

INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH  
TECHNICAL VISIT TO PEAK TRAM ON 1/12/2018



Institution of Mechanical Engineers Hong Kong Branch visited Peak Tramways Co., Ltd. on 1/12/2018

**The Call for Change**

Peak Tramways Co., Ltd. has proudly served Hong Kong for 130 years since 30/5/1888. The always long queue outside the Lower and Upper Termini in St. John's Building on Garden Road and The Peak Tower respectively for taking the Peak Tram between Central and Victoria Peak is the evidence of Peak Tram popularity among the local residents and foreign visitors of Hong Kong. The current fifth generation of the Peak Tram system, commissioned in 1989, has exhausted its capacity and, to meet the current and projected continuously growing patronage in future, as well as improving the passenger experience, Peak Tram is going to upgrade its entire operations with receiving its sixth generation funicular system.

The most significant change of the upcoming next generation of Peak Tram is the use of longer tramcars to increase the passenger capacity. The current fifth generation tramcar pairs, "Green Car" and "White Car" in 18.7 m length, can each carry 120 passengers and a driver, while the future 33 m long "Green Car" and "White Car" will be able to take 210 passengers and a driver. The higher capacity means that they will be longer and heavier, and hence the existing haulage and control system will be replaced with upgraded new one. Also, the track foundation and crossing bridges will be strengthened, and the existing Lower Terminus will be extended.

## **Termini Upgrades**

In conjunction with the increased capacity, another major objective of the system upgrade to the sixth generation is to improve the patrons' experience of using Peak Tram before boarding. Currently, not only is the queue at both Lower and Upper Termini is long on most weekends and public holidays and the queuing time can be as long as two (2) hours, as many as 1,300 passengers may queue for using Peak Tram in peak hours, inside and outside Lower Terminus can at most accommodate 420 and 450 queuing passengers respectively, leaving the rest has to wait outside the Lower Terminus and expose to weather. The queuing environment at Lower Terminus as such is less than satisfactory.

Simultaneously, while the existing platform in the Lower Terminus is too short to accommodate the longer sixth generation tramcars, the existing platform is unable to be extended because the track bends right outside the platform. The only solution is relocate the Lower Terminus platform to the nearest available straight track section, which will result in the Lower Terminus platform positions uphill of its existing location inside St. John's Building.

While the Lower Terminus locates in a highly congested sloped part of Hong Kong, surrounded by the listed 1916-built Edwardian Classical Revival style Helena May Institute building, St. Joseph College in where the recently deceased 2009 Noble Prize in Physics awardee, Charles Kao, used to study, and the Garden Road flyover pillars, the optimised arrangement will be the new 29.9 m long, 90 m<sup>2</sup> Lower Terminus platform situates about 42 m uphill from its original position and above an existing 2.4 m wide culvert. The original platform will be converted into a 70 m<sup>2</sup> waiting area and linked to the new platform and its attached 60 m<sup>2</sup> waiting area by a 27 m long moving walk at 12 degree gradient. The total 130 m<sup>2</sup> covered and air-conditioned waiting area will accommodate 1,300 passengers, completely removing the queues from the public area outside the Lower Terminus and reducing the waiting time at the Lower Terminus by 80 % from the current level. The future platform will be benefited from the optimised human flow with the aid of passenger flow modelling in the design of the platform, facilitating the achievement of 1.5 minute boarding time per trip and 7.5 trips per hour.

The Lower Terminus relocation will result in use of additional land. The government has agreed to grant Peak Tram the use of 101,634 m<sup>2</sup> unallocated government land between the existing tramway area and Helena May garden as well as 124,724 m<sup>2</sup> between the existing tramway area and Tramway Path nearby.

In addition, the upgraded Peak Tram will improve the access convenience for the disabilities. The new tramcars will be equipped with wider doors allowing roll-on and roll-off at all eight (8) doors, with wheelchair fixings at each gangway. As far as the Lower Terminus is concerned, a wheelchair lifting platform will be installed, the access ramps from the nearby Tramway Path will be provided for boarding and alighting, and the access paths from the main entrance, which will also be retrofitted with the water fountain removed and converted into the main entrance with an open space for displaying significant public artwork pieces, will be available. The existing static display of the haulage system in 1956 there will be vivified with projection mapping.

For the Upper Terminus, although it is not subject to relocation as the Lower Terminus because it has located at the end of the straight section of the track, it will also be revamped to improve passenger experience. The waiting area will be enlarged and the Control Room will be relocated from the existing boarding platform to the alighting platform in order to vacant more waiting space for the boarding passengers as well as improve the staff access to the Control Room. These will result in the complete removal of the queues in the public areas outside the Upper Terminus and reduce the waiting time by 93 % of the current level.

An exemption is, however, the termini platforms are unable to be fully levelled. This is necessary in order to maintain tension on the haulage rope prerequisite for the haulage of the tramcars. Such arrangement has been understood and accepted by the disabilities associations in Hong Kong with which Peak Tram has closely liaised.

### **The Tramcars for Future**

The new 33 m long tramcars are still under detailed design by the Swiss supplier. While the current modern-classic appearance will be retained, the new tramcars will significantly improve from the current fifth generation units.

Following the Peak Tram convention, the new tramcars will be equipped with no air-conditioning units. Instead, natural ventilation by means of opened windows optimised by computational fluid dynamic studies will be utilised to bring the passengers connection with the nature in the short ride uphill and downhill. The current bench seating arrangement is being reviewed. Various seat designs for improving seating comfort are installed on the tramcars before 07:00 for trail. Also, the tramcar operators are closely consulted in optimising the design of the driver cabin with a full scale mock-up of the future tramcar, tilted at 27 degree to simulate the steepest section at the May Road stop.

### **Haulage Breakthrough**

The current haulage system, controlled by programmable logic controllers, is the late 1980s technology and the speed variation of the Haulage Drum and hence the tramcars is attained by controlling the direct current (d.c.) haulage motor. The 510 kilowatt (kW) d.c. power is generated by a 545 kW d.c. generator which couples with a 560 kW alternative current motor. The conversion of 380 volt (V) a.c. power supplied by The Hongkong Electric Co., Ltd. to variable d.c. voltages for haulage by motor-generator set is energy inefficient, noisy and not maintenance-friendly. The new haulage system will be equipped with dual tailor-made variable voltage and frequency (VVVF) motors, which convert a.c. power into shaft power in variable speed directly.

Due to the limited Haulage Room space, the dual VVVF motors are unable to be arranged laterally with the same axis of the gearbox and the Haulage Drum. Instead, they will be perpendicularly coupled to the driving axis of the gearbox and the Haulage Drum, each delivering power of equivalent to the haulage speed of 4 m/s. Upon both VVVF motors yield their full strength, the gearbox will transmit shaft power for the maximum tramcar speed of 8 m/s. This arrangement provides

redundancy of haulage capacity, warranting the system can provide minimum 4 m/s of haulage capability even in the unlikely case of one (1) motor fails. In comparison with the current configuration of the haulage train is powered by a single d.c. motor, the system operation reliability is improved.

The Germany-made galvanised Haulage Rope for the current fifth generation tramcar is 41 mm in diameter. In spite of endowed with safety factor of 8, it is duly lubricated in accordance with the original equipment manufacturer advice in order to maintain its fitness across its service life, and replaced every three (3) years. The same replacement interval will be inherited by the upcoming sixth generation system, while its Haulage Rope diameter will be increased to 55 mm.

The current track gauge and length of 1,575 mm and 1,360 m respectively will be inherited by the new generation, except the existing rails will be upgraded to UIC60, which is the same as the current metro and heavy rail systems adopted in Hong Kong. The existing nine (9) bridges and the track foundations have been surveyed adequate for the future heavier tramcars and rails, after structural strengthening.

### **Track Changes**

“Green Car” and “White Car” travel synchronously. Although they come towards each other when they depart from the termini, they never collide because they pass each other on their dedicated track in the passing loop. The double flanged wheel on the hill-side of “White Car” guides “White Car” to use only the hill-side track in the passing loop. The “Green Car” setting is the exact opposite of “White Car”. Its double flanged wheel is on the sea-side which guides “Green Car” on the sea-side track only in the passing loop. The other wheel of both “Green Car” and “White Car” is flat to permit free cross-over of tracks. The same track configurations, as well as the existing 1,575 mm gauge, will be inherited by the new generation Peak Tram.

However, the relocation of the Lower Terminus platform will result in the use of shorter Haulage Rope and the tramcars will pass further uphill than the current condition, leading the centre point of the passing loop will be further uphill. Also, the new tramcars will be longer in length, and so is a longer passing loop required. The result is as part of the upgrade, the government has granted 45 m of the unallocated government land along the existing passing loop for the extension of the passing loop for the upgraded Peak Tram.

The wheels of the current fifth generation of tramcar are directly mounted on the chassis and the suspension is relatively basic. The new generation of tramcars, however, will use bogies to house the wheels and suspend the tramcars effectively. The vibrations from the rail-wheel contracts will be duly filtered, improving the cabin and hence passenger comfort.

Currently the Drive Station locates at the edge in the Upper Terminus boarding platform. The next generation Peak Tram will have the Drive Station, possibly with double control panels installed, relocated to the inner end of the alighting platform in the Upper Terminus.

### **Change by Phase**

The project of upgrading Peak Tram will commence in the fourth quarter of 2018. Upon the second quarter of 2019, Peak Tram will be subject to the first service suspension, whereby the Lower Terminus platform will be relocated to the new site temporarily, enabling the existing Lower Terminus to be reconstructed. Passengers will be queuing along Tramway Path sheltered by awnings similar to those currently used at Upper Terminus, while mobile foldable marquees will be provided to cover a dedicated queue zone, improving the passenger waiting environment.

The temporarily arrangements will operate until the second service suspension in the third quarter of 2020, when the entire Peak Tram operations and service will be suspended. The whole haulage and control systems and the tramcars will be replaced new altogether, as well as the Lower and Upper Termini, bridges and the civil foundations will receive upgrades, improvements and reinforcements until the first quarter of 2021, when the sixth generation of Peak Tram will be complete and open for service.

Across the first and second service suspensions, the Peak Tower at the Victoria Peak will remain open to visitors.

### **Remarks**



After the upgrade, the Peak Tram championship of the important tourist and recreational facility in Hong Kong will be enhanced. The current fifth generation system has served Peak Tram for 29 years, and the time to farewell it has come. Institution of Mechanical Engineers Hong Kong Branch (IMechE-HKB) was privileged to visit the fifth generation system for the last time and have a glimpse of the sixth generation delivered by Engineering and Operations of Peak Tram, which is responsible for all the engineering and operations of St. John's Building, Peak Tower, tramcars and their haulage, ticketing, tracks and civil establishments, on 1/12/2018. Very soon, Hong Kong will present its famous Victoria Peak with a brand new funicular system, a contribution of mechanical engineering for the better experiences for the tourists.

Mr. Chiu-Fai Kwan, Engineering & Operations Senior Manager (far left), Mr. Ray Chan, Director of Engineering & Operations (left) and Mr. Mark G. Lomas, Project Director jointly received the appreciation from IMechE-HKB

The organiser wishes to express the whole-hearted appreciated to Mr. Ray Chan, Director of Engineering

& Operations, Mr. Chiu-Fai Kwan, Engineering & Operations Senior Manager and Mr. Mark G. Lomas, Project Director of Peak Tramways Company, Limited for their generous hospitality.

Detailed description of the fifth generation Peak Tram systems and operations may refer to <https://nearyou.imeche.org/docs/default-source/Hong-Kong/20181201184b20ea83c06d3085eeff00007c07dd.pdf?sfvrsn=0>.

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# Peak Tramways Co., Ltd.

The current fifth generation of Peak Tram has been serving Hong Kong since 1989. Before it is replaced by the next generation of Peak Tram in 2021, IMechE Hong Kong Branch is privileged to be offered an opportunity to pay it a technical visit for the last time. Let us farewell our 29 year old friend of mechanical engineering in Hong Kong.

**Time:** 09:00 to 12:00  
**Venue:** Peak Tram Terminus in St. John's Building,  
33 Garden Road, Hong Kong

For details and enrolment, please visit IMechE webpage:  
<http://nearyou.imeche.org/near-you/north-east-asia/hong-kong/events>  
Only the successful applicants will be informed