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UK's First Urban Cable Car
A Project Review of The Emirates Airline

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Abstract. The Emirates Air Line is the UK's first urban cable car, it provides a low-emission, quick, direct and fully accessible link across the River Thames, travelling between two new terminals named Emirates Greenwich Peninsula and Emirates Royal Docks. It was completed in June 2012. This review discusses the conception, specification, technical challenges and unique features of this innovative project.

INTRODUCTION

The Emirates Air Line sits amongst a backdrop of some of London's most famous buildings including Canary Wharf, The Gherkin, Tower 42, The Heron Tower, The BT Tower and the newly completed and iconic building "The Shard". The latter was also constructed by MACE, the same contractor who won the contract to build the Emirates Air Line.

It was erected in advance of the 2012 London Olympic Games and was designed to be a major piece of transport infrastructure for the City as well as having the accolade of being a tourist attraction.

Mayor of London, Boris Johnson said of the project:

"London's cable car will boost the on-going renaissance of this easterly quarter of the Capital, helping to secure a massive legacy for Londoners coming from the 2012 Games."

In 2013 the Emirates Airline was the winning entry in the Elevator World Project of the Year automated people movers category

The system provides a major new passenger route from the O2 arena (a major London events stadium and the world's largest and busiest music venue) on the south side of the River Thames to the north side just west of the Excel Centre, a major exhibition centre at which the bi annual UK lift exhibition is held. The system makes travel to both venues far easier for persons on the other side of the river.

Both areas surrounding the Emirates Air Line have been earmarked for a number of regeneration projects with the Royal Victoria Docks selected as one of the new Local Enterprise Zones. The Emirates Air Line plays a key role in supporting these regeneration projects by providing a quicker and more direct link. It will also give local communities on both sides of the Emirates Air Line access to a range of entertainment, job and leisure opportunities that are set to become available as regeneration picks up its pace.

THE BEGINNING OF A CONCEPT

It had been identified that a high density traffic system was needed for moving people from the main Olympic site near Stratford to the equestrian games which were being held on the south side of the river and also that, long term, the expected development of the Canning Town and Silvertown areas of the north bank of the Thames would require better transport links

Analysts considered all options for a transport system including a bridge, water based transport and a tunnel.

Water based transport is comparatively slow and would carry fewer people as the boats have to moor each time to load and unload. There would also need to be a higher operational staff requirement and there would need to be provision for other vessels using the Thames and also the added complication of draft requirements on low tide.

A bridge would have taken a long time to construct and would have required roads to be relocated if vehicles were to use it. A tunnel would have taken even longer.

In April 2011 planning permission was granted to build the first UK Urban Cable Car system which, following sponsorship, acquired the title *The Emirates Airline*

The cable car was selected as the preferred option for a number of reasons including:

- Speed of construction
- Cost
- Traffic handling ability

The project was conceived, designed, installed, tested & commissioned with all the legal compliances required in a matter of 14 months.

THE BASE SPECIFICATION

The system consists of 34 cabins each with the capability of carrying 10 persons. The system can operate at speeds of up to 6 metres per second and at that speed takes 4 minutes and 14 seconds to complete a one way crossing. As a people mover it is capable of transporting 2500 people per hour, a significant number, and forms part of the transport infrastructure of London long after the Olympic Games have left town.

On its first day in operation the system carried over 20,000 people and has proved to be a highly reliable and effective automated people mover. Between opening on June 28th and 12th August 2012 the system carried over 700,000 people.

The transportation system consists of a continuous single rope measuring 50 mm to which up to 34 cabins can be attached.

An overview of the installation can be seen in ***photograph (1)*** with a back drop of famous London buildings.

Photograph (1)
Two of the cabins passing with the backdrop of the City of London behind them

The system is incredibly efficient and, as with a traction elevator system, only has to provide power to move the out of balance load when the cabins are out on the line and equally spaced.

The system had to be fully accessible for persons with mobility impairments and the system has a feature that allows cabins to come to a stand for loading and unloading whereas in normal operation the cabins keep moving at a slow pace in the station areas. In order to achieve this feature an anti-collision system had to be designed into the software to prevent cabins coming into contact with each other.

TECHNICAL CHALLENGES & UNIQUE FEATURES

The project had huge technical challenges as well as having enormous public expectations and high profile stakeholders (including the Mayor of London). During the Olympics the system was used by the public and the athletes to access the equestrian games which were being held on the south side of the river in Greenwich and the Excel centre where the boxing events were held.

The unique aspects of the project have called for some innovative construction techniques and a number of firsts in the industry, for example the erection of the South Tower called for the installation of the largest lifting capacity crawler crane in Europe. The crawler crane, which runs on tracks and not wheels to aid mobility, was put together, on-site, over a period of two weeks and delivered using more than 70 articulated lorries. When assembled, its reach was 120 metres with a height of 183 metres. The huge temporary structure dubbed LR 1350 had a maximum lifting capacity of 1,350 tonnes - the equivalent of 193 Routemaster buses. The immense lift capacity was required to lift the huge pieces of each tower section into place, weighing up to 68 tonnes each.

The Emirates Air Line has also achieved another first – appearing on the London Underground Tube map. It is the first time in the Tube map’s 78 year history that a commercial brand has been able to put their name to a transport link and station as a result of a partnership with Transport for London (TfL). The map highlights how the new scheme will integrate into the wider transport network by providing an additional step free access interchange between the Jubilee line and the Docklands Light Railway (DLR) - two key lines in east London.

The project team was immediately faced with some big challenges, the first being how they were going to construct the two main towers (both 86m tall and weighing 570 tonnes) to accommodate the river crossing and one smaller intermediate tower which measures over 65 metres in height and weighs 270 tonnes.

It is not only the size of the towers, and the fact that one had to be positioned in the River Thames, which made the construction so challenging, but also the need for exacting stability as a core requirement for the operation of the cable car. The design of the towers, using a complex helix structure to link the four steel ribbons assisted in providing this stability. The towers, made up of approximately 6,500 pieces of steel of varying thicknesses from 30 – 50mm ribbons shaped then welded together before being connected to helix tubes that run inside the tower and provide the required stiffness. The huge crane used to construct the south tower can be seen in ***photograph (2).***

Photograph (2)
The huge crane that was required for the construction of the towers

There are three main towers and two compression towers. The main towers support the system at height and the compression towers provide rope diversion from the stations to the head of the towers.

The towers were designed specifically for the project by an architect and structural engineers. The south tower can be seen in ***photograph (3)*** during construction along with the roller batteries waiting lifting onto the tower in ***photograph (4).***

Photograph (3)
The south tower post construction before the stringing* took place

*The cable car world call "roping" the installation "stringing!"

Photograph (4)
The south tower roller batteries on the floor prior to lifting onto the tower head

Three towers have been provided due to one of the engineering challenges being the need for a 51 metre tall ship to be able to pass under the system at high tide! The tide can vary up to 3.76 metres during its twice daily phase. HMS Ocean, one of the UK's largest warships, is the largest vessel that has been under the installation having been in London to provide security during the Olympic Games.

The only way the line could be maintained at a height to meet the tall ship criteria was by introducing a third tower. The towers are 86 metres tall and their baby sister (the north intermediate tower) is 65 metres.

Another challenge faced by the project team was how it was going to pull the cable between the terminals via the towers over the Royal Victoria dock and the River Thames. This has constituted a highly complex and intricate part of the construction of the landmark project.

Each tower has been topped with a Doppelmayr ‘head’ (named after specialist cable car contractor Doppelmayr) which allows the cabling to run across the tops of the structures. The cable, made of twisted steel comprised of 300 separate strands of steel and is 50mm thick, stretches 1.1km across the river. Boats were used to make the initial rope connection during the short night time window when the tide was at its lowest, working with the Port of London Authority to keep the river clear, and this was eventually replaced with the cable itself. The cable was pulled into place and tensioned using a 12-tonne winch located on the platform of the South Terminal (Emirates Greenwich Peninsula). The cable was clamped and secured at each terminal and tensioned to gain a minimum clearance of 54m above the mean high watermark.

The system has a traction sheave and a return pulley/diverter sheave (bull wheel) which is tensioned in a similar fashion to an escalator step chain. The return pulley/diverter sheave (bull wheel) can be seen in ***photograph (5)***

Photograph (5)
The main “bull wheel”* and tensioning system in the south station.

*The cable car world call “diverters” by the name “bull wheels”. The bull wheel is large as it acts as a spanning sheave setting the width apart that the lines run

Once the cable had been tensioned to the correct height, the next step was to carry out the rigorous testing and commissioning process for the whole system.

Another engineering challenge faced by the team was the fact that we had to be wary of the flight path into the nearby London City Airport. The lower end of the emergency approach into the airport is 110 metres only 23 metres above the top of the south tower.

The designers also had to be aware of the potential for an out of control vessel to strike a tower causing damage to the system and potential risks. Whilst the risk was assessed as incredibly low a ship impact system has been employed to divert any risk away from the towers. The south tower has been constructed in the main river itself which again presented challenges.

The construction programme was another challenge faced by the team. Construction started in July 2011 and the completed project was handed over on June 28th 2012 a little over 10 months. This is an incredible achievement given the design and constructions issues that the team faced.

After the design stage construction issues also had to be faced!

The UK has had its worst period of inclement weather since records began! It has, on most days, been pouring down with rain and there was also a period of snow!

One of the major time consuming construction issues was the fact that the bed of the River Thames was found to be unstable. Whilst this was no surprise given the exploits of Isambard Kingdom Brunel when he was building the East London Foot Tunnel in the early 1800's in discovering that this was the case it wasn’t anticipated that the problem would be some 30 metres deeper than expected!

Nevertheless the project was completed before the start of the Olympic Games. The newly delivered cabins still in their protective coverings can be seen in ***photograph (6)***

Photograph (6)
The new cabins in the garaging section at the south station with their protective coverings awaiting their inaugural run over the Thames

Another challenging issue was designing the system such that all passengers could be retrieved from the system in a timely manner in the event of failure. The design is such that there is a huge amount of redundancy and system support including an innovative emergency bearing system which has been incorporated in case of a bearing failure on the main traction and tensioning sheaves. The bearing design was developed specifically for this project and is the first time that it has been used although the success of the design means that it will be adopted on future cable car projects around the world.

OPENING DAY

A truly magnificent piece of infrastructure that will provide London with an aesthetically pleasing way of moving significant numbers of people for years to come. It is understood that on Saturday 11th August the system moved over 32,000 passengers in one day and we feel it is worthy of recognition.

Following the rigorous testing process, the Emirates Air Line was opened by the Mayor of London. Boris Johnson on 28 June 2012 – one month before the Olympic Games opening ceremony and just 12 months since construction commenced on site. The system is fully accessible to passengers in wheelchairs or with bikes, as well as parents with children in pushchairs. Our first wheelchair bound passenger can be seen in ***photograph (7).***

Photograph (7)
The first mobility impaired passenger using the system