25 January 2012

Greenford Station Inclined SFA Lift • Feasibility Study Paper
London Borough of Ealing • LU Greenford Station
Inclined Lift Feasibility Study Scope

The project to provide step free access at LU Greenford station was developed by LU as part of a broader range of enhancements, with construction works started but curtailed in 2009. More recently LB Ealing has undertaken a study to establish the potential for installing a lift and platform access route, in the manner of the LU proposals but using a smaller, 10-person lift of a type similar to that installed by LU at Southfields station.

It is now proposed to examine an inclined lift option, employing research and information recently compiled by LU Engineers. An inclined lift option assesses local area conditions and is less intrusive than an operating railway and, if considered feasible, may deliver the most affordable step free access.

The intention is for London Borough of Ealing to appoint Tony Meadows Associates, the designers of both the LU and LBE proposals, to work with the LU Capital Programmes Directorate engineering team and the lift manufacturers, Hutter Aufzuge GmbH, to examine the feasibility of installing an inclined lift in the LU Greenford stair and escalator shaft.

TMA will develop the stair and escalator shaft layout, including coordination of design support information provided by LU CPD and Hutter Aufzuge.

• TMA will employ record documentation and previously developed TMA drawings as a basis for the feasibility assessment.
• TMA will coordinate the equipment distribution design provided by Hutter Aufzuge with the requirements for access and maintenance provided by LU L&E Engineers.
• TMA will take spot dimensions to confirm or compensate for record information where clearances may be critical.
• TMA will prepare site-specific drawings and, with Hutter Aufzuge, prepare a workscope for costing by LU QSs.

LU Capital Programmes Directorate will manage the timely input of Hutter Aufzuge and LU engineering and cost estimation.

• LU will arrange and accompany access to areas beneath the existing stair and escalators and all other areas necessary to confirm dimensional constraints.
• LU will instruct Hutter Aufzuge to provide all necessary lift design data and to liaise with TMA and LU regarding the dimensional, structural and maintenance requirements at LU Greenford.
• LU will provide structural and services engineering support to the study.
• LU will provide an installation cost estimate on the basis of the developed information.
• LU and TMA will prepare a risk assessment to define and focus the next stage of activities.

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Internal Lift Feasibility Study Scope
1.0 Executive Summary

1.1 Project Scope and Accommodation

Greenford station has been the subject of three proposals for the installation of step free access in recent years. Tony Meadows Associates (TMA) has been appointed as the designer in each case and is well placed to compare the different options.

The initial proposal, for LU and the London Borough of Ealing (LBE), was developed to a level of construction detail and included a new LU standard 16-person lift accompanied by significant station services. The second proposal, for London Borough of Ealing, examined the option of installing an inclined lift and identified that this may introduce alternative equipment dimensions and tolerances to those specified for other LU lifts. The third proposal, initiated by LU and the subject of this Feasibility Study, examines the potential for an inclined lift within the stairwell, avoiding the access route works required for the vertical lift options.

At this stage it is recommended to progress either Option 1 or Option 2, which are broadly similar in cost, until further detail of the extent of and risks inherent in the enabling works is determined. A preliminary review suggests the work to the structural prop at high level of the stairwell.

1.2 Project Development Process and Data Employed

The Feasibility Study has been developed on the premise that the inclined lift will replace one of the existing stairs in the stairwell, and avoid interference with the existing escalator. It is anticipated that one of the existing staircases would remain in the primary configuration of step free access in recent years. TMA has been appointed to lead the Feasibility Study, with engineering, cost and management input from LU Capital Programmes, and lift supplier design and specification input from Hutter Aufzuge (HA’s equipment and below the existing staircases have been gained from site visits organised by LU.

3.0 Site Visits

In parallel, it is proposed to create a Memorandum of Understanding between London Borough of Ealing and London Underground, which will jointly finance the project and deliver the project risk. The project design and procurement of the inclined lift and the enabling works contractor will occupy 2012, with an 11 to 16 month construction programme. It is intended that selection of a single option will only occur after a further round of site visits and a costed assessment of the implications for the enabling works. The project will also involve minor civil structural works and station works, with reduced project risk.

The cost:benefit of a second escalator is high and it is decided to progress with a second escalator rather than an incline lift.

While this study indicates that the installation is feasible from a dimensional perspective, the three primary project risks at this stage are:

1. The availability of project funding
2. The nature and extent of the station services to be relocated and supplied
3. The development and approval period of an appropriate inclined lift specification

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Should any of these options progress, there would not be opportunity to install at a later stage. It is anticipated that one of the existing stairs would remain as the primary configuration for step free access in recent years.

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The cost:benefit of a second escalator is high and it is decided to progress with a second escalator rather than an incline lift.
The stairwell, containing two escalators and one exit, provides the only route between platform and the street level concourse. The stairwell was constructed with the intention of installing three escalators, and a number of station services have since been routed through the area beneath the stairs, and the area houses various switchgear cabinets. A full structural, services and condition survey of the shaft and under-stair area has not been undertaken, and a more detailed impact of a inclined lift installation will be required to confirm the detailed impact of an inclined lift installation.

2.4 Passenger Capacities

An assessment of the capacity of a single staircase is based on the busiest 15 minutes. RODS 2010 data shows that the busiest 15 minutes is between 0800-0815 with 407 passengers. The majority of these passengers are entering and would use the escalator to reach the platform. The busiest time for the stairs is in the PM peak with passengers exiting to station. Between 1500-1515 there is a busy train service, with 315 passengers above, 239 passengers alight from Westbound trains and 56 passengers alight from Eastbound trains. The busiest train, 2200, carries 239 passengers and 220 passengers and is a concession. The project would also require a revised fire strategy and discussion with operations.

The passengers will be alighting from trains rather than arriving evenly spread through the 15 minutes. Therefore a more realistic consideration of the passenger flow is needed. During the PM peak, 14 trains enter the station, each one carrying 239 passengers. Of the 315 passengers above, 239 passengers alight from Westbound trains in the busiest 15 minutes, in 89 passengers alighting per train, making a total of 115 in two 15 minute periods.

There are currently 100 pax/minute on the escalator as it is not in service. The service is currently operating at a capacity of 1.1m stair in under 3 minutes. The total daily passenger flow at Greenford is 12,056 passengers from Rolling Origin and Destination Survey (RODS) 2010. This figure is made up of 5,837 accessing passengers, 5,705 exiting passengers and 514 interchange passengers.

2.5 Operational Arrangements

The stairwell contains two staircases and one escalator, which provides the only route between platform and the street level concourse. The stairwell and gateline is normally staffed and the area houses various switchgear cabinets. A full structural, services and condition survey of the shaft and under-stair area has not been undertaken, and a more detailed impact of an inclined lift installation will be required to confirm the detailed impact of an inclined lift installation.

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2.3 Conveyance and Considerations

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3.0 Design Solution

3.1 General Arrangement

TMA has reviewed the overall feasibility and implications of installing an inclined lift at LU Greenford station, in lieu of a second escalator, to provide step-free access between concourse and platform level. It is intended that the inclined lift be installed in the area of the two steel passenger stairs rising from the concourse to the platform in the station stair and escalator shaft.

To minimise the cost and disruption of the installation, it is proposed that the new lift should affect only one of the stairs, and that the other will remain operational throughout the construction and installation period.

Three inclined lift options have been considered:

Option 1 – positions the inclined lift to the north of the concourse shaft, with the trusses resting on the engineer’s stair.

Option specific benefits are:
- Direct site/compound access
- Single lift side screen - cantilevered or propped
- Distinct passenger waiting area outside the primary concourse flows

Option specific associated works are:
- Creation of linked works compound
- Station cables to be relocated
- Fire main to be relocated
- Switchgear to be relocated
- Secondary LMC evacuation route to be relocated
- RC escalator plinths to be broken-out

Option 2 – positions the inclined lift at the centre of the concourse shaft, with the trusses resting on the engineer’s stair.

Option specific benefits are:
- Avoidance of the majority of services relocations
- Retention of secondary LMC evacuation route

Option specific associated works are:
- Creation of separate works compound
- Two lift side screens - portalised
- RC escalator plinths to be broken-out
- High level RC prop to be replaced and broken-out

Option 3 – positions the inclined lift at the centre of the concourse shaft, with the trusses resting on the RC escalator supports.

Option specific benefits are:
- Avoidance of the majority of services relocations
- Retention of secondary LMC evacuation route
- Retention of RC escalator plinths

Option specific associated works are:
- Creation of separate works compound
- Two lift side screens - cantilevered or portalised
- High level RC prop to be replaced and broken-out

3.2 Accessibility and Circulation

The passenger waiting areas of each option will be separated from the normal passenger flows by the existing end of stair and escalator extensions.

Option 1 places the inclined lift against the north wall and so allows good surveillance of the passengers on the remaining central stair from the concourse and escalator. In Options 2 and 3, with the inclined lift at the centre of the overall stair well, the remaining stair will in part be hidden from view. Glass sides to the lift envelope will reduce but not totally obviate the effect. The SCR will continue to have good views of the stairs in all options.

Given that the predominant use of the stair is from platform level, where the approach is orthogonal to the stair well, it is not considered that wayfinding will be compromised with any of the options.

During the course of design development the cost and approvals implications of widening of the remaining stair to 1.8m will be investigated, to accommodate future passenger growth. There is sufficient width to do so, the issue to be resolved is one of detailed construction staging.
3.3 Form and Materials

The inclined lift documentation and information employed for this study has been supplied by Hutter Aufzuge GmbH. The options employ the same steel framed, stainless steel and glass clad lift car in three different locations. The difference between the options is the requirement and structure of the glazed side screens. Option 1 requires only one side screen, which may be cantilevered, or propped for most of the incline from the shaft wall. Option 2 and 3 require two side screens, which would be portalised to minimise the structural depth and moment.

The infill sections between the stair and escalator and the new inclined lift will repeat the existing stainless steel cladding.

3.4 Hutter Aufzuge • Inclined Lift Description

A 10 person lift with two panel side opening 900mm or 1000mm wide clear doors.

Noise / Vibration / Ride Quality

There are no specific figures in respect of vibration and noise for this type of lift given that in the majority of instances the background noise and vibration far exceeds any output from the inclined lift.

The ISO document associated with the measurement of ride quality in lifts relates to vertical lifts and as the parameters associated with inclined lifts are different it is not possible to use this document as a guide.

Providing machine T-guides are used coupled with a high quality gearless machine, as proposed by Hutter Aufzuge, a good ride quality should be achieved. Time is spent in the commissioning period to refine the ride quality, which is affected by both vertical and horizontal moments.

Vertical/Inclined Cost Comparison

There are fundamental differences between vertical and inclined lifts which leads to inclined units being more expensive.

1. They are a less standard item by the nature of them being uncommon.
2. The forces change with the inclination so each lift will be unique in set-up deal with the horizontal moments that do not affect vertical lifts.
3. The truss structure is more complex than a conventional lift, again as it deals with both horizontal and vertical forces.
4. Invariably there is more glass in an inclined lift and for this reason there is more cost and complexity of the car design in order to achieve sufficient rigidity.
5. Steel supports would be required for the adjacent stairwell rather than opening them vertically, the most reliable system for an inclined lift is automatic doors.
6. The lifts need to be fully enclosed with doors to the extent of the approach inclining under control. There are a specialist enclosed design.
7. The control system has been configured very differently.
8. This results in a much smaller area only as far as the skills to deliver such a project safely.

Typical Costs

In respect of typical costs, a lift for the Hamburg Metro would cost approximately £250,000, however Underground Lifts currently consider the inclined requirement which should considerably increase the cost.

In the context of Greenford I would estimate a cost of between £500,000 and £700,000 assuming a non-disruptive working pattern, i.e. a point of storage within the same hoarded area as the work site allowing productive working during normal working hours.

Operation and Consumption

<table>
<thead>
<tr>
<th>Speed</th>
<th>Payload</th>
<th>Cabin weight</th>
<th>Counterweight</th>
<th>Inclination</th>
<th>Acceleration</th>
<th>Cabin Area</th>
<th>Persons</th>
<th>Door opening time</th>
<th>Power</th>
<th>Current</th>
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<tbody>
<tr>
<td>1.6m/s or 0.7m/s</td>
<td>1000kg</td>
<td>1400kg</td>
<td>1900kg</td>
<td>30deg</td>
<td>0.3m/s/s</td>
<td>1.86sqm</td>
<td>10</td>
<td>6sec</td>
<td>1.7kW or 0.7kW</td>
<td>18amp or 9amp</td>
</tr>
</tbody>
</table>
3.5 Structure

Each of the options requires an enabling works structural package to be completed in advance of lift installation. The enabling works package will include the construction of a 1-hour fireproof surround to the lift zone, separating it beneath the existing stairs from the retained escalator chamber (to BS EN12845 cl 5.3).

On completion of the separating wall, Options 1 and 2 require the removal of a row of the reserved concrete escalator plinths. This work will create significant noise and dust, requiring high specification works hoardings to protect the escalator and the general public above stair level.

Option 3 requires the removal of the existing shaft prop at high level above the stairs and escalator. This work will create noise and dust, albeit in a more contained area than that of the RC escalator plinths. The forces taken by the existing prop and the support it provides to the shaft will require either a substantial steel prop that is specially fabricated to pass over the zone required for the inclined lift. The condition of the shaft and its member will require investigation and monitoring at an early stage and before the option is adopted.

3.6 Services

Each of the options requires an enabling works services package to be completed in advance of lift installation.

Option 1 requires the relocation of a significant number of services within the chamber beneath the existing stairs. Given the location of the existing RC supports and the central stair, it would be impractical to retain these existing cable arrangements and maintain access to maintain or replace them after the inclined lift is installed. Any relocation would add cost and time to the project.

Options 2 and 3 avoid the need for any re-routing of small power and lighting, and the relocation of the lift shaft.

In all cases the lift shaft will require fire suppression but does not require separate protection from the existing sprinkler system employed in the escalator machine chambers (Ref BS EN 12845).

3.7 Operations and Maintenance

The inclined lift is passenger operated and needs no special day-to-day operational input from the station staff. Ideally the installation may be preferable alternative to the escalator and stair and managing the waiting area may require some staff involvement. It is intended that the lift travel be noticeably slower than the escalator and stair use, in order to ensure the safety of all passengers for whom it is primarily intended.

As a specialist piece of equipment, it is anticipated that the maintenance of the inclined lift will be a long-term contract with the lift supplier.
3.8 Construction Methodology

A high-level workscope for each option has been developed to inform the sequence, programme and costing of the installation.

The preliminary programmes appear in Table 3. Further investigation of the existing structures will be required before a realistic programme can be prepared for Option 3.

**Option 1 Workscope**

1. Relocate fire main
2. Relocate switchgear cabinets
3. Relocate small power and lighting
4. Construct new secondary LMC egress route
5. Construct separating walls around hoistway and machine chambers to underside of stair structures
6. Re-run wall mounted cables onto new hoistway walls and commission
7. Decommission and remove existing cables
8. Remove existing passenger stair
9. Extend hoistway walls to high level, with temporary infill to walls and lid
10. Make good retained stair edge to hoistway walls
11. Break out RC escalator support walls
12. Prepare floors to receive inclined lift trusses
13. Install inclined lift and finishes
14. Make good to concourse and platform floors and thresholds
15. Construct ramp to ticket machines
16. Replace temporary hoist wall with glazing
17. Adjust signage, commission lift and bring into use

**Option 2 Workscope**

1. Relocate small power and lighting
2. Construct separating walls around hoistway and machine chambers to underside of stair structures
3. Remove existing passenger stair
4. Extend hoistway walls to high level, with temporary infill to walls and lid
5. Make good retained stair edges to hoistway walls
6. Break out RC escalator support walls
7. Prepare floors to receive inclined lift trusses
8. Remove existing passenger stair
9. Extend hoistway walls to high level, with temporary infill to walls and lid
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16. Replace temporary hoist wall with glazing
17. Adjust signage, commission lift and bring into use

**Option 3 Workscope**

1. Construct temporary access to high level prop
2. Relocate small power and lighting
3. Install monitoring
4. Undertake remedial/strengthening works to shaft walls
5. Install permanent access stair
6. Break out RC escalator support walls
7. Install inclined lift and finishes
8. Make good to concourse and platform floors and thresholds
9. Construct ramp to ticket machines
10. Replace temporary hoist wall with glazing
11. Adjust signage, commission lift and bring into use
3.9 Approvals and Agreements

LU and Hutter Aufzuge are currently developing the specification of the inclined lift for the specific requirements of the LU system.

It is intended that four inclined lifts will be installed in the Crossrail stations and a Transport for London procurement system is already underway, with a likely conclusion in March 2012.

All associated construction works will require passage through the normal LU approval system.

3.10 Cost Estimate

LU consider that an accurate cost estimate of the options is not possible at this stage, principally due to the limited knowledge of the existing conditions identified as part of the study and the absence of verified cost data for the inclined lift.

LU has determined that the worst case construction costs would be in the order of £3,000,000, but that further investigations and procurement work may reduce these by up to 25%.