

# D Stock Refurbishment

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## SYNOPSIS

London Underground has refurbished most of its trains approximately twenty years from service entry, or in other words, at roughly half life. Following the Public Private Partnership (PPP) contract award to Metronet Rail SSL, the District Line D Stock Fleet is the first such refurbishment to take place under the new PPP arrangements. This paper summarises the planning, scope of work, impact of the new contract arrangements, technical features and progress to date on the refurbishment project.

## 1. INTRODUCTION

London Underground's D Stock entered service on the District Line between 1979 and 1983. The fleet consists of 150 three-car units, 20 of which are 'double ended', with a cab at each end, the remainder being equipped with a cab at one end and a shunting control panel at the other. The fleet is one of the most reliable on the LU network, achieving typically over 15,000 kms between Service Affecting Failures.<sup>1</sup>



*Fig 1 – Existing train*



*Fig 2 – Existing interior*

To date, D Stock has already undergone several major engineering modifications programmes. These include replacement of the Train Equipment Panel with a new Train Monitoring System (1995/96), which aided a step-change in reliability and bogie replacement (2000/03), to mitigate against fatigue life limits and improve wheel unloading characteristics.

The trains have also undergone various reliability and safety modification initiatives (e.g. water ingress prevention, whistle relocation, door top tracks replacement).

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<sup>1</sup> Service Affecting Failures are defined as those causing a delay to the service of 2 minutes or more.

## 2. PROTOTYPE DEVELOPMENT

Whilst the fleet continues to perform reliably, the vehicles are showing their age and in common with its policy on previous fleets, LU decided to carry out a refurbishment programme. Over the period 2000/01 one 3-car unit was modified by LU's Train Modification Unit. This prototype vehicle featured a new interior layout, external livery, car end windows, flooring, interior panelling and ceiling finishes, lighting and a passenger information system demonstrator, for in-service monitoring and market testing purposes.



*Fig 3 – Prototype interior*

This prototype unit continues in passenger service today, but will be re-worked towards the end of the full refurbishment programme to bring it to the same standard as the rest of the (refurbished) fleet.

## 3. PPP CONTRACT

Although the original scoping for D Stock refurbishment was undertaken as early as 1998, and the prototype unit completed in 2001, negotiations over the PPP deal between LU (as operator) and the various consortia bidding to be Infrastructure Providers, effectively put the programme on hold until 4 April 2003.

Metronet's bid scope encompasses replacement of the complete sub-surface railway fleet by 2016, the District Line D78 trains being replaced in 2015 – 2016. Thus the Metronet and LU bid teams agreed a scope of refurbishment works giving a "value for money" enhancement of the D78 fleet, based on a remaining expected life of 8 – 10 years.

## 4. STAKEHOLDERS' INCENTIVES

In the past, LU had specified the scope of refurbishment works in some detail, then gone to market and determined a supplier through a tendering process. However, with the advent of the PPP, LU had developed a much looser, output based scope of works and the detailed work of specifying the refurbishment fell to Metronet.

Whilst Metronet has to ensure it meets LU's engineering and other standards, and the high level scope of works agreed under the contract, the detail of how to deliver to these requirements is largely down to Metronet. Their incentives are geared around

- the need to maintain the trains and offer a reliable fleet for service (they are penalised under PPP if they fail) and

- offering a high level of passenger amenity and ambience (again ambience is measured under the PPP contract and ‘Service Points’ scores are translated into payments).

So whilst LU’s suppliers were always required to meet its standards, to some degree they are now better incentivised to present a refurbished train which is both reliable and easy (and cost effective) to maintain. From the end of 2007, Bombardier will be responsible for all D78 fleet maintenance further incentivising them to develop reliable, maintainable products.

## 5. SCOPE OF WORKS

Despite the limited remaining life of D Stock, the refurbishment scope is quite extensive and includes the following features:

### 5.1 Carbody – exterior

Window apertures are cut into the intermediate ends of cars to improve passengers’ perception of security, in line with other recent LU refurbishments and new builds. Single glazed laminated glass is used in these positions and the design caters for replacement from within the car in the event of breakage. The car end “porter” buttons are repositioned to accommodate the new glazing and interior panels modified accordingly. In cab positions, all 3 train operator’s and instructor’s windscreens are replaced with new items constructed of 14.6 mm thick impact-resistant glass with an anti-spall layer. The exterior of the vehicles is painted in LU corporate livery using a 2 pack polyurethane colour coat with a clear graffiti resistant top coat.



*Fig 4 – UNDM car showing new car end windows*

The choice of paint finish satisfies LU’s requirements in terms of corporate livery and quality of finish. From the maintenance standpoint, this coating system has good abrasion resistance, graffiti resistance, and adhesion to prepared surfaces. The paint system is similar to that used on other LU builds and experience to date has been generally good.

MRSSL typically washes trains every 3 - 5 days with a heavy clean every 18 days. They also have to clean off graffiti to avoid incurring PPP Ambience penalties. The ambience scores can only be maintained if most graffiti removal can be accomplished within normal cleaning cycles.

### 5.2 Carbody –interior

Inside, the old maple flooring is stripped out and replaced with a rubber floor laid on a Dricon fire retardant plywood deck. Centre sections are constructed on aluminium and plywood box sections which can be removed to allow access to the cable trays

underneath. Contrasting floor colours are used in the seating and vestibule areas as an aid to visually impaired passengers, in line with RVAR guidelines.

The majority of the interior panels, including the ceilings, are replaced with new polyester powder coated aluminium panels. This coating system has excellent abrasion resistance, graffiti resistance, and adhesion. It has been used extensively on other LUL vehicles and is included in the MRSSL approved materials list for this type of use.

In two areas, namely the sliding passenger door interior faces and the draught screens, a thin polycarbonate film is being applied to the panels to facilitate a good quality finish, whilst aiding production. A range of options was investigated for these areas. The doors are of aluminium honeycomb construction with an outer aluminium skin, overlaid on the interior surface with a melamine finish. This type of construction does not lend itself to being stripped down - it's extremely difficult to remove the melamine, and there's a risk of damaging the honeycomb. Therefore, instead of removing the melamine covering, a polycarbonate film was chosen to overcoat the doors in a durable finish, in line with the new interior colour scheme.



*Fig 5 – Draught screen & door<sup>2</sup>*

The chosen self adhesive film will be able to resist repeat attacks from vandals and be easily cleaned by maintenance staff. The self adhesive films have been tested for graffiti removal using some of the 'artists' favourites, such as felt pens, spray paint and shoe dye. These films can be removed and replaced if badly soiled.

New seats and arm rests are provided in a revised layout incorporating a Multi Purpose Area (MPA) measuring around 950mm long x 700mm across. This wheelchair useable space is broadly in line with RVAR guidelines<sup>3</sup>, although it has



*Fig 6 – New interior, inc. RVAR style handles*

not proved possible to fully meet all the dimensional and layout recommendations in this vehicle. The MPA (and indeed all the refurbishment features) has therefore been designed to meet the spirit of the RVAR requirements as far as reasonably practicable, given the age, life expectancy and basic superstructure of the vehicles. The seats are of plywood and aluminium construction, featuring removeable moquette covers, with a sprung cushion with anti-vandal mesh layer.

<sup>2</sup> Note on Figures 5 and 6: Train interior is sheeted-up for test running & final finishes are not shown.

<sup>3</sup> Note that D Stock is not a regulated vehicle under RVAR.

The new seats have passed BS6853 Cat 1a fire and smoke tests. The arm rests are aluminium castings with a powder coated finish, whilst new RVAR compliant handles are provided on the transverse seat backs to replace the existing non-compliant ‘loop’ handles. The last of LU’s old style “ball and spring” strap hangers will disappear as part of the refurbishment, to be replaced with modern grab poles and rails, finished in bright “District Line” green.

The layout is designed to encourage people to use all the available standing space and the new grab poles and new continuous rails are more convenient and sturdy than the strap hangers they replace. As well as providing a bright modern interior and incorporating a wheelchair space and other passenger amenities, the interior refurbishment considerably improves the fire performance of the vehicles, with the vast majority of the materials brought up to modern standards.



*Fig 7 – New interior: MPA<sup>4</sup>*

### 5.3 Lighting

The new ceiling incorporates new lighting (22 tubes per car<sup>5</sup>), with 4 of these tubes per car providing emergency lighting, compared to 2 per car in the existing design. A load shedding system, designed to shut down non-vital systems, has been incorporated to reduce the load on the train batteries and thereby maximise the availability of emergency lighting in the event of traction power loss. LU’s requirement is for a minimum of 2 hours availability of emergency lighting in this situation.

### 5.4 Passenger Information System (PIS)

A new PIS is provided. This completely replaces the existing cab-to-cab and Public Address systems, and incorporates several new audio and visual information features, which are described in more detail in the following paragraphs. Door close warning chimes are included on the refurbished trains. Whilst these are triggered by the door control system (when the Train Operator operates the ‘Door Close’ button) the chimes will sound over the new PA speakers.

New passenger emergency alarms (PEAs) are fitted in each door vestibule, plus an additional low-level alarm handle sited adjacent to each wheelchair location in the Multi Purpose Area (giving a total of 5 handles per car). The alarms feature a talk-back facility allowing two-way communication with the driver when a PEA handle has been activated.

Side and front mounted exterior line and destination displays are provided to assist passengers on platforms. The side units are mounted between the inner and outer casement window panes (which form the sliding door pockets) and accessed for maintenance via the hinged inner casement frame to which they are mounted. ‘This

<sup>4</sup> Note: the car is set up for test running so floor finishes are covered with protective sheeting.

<sup>5</sup> All cars except DM (driving motor), which has 20 light tubes owing to slightly smaller saloon area.

station', 'Destination' and 'Next Station' information will be provided simultaneously over the speaker system (14 new ceiling mounted speakers per car<sup>6</sup>) and new interior visual displays.



*Fig 8 – Car end windows & new PIS pod*

A novel feature is the provision of 'real time' service disruption information over the PA and visual displays. On advice from the Line Controller, the Train Operator will key in a message code related to the given type and location of disruption (e.g. NN Station is closed, please change at XX for the YY line). The selected message(s) will be automatically triggered at pre-defined locations based on the particular message and the train's location.

In this way, the aim is to provide meaningful, up to date, helpful information, (whilst avoiding an endless stream of spurious messages, delivered at locations where the information is more of a nuisance or irritation than a help!) Providing a semi-automated system is geared towards minimising the burden on the Train Operator, by reducing the need to make station by station announcements over the PA. Nonetheless, a full PA capability is provided, and if selected, this suppresses the automated messaging system.

### **5.5 Saloon Surveillance Closed Circuit Television (CCTV)**

Two CCTV cameras per car will be provided, mounted in the PIS visual display pods located at each car end. Recording will be continuous at 12 frames per second, on to a hard drive mounted one-per-car in the ceiling of each vehicle. For certain trigger events, e.g. when a PEA handle has been activated, the event will be logged on the recording, for use in support of any subsequent investigation. Overall the system will provide a capacity of at least 72 hours recording time (before the system starts to automatically overwrite the oldest material). Based on experience elsewhere on the network, this will give Metronet and LU sufficient time to manage the retrieval of video data if requested to support British Transport Police or technical investigations.

### **5.6 Cab Air Conditioning**

In common with most Train Operators' cabs on the tube network, D Stock cabs can be far from comfortable in hot weather. Therefore at refurbishment, the cab will be equipped with a new air conditioning system. The cooling unit itself is ceiling mounted above the cab and saloon in the driving motor cars, with 6 ceiling mounted, directable, filtered outlets into the cab. The air conditioner power supply is fed from a static inverter, mounted on the underside of the trailer cars, which form the middle car of each 3-car unit. In light of the limited remaining life of D Stock, LU decided not to explore passenger saloon air conditioning as part of the refurbishment. It is, however,

<sup>6</sup> All cars except DM (driving motor), which has 13 speakers owing to slightly smaller saloon area.

planned to include air conditioning on the future generic Sub-Surface train for the Underground, which will start to appear on the Metropolitan Line around 2009.

### 5.7 Other cab features

The cab will also get a general refit, including repainted panelling together with new flooring to the same standard as the saloon. A new Train Operator's seat is provided, together with a new instructor's seat mounted on the offside cab back wall. The Train Operator will also benefit from an additional 'Door Close' and replacement pair of offside 'Door Open' buttons mounted on the main console (enabling offside door operation from the seated position).



*Fig 9 –New livery*

A new numeric key pad and telephone style handset are provided to support operation of the new PIS.

## 6. DELIVERY PROGRAMME

Train 1 is currently undergoing brake testing on LU's dedicated test track in London. Refurbishment has added roundly 1 tonne per car in weight, and Metronet will put the train through a full set of brake tests under tare, crush laden, wet and dry conditions, to confirm revised brake system settings. These brake tests will be completed in November 2004, following which the train will be used to test the triggering of the PIS messages at all District Line locations, as well as undergoing dynamic testing to demonstrate the performance of the cab air conditioning. On completion of this testing programme, Train 1 will be returned to Bombardier's Wakefield works to undergo further works to bring it up to passenger service standard<sup>7</sup>.

Train 2 is already being fitted out at Wakefield (with completion expected early 2005), but for Trains 3 to 75, production will be transferred to Bombardier's Derby works. Production planning for this main phase of the build programme is already underway and Metronet and LU will be working with Bombardier to ensure the lessons learned on Trains 1 and 2 are transferred to the new production line.

The first of the refurbished D Stock trains will enter passenger service in early 2005, with the full compliment of seventy-five 6-car trains completed by 2008.

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<sup>7</sup> Photographs in this paper show Train 1 in works at Wakefield and set up for testing in Ealing Common Depot. The finishes give an impression of the train only, and are not fully representative of the final product as it will be presented for passenger service.