DOUBLE DECK ELEVATORS – A REAL SOLUTION?

BY SIMON RUSSETT

by Simon Russett, Principal of Hoare Lea Lift Engineering

Introduction/History

Ever since humans first looked to the skies, they seem to have felt an inherent need to create tall structures in which to live, work or pay homage to their chosen gods. In the last 5000 years there have been a number of large masonry buildings constructed throughout the world as temples, places of rest, or for protection, for example the Pyramids in Egypt, Anchor Watt in Cambodia and Machu Pichu in South America.

Such buildings obviously had no means of mechanical vertical transportation! This came about in the late 19th century, when Elisha Graves Otis invented the first safe elevator and demonstrated this at the Institute Fair in the Crystal Palace, New York City, in 1854.

This invention, along with new building techniques using steel, ushered in a generation of high rise structures such as the Chrysler Building, the Empire State Building and the Eiffel Tower. All buildings constructed up to 1930 used conventional single deck (SD) cars arranged to serve building zones. Otis Elevator Company pioneered an invention using two cars contained within a common sling and, in 1931, installed eight ‘double-decker’ elevators with attendant operation in New York City’s 66 storey ‘Cities Service Building’. The upper car provided service to the even floors and the lower car served the odd floors. The application of this technology to this building was not wholly appropriate as the lower deck was meant to serve a subway station, planned for the basement. The subway was never constructed and eventually it was discovered that using only the upper cars to serve all floors was sufficient to handle the passenger traffic!

Double deck elevators (DD) can be compared to railways. These move large numbers of people horizontally using common connected carriages with a single drive system - double deck elevators use the same principle by creating vertical trains with double stacked cars. DD elevators comprise two passenger cars, one located above the other, connected to one suspension and drive system. The lower and upper decks can serve two adjacent floors simultaneously and during peak periods the decks are arranged to serve `even’ and `odd’ floors.

Since 1930 there has been a steady increase in the demand for DD elevators as buildings became taller and more complex. During the 1960’s a new dawn rose in North America that coincided with new found prosperity and some of the tallest buildings in the world were designed. For example the 110 level Sears Tower in Chicago, completed in 1973 was the first building to use sky lobbies with DD elevators and local SD elevators. These mega structures required a new approach to people movement and it is during this period that DD elevators came into their own.

Sears Tower, Chicago.

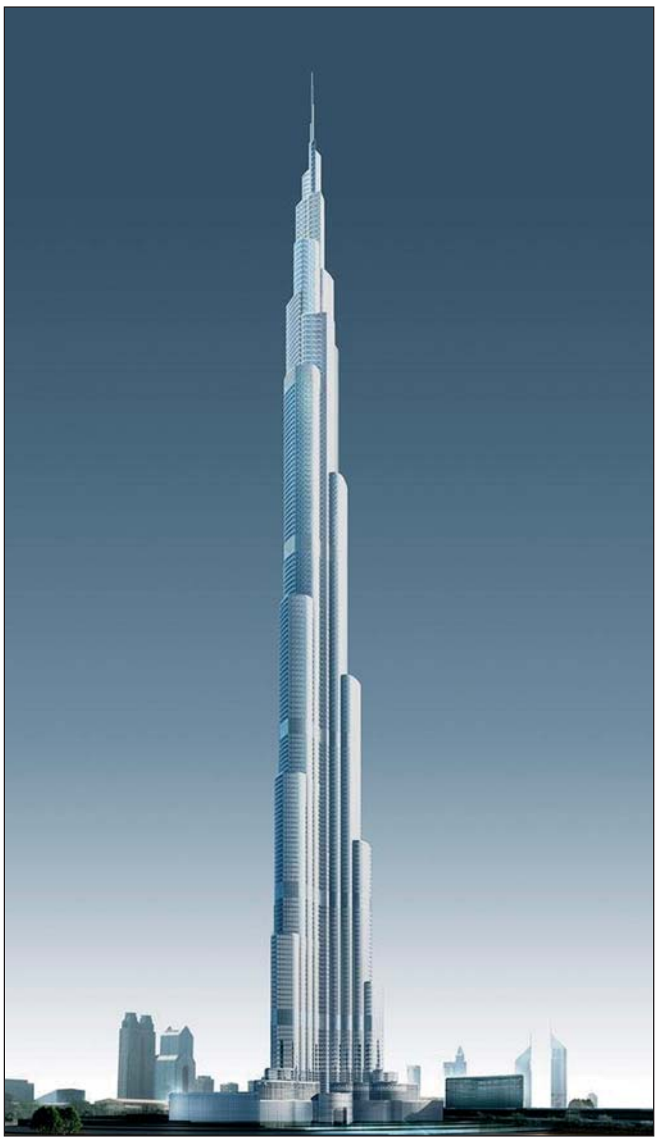
The first buildings with all DD local elevators and a single zone of DD shuttle elevators were the twin 88 storey Petronas Towers in Kuala Lumpur, completed in 1997 by Otis. The same technology was used on the 88 storey International Finance Centre (IFC)

Petronas Towers, Kuala Lumpar.

BY SIMON RUSSETT

Tower in Hong Kong, completed in 2004 also by Otis. The first building with all DD local elevators and dual zone DD shuttle elevators was the 101 story Taipei Financial Center, completed in 2004 by Toshiba. This 508 metre high building became the worlds tallest, breaking the half kilometre mark. It also smashed the record for high speed elevators from 12m/s to 16.8m/s. This equates to a vertical top speed of just over 60km per hour. The tallest building crown will soon be worn by the mixed use residential development called the Burj Dubai, which is estimated to be over 700m when completed and contains two DD elevators at 10m/s, as well as a number of SD elevators.

International Finance Centre (IFC) Tower, Hong Kong.



Burj Dubai.

Taipei Financial Center.

BY SIMON RUSSETT

Europe/North American model

Globally there are around 650 DD elevators in circa 50 buildings. When compared to the near 6.5 million elevators in operation today (see image global elevators), DD elevators account for only 0.01% of the global elevator market and are only used for high rise buildings. Otis supply approximately 80% of global sales; other suppliers are Kone, Mitsubishi, Schindler, Hitachi and Toshiba.

The Nat West Tower, now Tower 42, UK.

DD lifts are relatively common in the USA, Asia and China. Although Europe has over 50% of the world's elevators, it has only 24 DD elevators in six buildings. The first DD system in the UK was installed in what was the Nat West Tower, now Tower 42, by The Express Lift Company. The tower was provided with Five DD elevators, as well as a number of SD elevators.

In London there is around 86M square feet of occupied commercial space. New commercial offices are in demand and pressures on space means buildings are getting taller. If the market necessitates buildings of more than 35 storeys, then DD elevators may offer a solution to the problem of vertical movement.

The North American model is largely used in buildings of around 100 storeys with SD local elevators and DD elevators acting as shuttles to sky lobbies. It seems unlikely this model will fit the UK or Europe; generally because few buildings in Europe are this

Broadgate Tower.

BY SIMON RUSSETT

high – most are likely to be between 30 - 60 levels. In the UK it is likely DD elevators will be used as the passenger elevators – not as shuttle elevators. For passengers, the experience will be the same – they will not necessarily be aware they are travelling in a DD elevator.

DD elevators have been designed as the primary source of vertical transportation for a number of tall buildings planned for London, for example British Land's Broadgate Tower, Gerald Ronson's Heron Tower, Sellar Properties London Bridge Tower, Land Securities Blackfriars Bridge Tower and DIFA's Bishopsgate Tower. If these projects are constructed the number of DD elevators in the UK looks set to increase to circa 50 units over the next 5-10 years, tripling the number of DD installations in Europe.

London Bridge Tower.

Heron Tower.

Bishopsgate Tower.

BY SIMON RUSSETT

Advantages/Limitations of Double Deck Elevators

The real benefit of the DD elevator is that while people can be transported in the same time as SD elevators, the required shaft area is reduced. The ratio of cars is around 2:3, so 8 SD cars will become 5 or 6 DD cars. The rule of thumb for DD to operate efficiently is a zone of around 15 to 18 levels for each group, though this is wholly dependant on the building layout. Care has to be taken when selecting elevator systems for specific buildings as in some cases the technology may not be appropriate. For DD elevators to work efficiently it is necessary to have a floor area in excess of 2000m^2 to ensure a balanced demand and a high level of coincidence for people travelling to consecutive levels. This can be calculated using software such as Elevate (from Peters Research) to determine a figure of merit. The results can then be checked using the Elevator Handbook (Barney 2005) to determine if DD elevators provide an effective solution.

Passengers are guided to escalators; from here they can select the correct deck to travel to, either even or odd floors. As soon as an elevator stops to answer a call from an upper floor, car calls to any destination floor are admitted. A well-known approach in serving landing calls is that the landing calls are allocated to the trailing deck. The leading deck serves the calls that are coincident with the stops of the trailing car. A more efficient solution is to choose the landing call to the best deck. Modern DD elevators employ sophisticated controls to ensure the best elevator deck is selected to minimise passenger waiting times, journey times and the number of stops each elevator makes. When travelling up, the lower deck answers up hall calls and when travelling down the lower deck answers down hall calls.

Modern control systems, such as Hall Call Allocation (HCA) do away with the problems associated with people deciding their destination when inside the car as this is entered on a touch screen in the lobby. The destination requests are personalised and then grouped into stacks of floors for vastly improved operational efficiency. HCA also eradicates the disadvantages for passengers during off peak periods when one deck may stop for a call with no coincident landing or car call on the other deck. It also does not required CCTV cameras and display screens in both cars to view loading conditions.

The majority of DD installations in the UK will utilise HCA controls and some, such as Heron Tower, designed by Kohn Pederson Fox even have glass DD cars! (see scenic DD for reference, as this is not from Heron).

Some examples of scenic DD lifts.

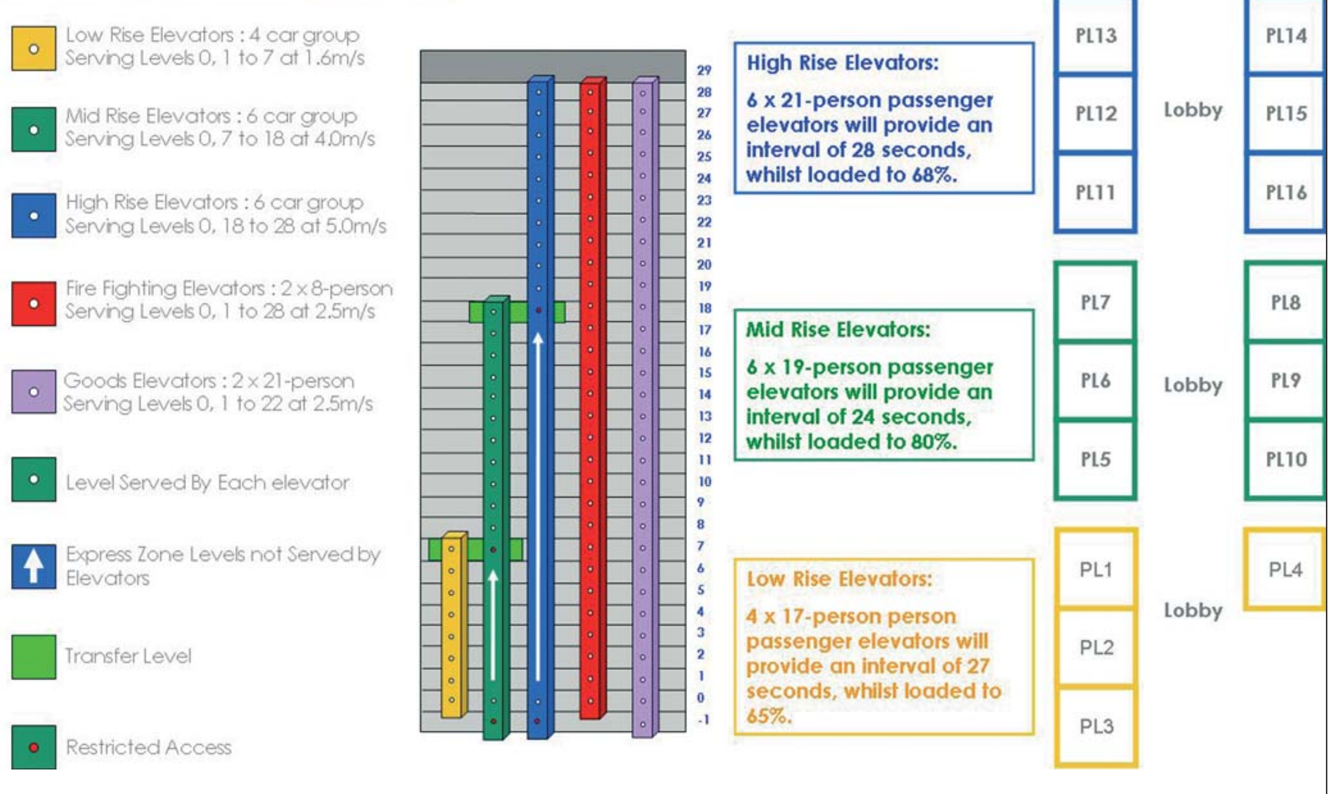
Case Study

Recently I was involved in the design of new vertical transportation (VT) systems for an existing tower in Victoria. This tower consisted of 27 levels and provided around 280,000ft^2 of office space. The building refurbishment was to provide 440,000ft^2 by the addition of up to three high levels and by extending the facades. The existing VT systems consisted of two 6 car groups serving high and low zones. The increase in office space would render the performance of this configuration unacceptable. To overcome this problem numerous solutions were reviewed:

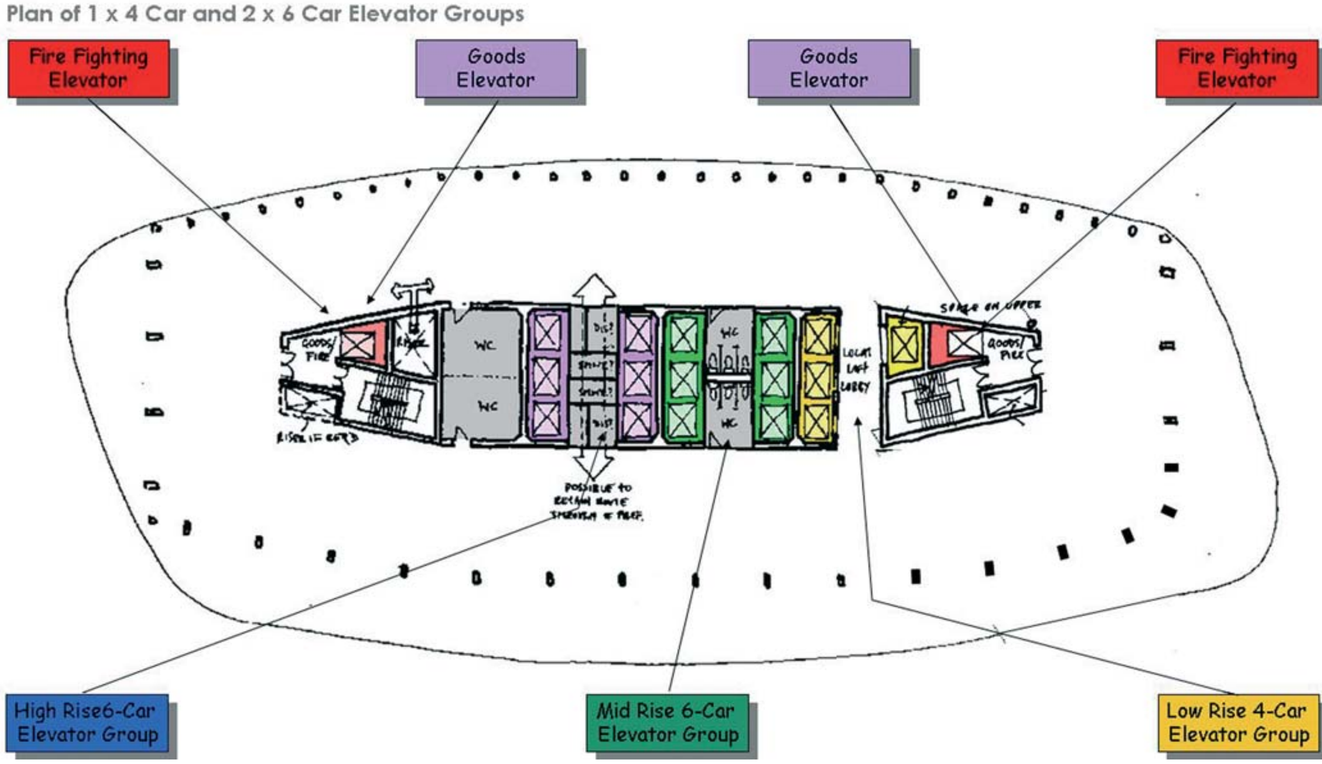
1. Retain the existing 12 shafts and include 4 new shafts. This would provide low rise, mid rise and high rise systems capable of achieving BCO performance. The obvious problem was where to locate the four new shafts and the loss in NIA. (see low mid and high rise images 1 & 2).
2. Provide low, mid and high rise systems and improve system performance with HCA control systems. This still necessitated the same systems, but only reduced the low rise group to three. HCA controls work most efficiently in the up peak mode but not as efficiently during the two-way and down peak modes.

BY SIMON RUSSETT

5.1 1 x 4 Car and 2 x 6 Car Elevator Groups



Plan of 1 x 4 Car and 2 x 6 Car Elevator Groups



BY SIMON RUSSETT

3. Retain existing shafts and provide double deck passenger elevators. The analysis resulted in the provision of four low rise and four high rise double deck elevators. With a 77% figure of merit for coincidence of calls, this achieved BCO performance requirements. This option gave back two shafts in each group and these shafts could then be used to accommodate two new goods elevators as the building only had minimal provision.
4. To overcome the problems with simultaneous loading of the upper and lower decks, escalators were required to serve between two lobby levels. To ensure compliance with the Disability Discrimination Act (DDA), two shuttle elevators were also required between the loading levels and conveniently, two shafts were also available for use (see double deck group images 1 and 2). Interestingly, the shaft area above the shuttle requirement could then be used for M&E services risers.

This case study demonstrates some key advantages double deck elevators can offer. For example a reduction in the use of core space, the installation of fewer lifts and space being made available for other services. The general principles can also be applied to new projects.

It also shows some possible limitations. Main access areas need to be increased in size to accommodate escalators and shuttle elevators to achieve compliance with the DDA. Appropriate signage to ensure passengers are guided into the correct deck to reach their required destination must also be considered. As discussed earlier, HCA controls do go along way to alleviate these problems.

When comparing DD against SD elevators it is of course important to consider financial implications. It is widely understood that DD are up to twice the capital cost of SD elevators. Whilst fewer DD cars are required to achieve the same performance requirements as SD cars, it is not half as many. DD elevators are therefore a more expensive solution. However the spatial saving made will be attractive to building owners as increased office space will mean increased revenue over the life of the building. The annual maintenance costs are lower for DD than a SD solution and the journey times during up peak will be less than SD, due to the reduced number of stops. This reduction in stops also relates into energy saving.

Modern DD elevators can also overcome the standard set of objections and concerns, such as those listed in the table below:

Conclusion/The Future

At present there are approximately 250,000 lifts in UK and only two double deck elevators. When considering the buildings planned over the next 5-10 years it seems likely another 50 units could be installed. This is a huge increase and the UK alone will represent around 7% of the global market in DD elevators.

Problem	Old Solution	New Solution
Uneven floor heights.	Odd floor heights require both decks to stop.	Articulating platforms (Otis SDD) provide for a maximum 2.0m in floor to floor height variations.
Main lobbies odd/even floor selection required for dispatching.	Must be selected.	Hall Call Allocation (HCA) at elevator lobby entry provides proper deck selection and no odd/even dispatching required.
Top floor in zone cannot be served by bottom deck.	Requires 1 floor of extra over travel for this to happen.	HCA always assigns top floor hall call to top deck.
Other deck loading activations, i.e. one deck is loading/unloading while the other is not.	“Other Deck Loading” message on alternate car display. In car CCTV cameras display on alternate cab screens.	Almost never occurs as HCA system assigns passengers to contiguous floor stop decks only.
Double deck floor dispatching only required during morning up-peak condition.	Can only be switched on and off for scenic cars as no other alternate dispatch displays are available.	HCA at elevator lobby entry provides seamless dispatching and reverts to single deck operation (normally upper deck dispatching) during non-peak times.

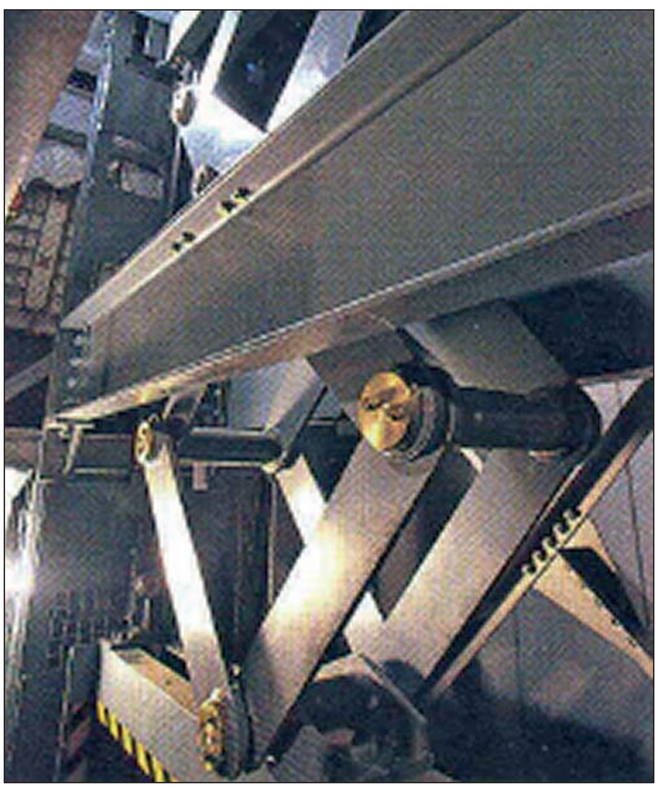
BY SIMON RUSSETT

These installations will differ from the US model. The European model is likely to see DD elevators acting as the main VT systems, rather than as shuttles. This is similar to the Asia Pacific model where buildings such as Petronas Towers, IFC Tower and Taipei 101 use DD cars for shuttle and local elevators.

Looking to the future, other developments relating to DD technology include the Thyssen Twin System that enables two cars to operate independently in a single shaft, with separate drive systems. This technology was designed in the 1930s but only became a commercial reality in the current millennium through developments in control techniques, such as HCA. There are a number of Thyssen Twin installations either underway or planned, such as the Federation Towers in Moscow. At 340m this development will be the tallest building in Europe and all but two of the elevators are Twin cars. It was essential this technology was used at the Federation Towers, as DD and SD cars would have rendered the net to gross efficiency rather poor and the building would not have proceeded.

Otis has developed a system called 'Super Double Deck' that allows a maximum extension between the upper and lower cars of up to 2m. DD cars can then serve floors with varying heights, without requiring both decks to stop. This system is driven by a ball screw and helical gear and the pantograph joint provides smooth precise control with minimum weight and space penalties. Nippon Otis first installed super double-deck elevators in 2004 in the 54-story Mori Tower, a building in Tokyo's Roppongi Hills complex with irregularly spaced floors.

The Federation Towers, Moscow.



'Super Double Deck' from Otis.

The global threat of terrorism does not appear to have impacted on the demand for tall buildings and our insatiable need to build taller remains intact. It seems likely that DD installations and the technologies developed to improve performance will one day achieve Frank Lloyd Wright's mythical 'mile high' building. ❑