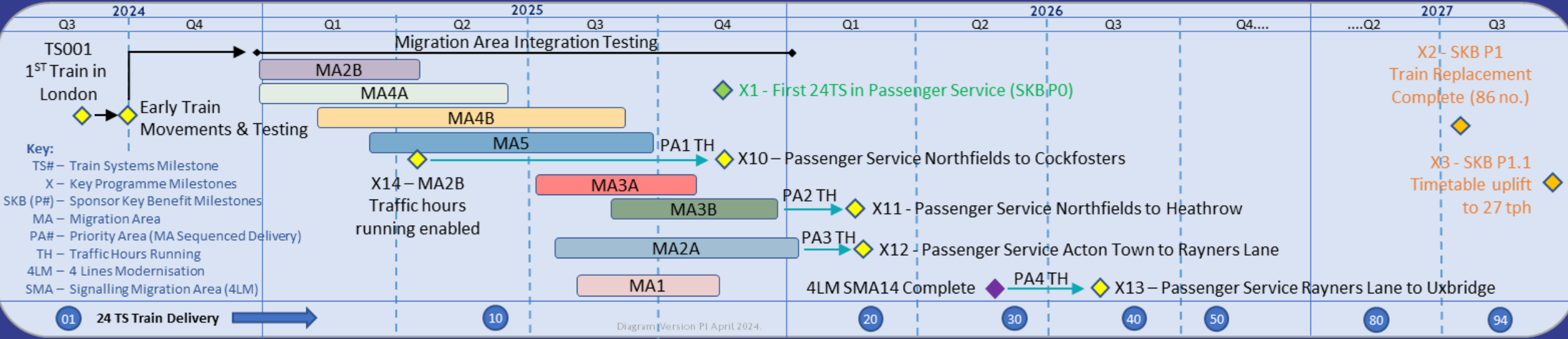
**Note**

This is a high level representation of PLU T&C activities for Stage I. For further details refer to the [GoA Test & Commissioning Plan Issue 1](#)

**DRAFT WIP**  
 PLU-2344.2.2-LIL-DIA-00006  
 Date - 24/11/2022  
 Drawn - RD

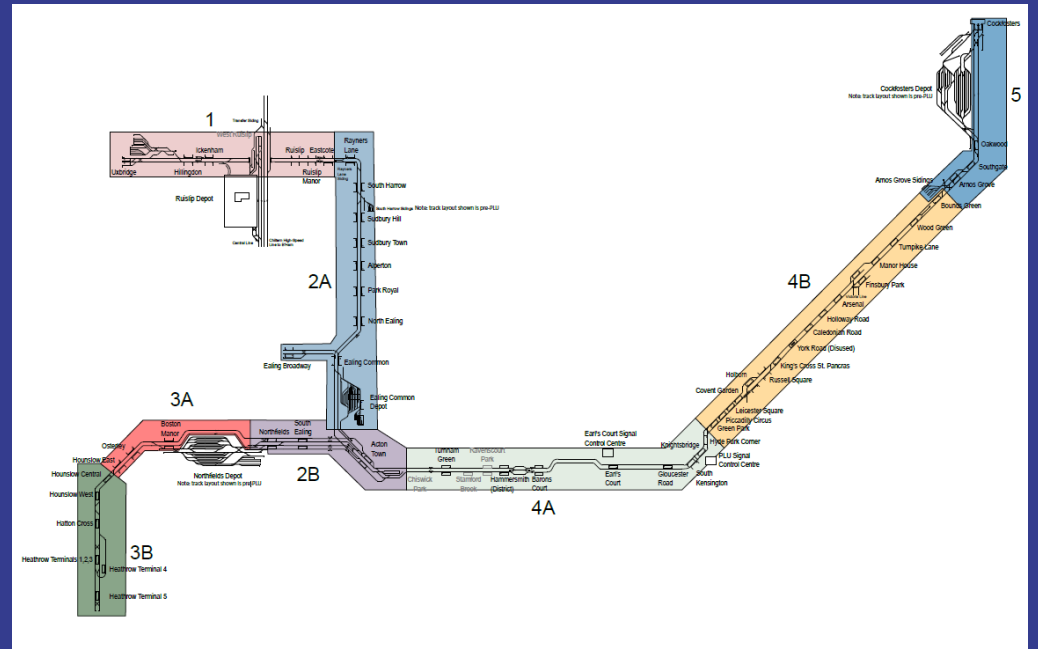


# PLU Delivery Summary



Delivery Sequence (multiple MAs in a priority area to be delivered together)					
Priority 1	MA2B	MA4A	MA4B	MA5	Northfields to Cockfosters
Priority 2	Northfields to Heathrow		MA3A	MA3B	
Priority 3	Acton Town to Rayners Lane			MA2A	
Priority 4	Uxbridge Branch				MA1

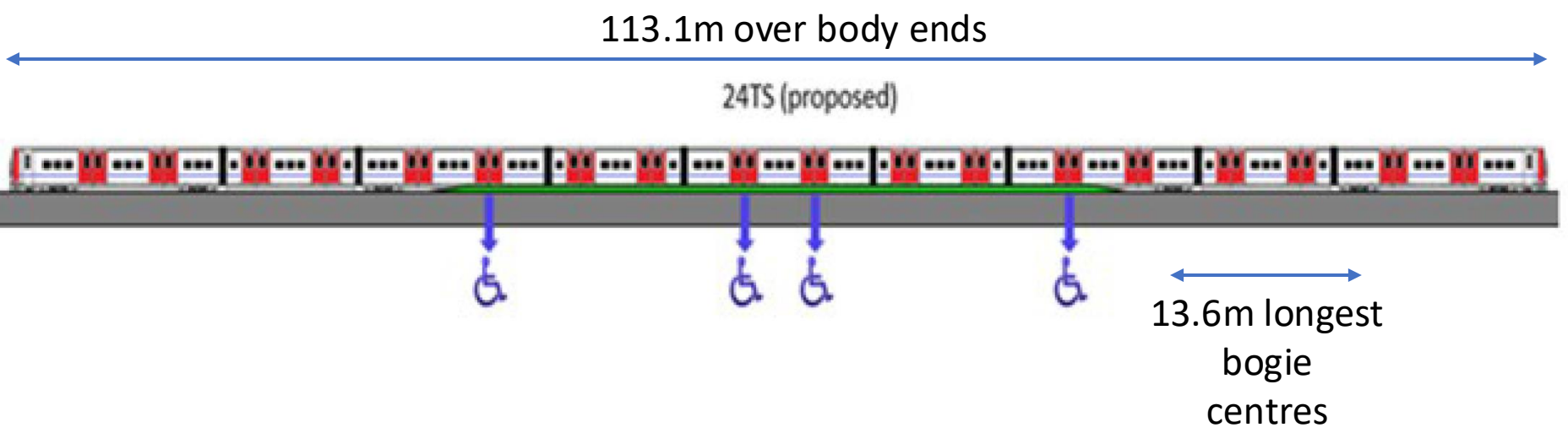
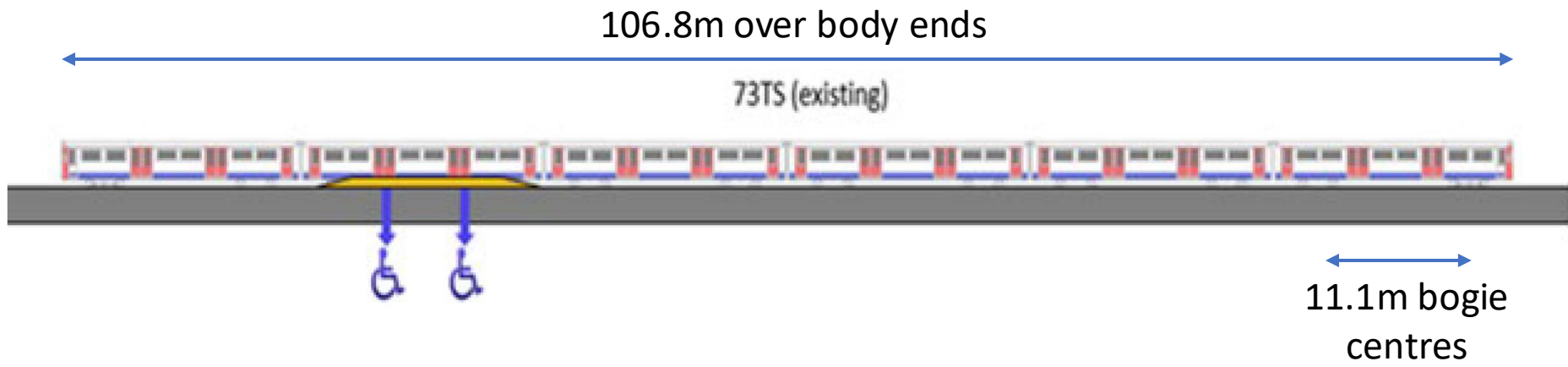
- Benefits:**
- The ability to start integration testing with 24TS, traffic hours running, and passenger service earlier - facilitates Northfields to Cockfosters passenger service
  - Removes constraint on Uxbridge Branch (MA1) readiness first therefore significantly mitigating the interface risk with 4LM (SMA14)
  - Facilitates earlier test train arrival at Cockfosters for train familiarisation for drivers, and training for O&M colleagues
  - Essential for the utilisation of the initial maintenance facilities and stabling capacity at both Northfields and Cockfosters
  - Optimises timetabling and faster fleet introduction and 73TS removal, critical to maintaining 24TS delivery beat rate
  - Enables optimisation of available access



# Train Architecture

## 73 Train System v 24 Train System

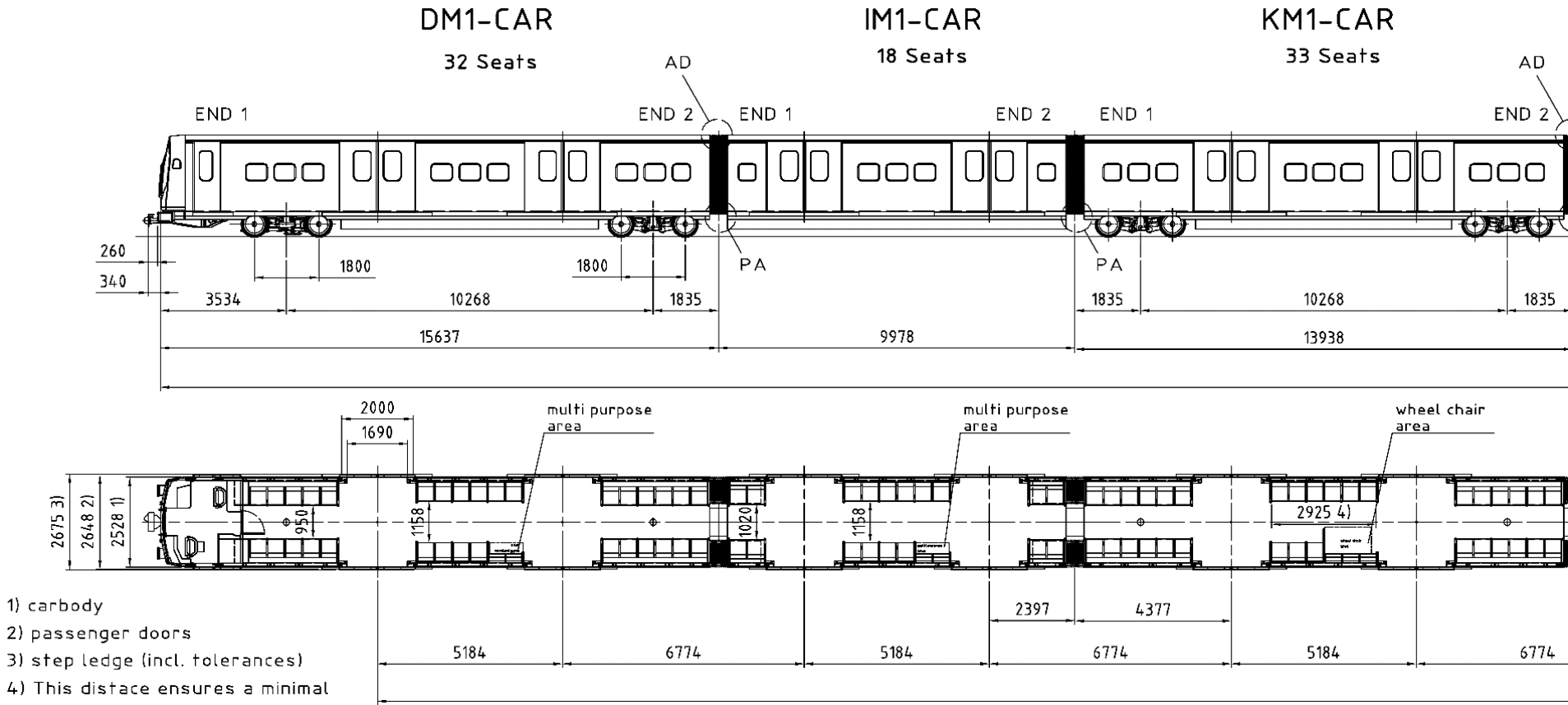
Output specification, valuing  
Passenger Throughput,  
Passenger Comfort, Power  
Consumption & Whole Life  
Cost



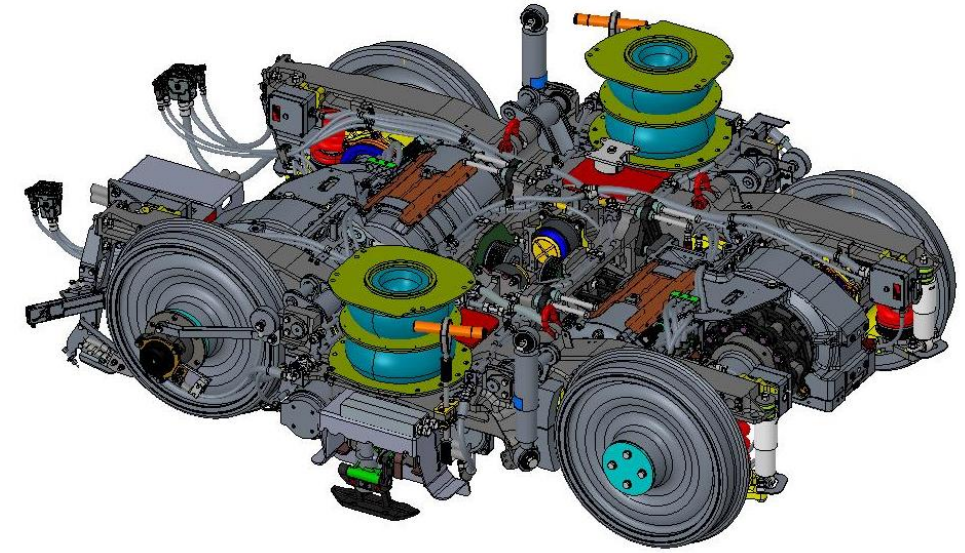
# Train Architecture

## New Train Configuration

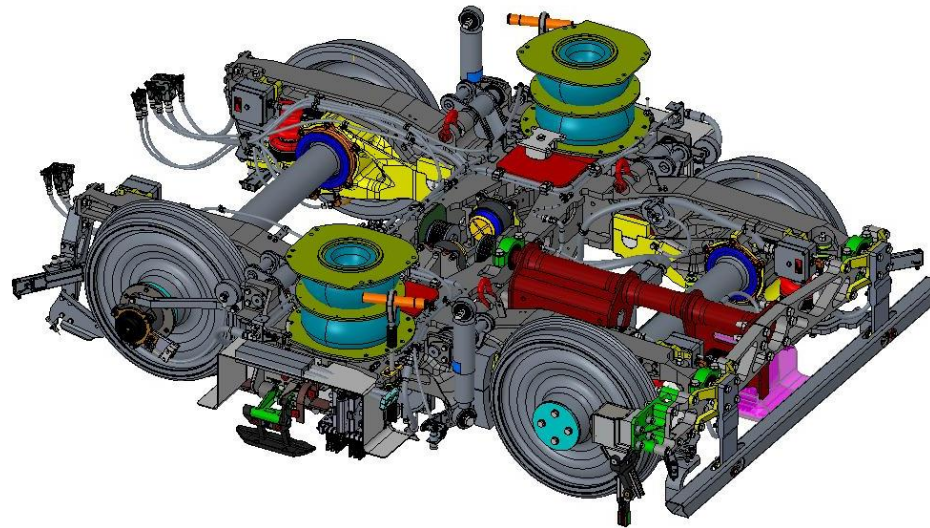
Walkthrough, increased headroom, Air Cooling



- Motor and Trailer variants
- Welded steel plate construction
- Hollow Axles
- 1.8m wheelbase & hydrobushes
- 700mm diameter wheels (new)
- H-frame
- Permanent Magnet Motors



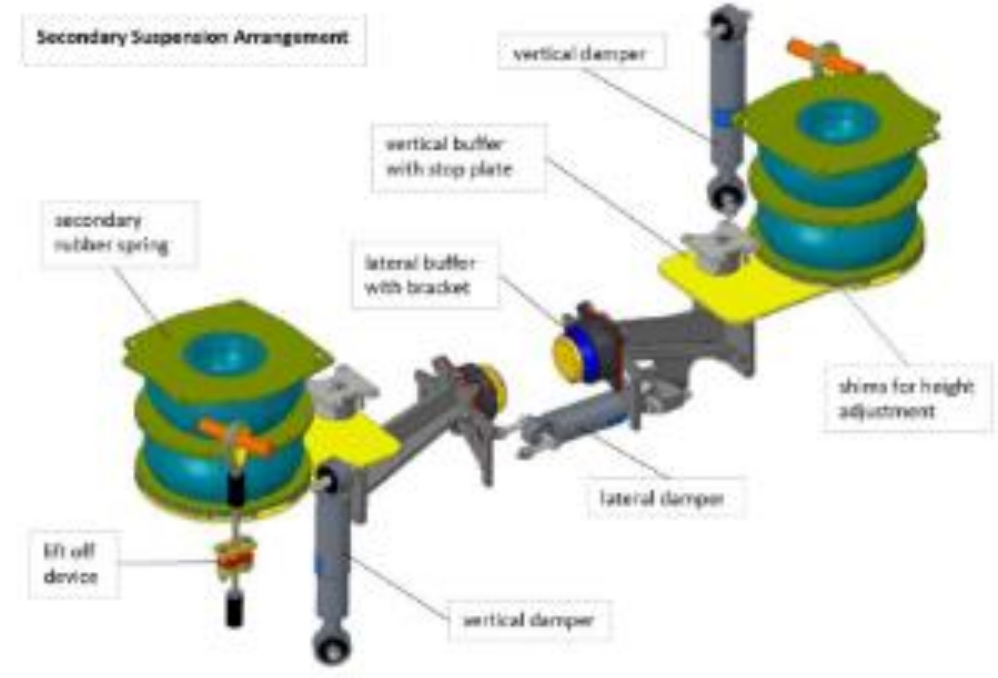
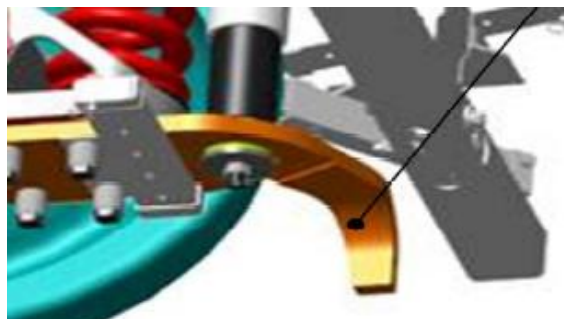
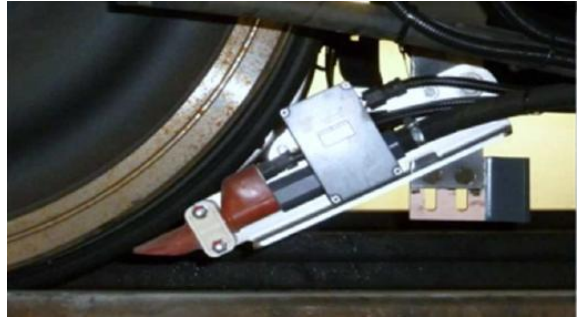
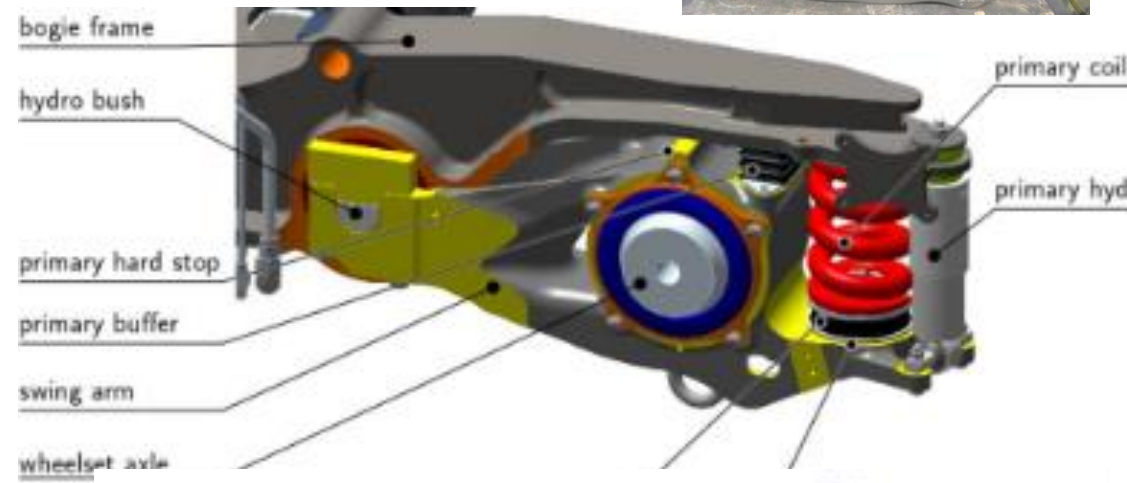
## Bogies





## Interesting Features:

- Primary suspension - steel coil & rubber springs
  - Hydro bush
- Secondary suspension
  - Metalastic rubber (hourglass)
- Rough Ride Detection
- Friction modifiers (Flange and Back)
- Adhesion modifiers
- Sanders
- Lifeguards





9

Carriage, air conditioned walk-through trains

94

New 'Inspiro' trains

880

Passengers per train

4

Wheelchair spaces per train

10%

Increase in passenger capacity

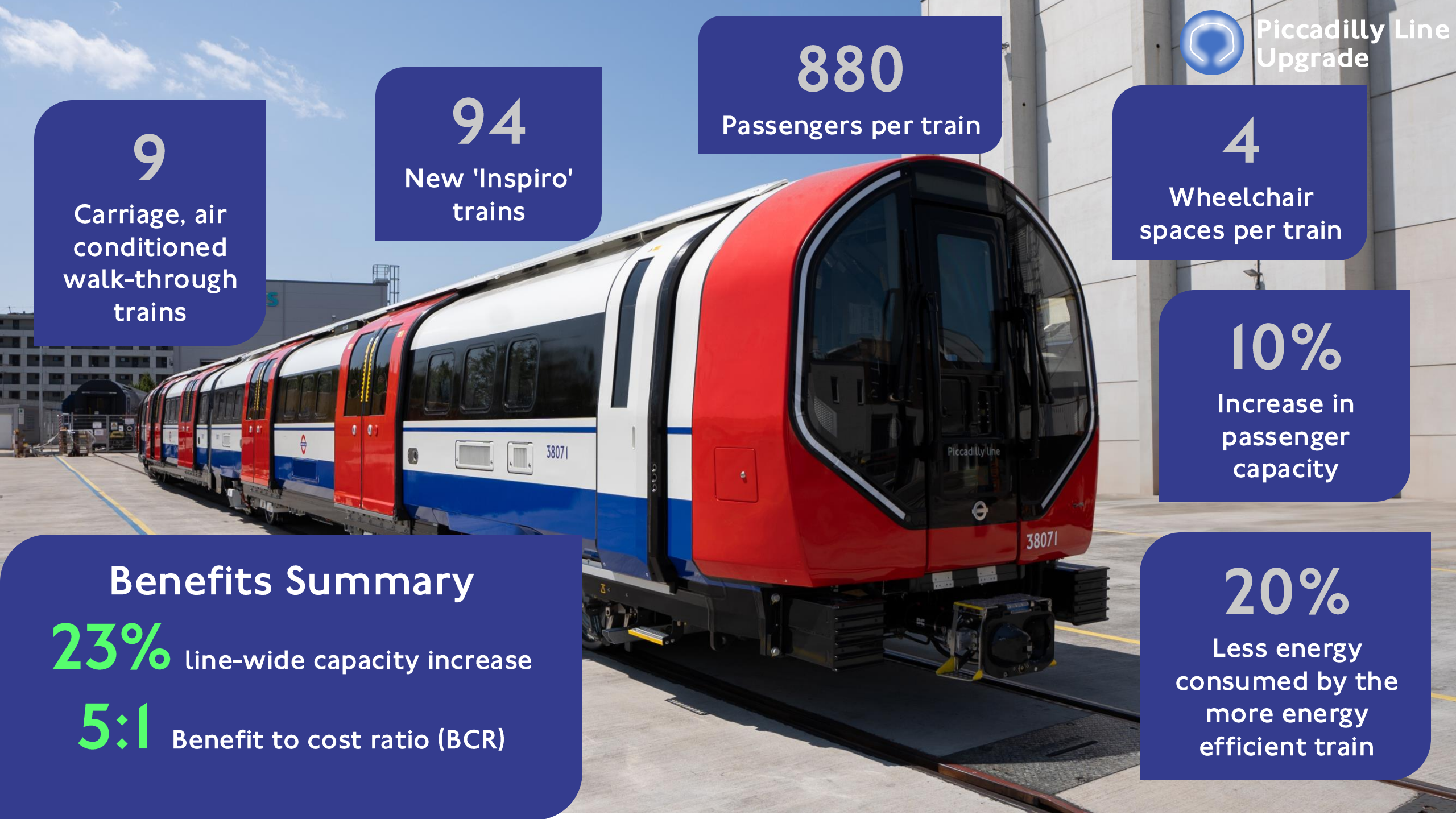
20%

Less energy consumed by the more energy efficient train

## Benefits Summary

23% line-wide capacity increase

5:1 Benefit to cost ratio (BCR)





## Piccadilly Line Upgrade

23% uplift in peak capacity  
(27TPH or 1 train every 2m 13s)

94 No. 24TS

86 No. 73 TS

# Train Systems



## Trains

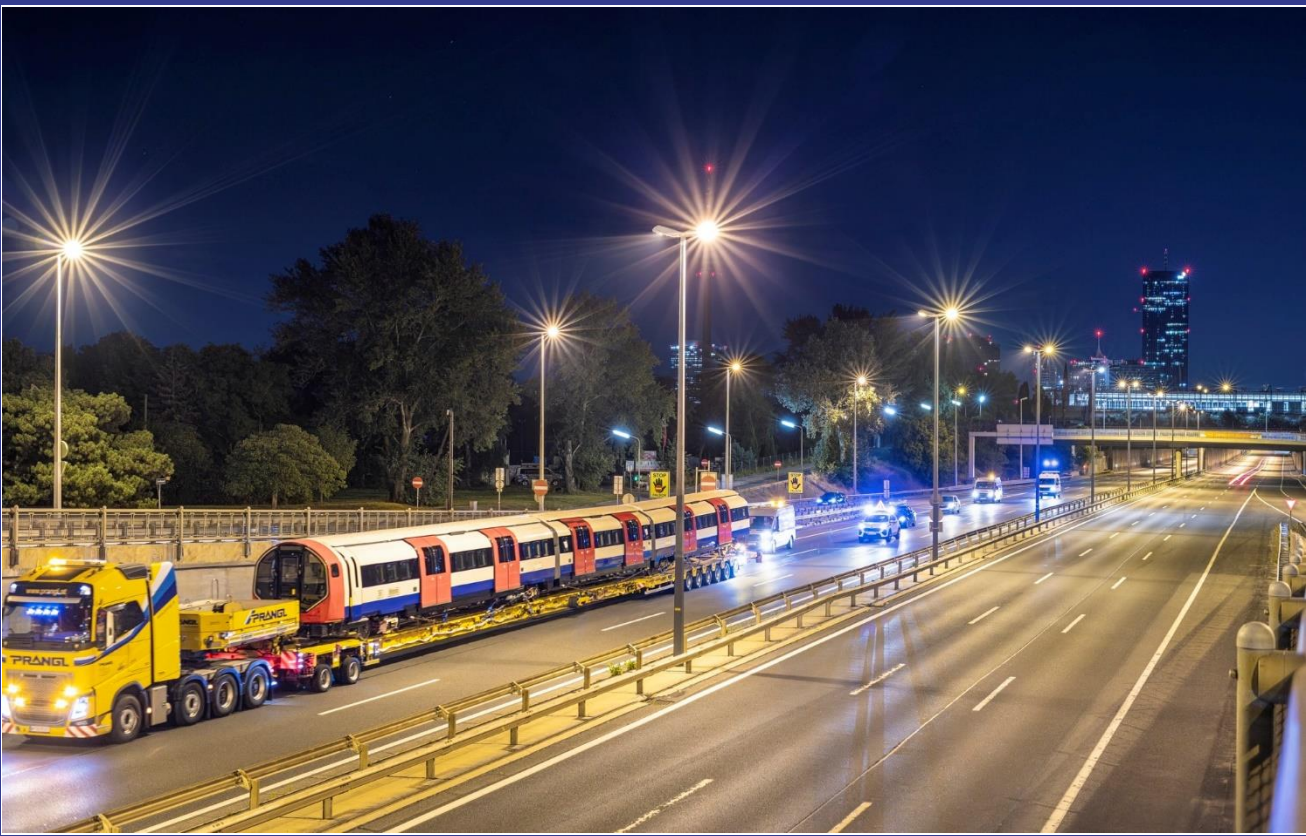
- 94No new state of the art 24TS trains including Spares and special Tools
- 4No Train Driver Simulators
- Off Train Communication (OTC) Data Tool
- Operational and Maintenance Training, Readiness and Manuals
- 73TS De-commissioning
- 2No Rail Adhesion Trains (permanent conversion from legacy 73TS)

## One Person Operation Closed Circuit Television (OPO CCTV) system

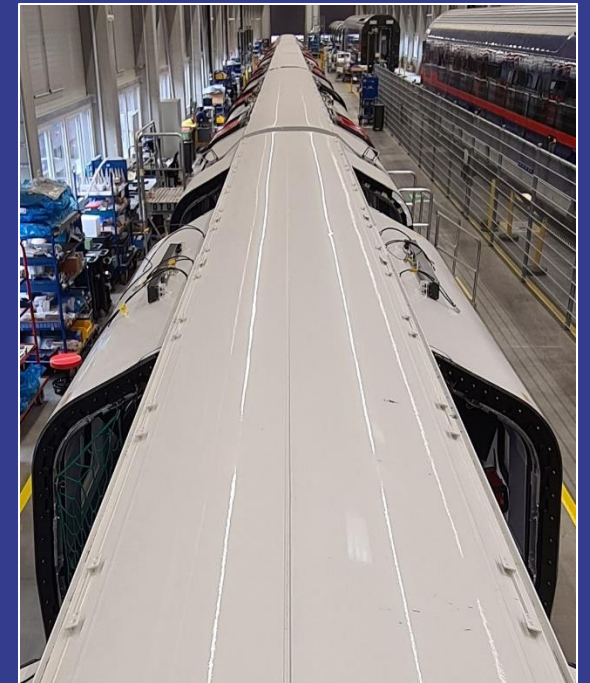
- 1st digital system on deep tube
- OTC Broadband (Wi-Fi) and RX bases (Correct Side Door Enabling)
- Platform stopping markers
- OPO enabling works: Communication Equipment Room (CER) works, power connections, ventilation & cooling, reactive works
- Platform enabling works: Platform End Barriers and Operational Signage



# Train Systems In Pictures



# Train Systems In Pictures



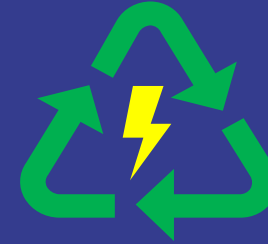
# Train Architecture

Test Train Track Video





## Power



### HV Network Upgrades

- 10 Substation Upgrades, new Transformer Rectifiers, HV, DC and LV Panels, SCADA and other associated equipment
- Over 100km HV and fibre optic cabling installation including associated CRMS across Pic, Central and Vic Lines
- Two large scale substation extensions to provide space for new HV equipment
- Completion of Power Package 2 (substation vents, DC/HV cabling) on behalf of RSE

### Transformer Rooms

- Delivery of four new Transformers Rooms across the Pic Line including integration in existing power network

### 600v Immunisation

- Installation of a new LV main cable network and substation equipment upgrade between Sudbury Hills and Ealing to enable signalling to train EMC mitigation



# POWER In Pictures

**Batch B – Manor House substation**  
Thales enabling works complete



**Batch A – Sudbury Hill Substation**  
DC Switchboard Commissioned



**600V Immunisation**  
Distribution boards and LV extension panel delivered to Alperton substation



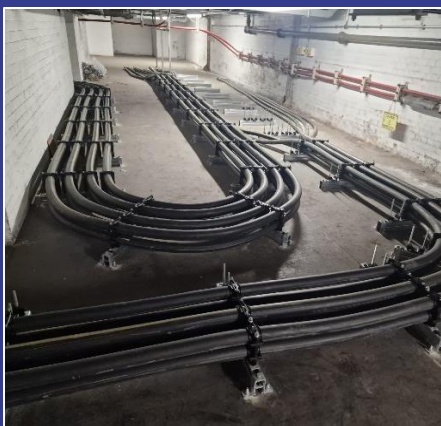
**Transformer Rooms**  
Concept Designs completed at Piccadilly Circus and Hounslow



**Batch D – ITT Issued**  
Ravenscourt Park, Acton Town Substation Upgrades, Cabling, PP2



**Batch C – Contract Awarded**  
2 No substation upgrades and building extensions at Hatton Cross and Hounslow East





# Infrastructure



Track; Replacement of 21km of conductor rail for composite type



Train Arrestors; Renewal of Train Arrestors within sidings and terminus stations



Infringements; Enabling Route Clearance for 24s



Platform Train Interface; PTI improvements in advance of 24s introduction



RVAR; 27 new platform humps, track raisings and provision of mobile ramps to meet accessibility requirements



LV Station Main; Upgrade of low voltage supplies across network to support OPO functionality



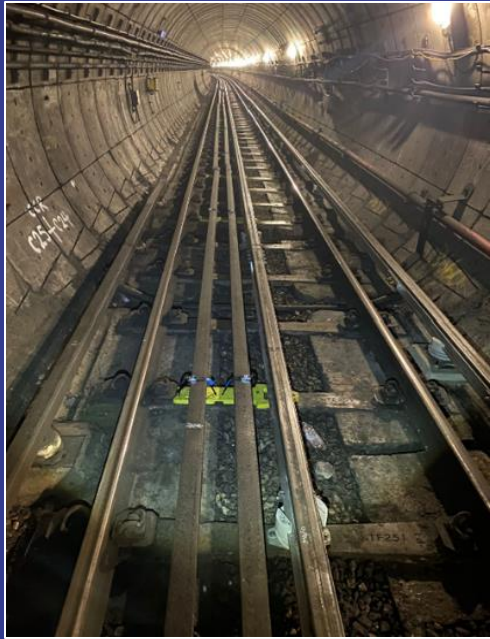
DC Power; Upgrade of trackside power infrastructure to support re-gen braking & increased power draws from 24s



Capital Efficiencies; Co-ordination of CRMS and SER requirements across PLU delivery teams



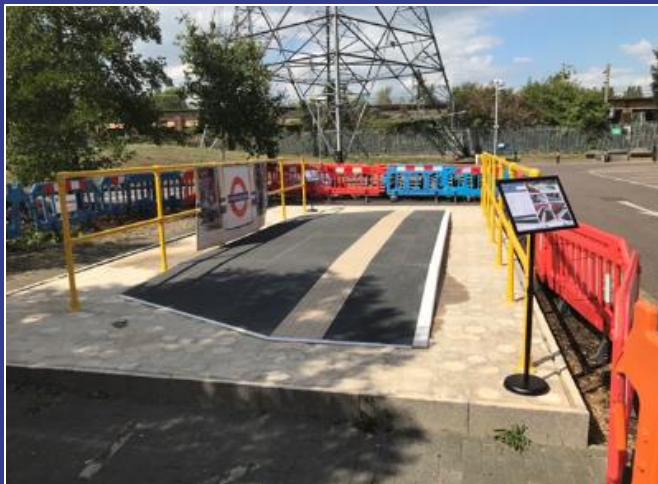
# INFRASTRUCTURE In Pictures



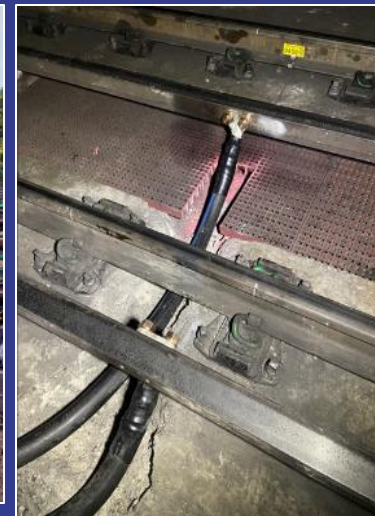
- Over 8000m of CCR installed across network by end of 2023.



- Wood Green Siding temporary train arrester installed



-Innovative hump installed at TUCA, plans now for Charing X

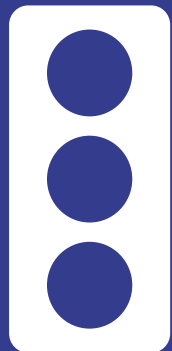


- Aluminium cable trials successful  
- DC feeder commissioned into use Sudbury Hill to SHS

 RCS

## Legacy Signalling – Signalling Control Systems

- Immunising the railway between South Harrow and North Ealing
- Installing and commissioning co-acting signalling assets to improve signal sighting from a 24TS



## Extended Line Management System – Non Signalling Systems

- Designing, installing and commissioning a system to dispatch a 24TS from the Pic Line Control Centre in the event of an OPO CCTV failure
- Installing the Off Train Communication assets in mainline sidings, and stations, as well as implementing the protocols for data encryption and cyber security
- Designing and manufacturing a Type 5 24TS Connect Radio
- Designing, installing and commissioning a real time disruption messaging system between the Pic Line Control Room and the 24TS/Pic Line Stations



# RCS In Pictures



210 Type 5 Connect radios manufactured



Thales OTC BB reference site validated with a train in a box



Signal co-actor installed in open and tunnel sections



Immunisation transformers and capacitors installed and commissioned into service ready for Phase 2



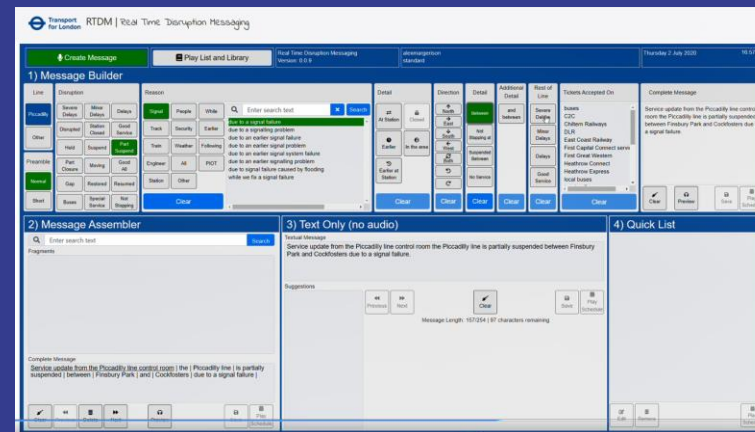
Assisted Dispatch latency pilot trial



RTDM User Interface



OTC cable route surveys





# Depots & Stabling

**South Harrow & Arnos Grove  
Sidings**

**Cockfosters  
Depot**

**Northfields  
Depot**



Initial Maintenance and Stabling team – enable existing depot roads and facilities to maintain and berth the new rolling stock as it arrives in London

Cockfosters & Northfields Critical Delivery – enable and deliver initial berthing capability, Train Driver Simulators and new Wheel Lathe facility at Cockfosters

Sidings (South Harrow & Arnos Grove) new berthing capacity (SHS) and enable for 24 stock use (both)

End State Maintenance Facilities - Cockfosters & Northfields Maintenance facilities and fleet accommodation to support the life of the train

End State Track Environment – provide berthing capacity and depot control systems to support new fleet and 27 TPH



# DEPOTS In Pictures

CFD site clearance



CFD temporary welfare



South Harrow Sidings



IMS mobile Lifting Jacks



TfL RESTRICTED

Northfields NE Sidings



CFD roads 32 & 33



# Operations & Maintenance Readiness



- Operational Concept
- Development of operational and maintenance requirements



- Analysis of design/scope against requirements
- Support to Infrastructure works/changes



- Support to Enablers/Transition plans
- Development of new rules and procedures

- Development of training material
- Trade Union consultation
- Training of all staff
- Testing and Trial Operations
- Introduction into service
- Post implementation support
- Benefit realisation



# Operational Readiness In Pictures

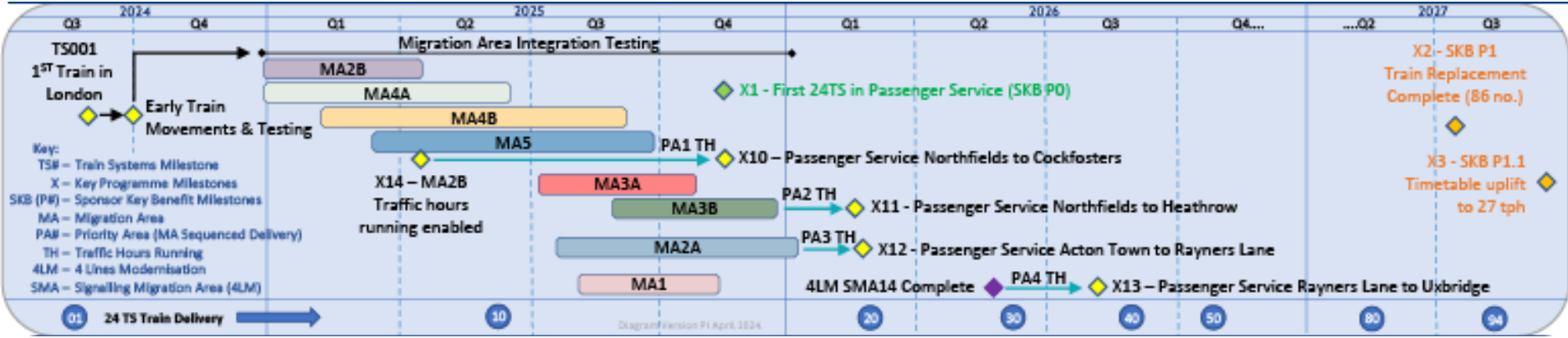
## 24 Stock – Cab simulator

## Maintenance Validation Exercises





# Key Milestones



## PLU Major Milestones (dates are indicative)

Major Milestones	Forecast Date
The first 24 tube stock train is delivered to London	Late 2024
Sponsor Key Benefit P0 - First 24TS in Passenger Service	Early 2026
Sponsor Key Benefit P1 - Piccadilly Line Train Replacement Complete	2027
Sponsor Key Benefit P1.1 - Timetable uplift to 27 tph	2027
Note - full completion of depots maintenance facilities runs beyond 2027	

# The Piccadilly Line Upgrade

Q&A / Discussion



# Car Body Assembly

Timelapse Video

