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How Vertical Transportation is Helping Transform the Modern City
垂直交通如何改变了现代城市

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通过参与澳大利亚房地产理事会，维多利亚州建筑工程上诉委员会以及澳大利亚建筑规范审查小组的工作，格林对澳大利亚的建筑业作出了积极的贡献。

Abstract

Elevators are the most important service in modern high-rise buildings, occupying more space than any other service. With increasing land and construction costs and the need to be economically sustainable, the pressure to increase building floor areas grows each year.

Advances in technology have enabled elevators to develop from early speeds of 0.2 m/s, to today's high speed elevators which can reach speeds faster than 16 m/s, allowing people to move vertically more efficiently.

This paper discusses the technologies developed which can improve elevator services, minimize building cores and increase building efficiencies while meeting the demands of architects, developers and occupants.

Keywords: Elevator, Double-Deck, Building Efficiency, Hall Call Allocation, Regenerative Drives, Twin.

摘要

现代高层建筑中电梯是最重要的服务设备。与其他设备相比电梯占据了最多的空间。随着土地及建筑成本的上升和经济上可持续发展要求的增涨，增加建筑楼层使用面积的压力逐年增加。

技术进步使电梯从早期每秒0.2米的速度发展到今天每秒16米以上的速度，大大提高了人们垂直移动的效率。

本文将讨论如何利用发展至今的技术提高电梯的服务水平，减少建筑核心筒的面积，增加建筑节能效率，同时又满足建筑师、开发商和住户的要求。

关键词: 电梯，双层轿厢，建筑节能，门厅呼梯分配，再生驱动器，一井双梯。

Introduction

In 1851, Elisha Otis was a factory manager and part-time inventor working for Maize & Burns in Yonkers, New York. Given the task of moving debris from the ground floor to the upper level of the factory, he thought of using a hoisting platform, but realized they were unreliable and often failed. Otis invented a safety device which prevented the platform from falling if the rope failed, making the task safer.

Initially, Otis thought very little of his invention. Back then, he couldn't have imagined the influence his safety device would have on the development of the elevator and its role in allowing the construction of tall buildings.

Since 1851, the world's population has increased by more than 6 billion people and is continuing to grow rapidly. Every year there is less area per person to live on making land more scarce and more valuable, and increasing the need to build taller.

介绍

1851年，奥的斯•以利沙是纽约扬克斯美姿奔驰公司的一个工厂经理并兼职从事发明工作。在接到一项把瓦砾从工厂一楼运到上面楼层的任务后，他先想到了用升降平台，但发现他们并不可靠，而且常常出现故障。于是奥的斯发明了一种安全装置。这种装置能在绳索出现故障时防止平台掉落，提高了执行任务时的安全性。

最初，奥的斯并没想到这是一项发明。那时，他无法想象到他发明的安全装置对以后电梯的发展及其在高楼建设中所具有的影响力。

从1851年至今，世界人口已增长至60多亿。人口快速增长的势头仍在继续。人均占有适宜居住的土地面积每年在减少，这使得适宜居住的土地变得更加稀缺，更有价值，于是建造高楼变得日益迫切。

香港的发展显示了人口增长如何改变了许多世界上的大城市。1851年，香港人口约为33,000。图1为拍摄于1869年和1900年之间某个时间的香港中环的照片。图2是今

Figure 1. Central Hong Kong - 1869-1900 (Source: https://www.flickr.com/photos/andrewlyk1978/11135689446/)
图1: 1869年至1900年的香港中环 (来源: https://www.flickr.com/photos/andrewlyk1978/11135689446/)

Figure 2. Victoria Harbour Hong Kong - now (Source: http://www.worldpropertychannel.com/europe-commercial-news/london-is-most-expensive-office-market-cushman-wakefield-hong-kong-cbre-jones-lang-lasalle-global-office-markets-8013.php)
图2: 如今的香港维多利亚港 (资料来源: http://www.worldpropertychannel.com/europe-commercial-news/london-is-most-expensive-office-market-cushman-wakefield-hong-kong-cbre-jones-lang-lasalle-global-office-markets-8013.php)

Hong Kong provides an illustration of how population growth has shaped many of the world's major cities. Hong Kong had population of around 33,000 in 1851. Figure 1 is a photograph of Central Hong Kong taken some time between 1869 and 1900. This is contrasted with Figure 2 which is an image of the same area today, an area which is now estimated by countryeconomy.com to be home to more than 7.1 million people. Cities like Hong Kong have been able to continue to accommodate increasing populations by building upwards, with more tall buildings being constructed every year. Elevators have a major role in allowing access to tall buildings, on the development of our cities and the way we all live.

Every day there are more than 7 billion elevator journeys taken in buildings all over the world - the equivalent to the entire population of the world taking a daily journey in an elevator

Tall Buildings

With growing populations and increasing urbanization, the need for more people to live on less land makes the increasing construction of tall buildings inevitable. The continuing development of the modern elevator has been a major factor in the ability to construct and access tall buildings. Traditionally the technological advances in elevators have been increased speeds and improvements in elevator traffic control.

天摄于同一地区的照片。根据countryeconomy.com这一网站，该地区现居住着710万人。随着每年更多的高楼大厦被建造起来，像香港这样的城市能够容纳不断增加的人口。电梯使我们进出高楼成为可能，电梯对城市的发展和人们生活方式的变化都产生着重大影响。

每天全球有超过70亿次电梯旅程，这相当于全球每人每天使用一次电梯。

高层建筑

随着人口增长和城市化的进程，人均可占有土地在减少，更多高层建筑的出现将不可避免。现代电梯的发展成为推动兴建高层建筑的主要因素。电梯的技术进步一般表现在速度的提高和电梯交通控制方面的改进。

电梯速度

1857年，纽约百老汇488号安装了世界上第一台奥的斯电梯 (参见图3) 。它以蒸汽为动力，运行速度每秒0.2米。此后电梯速度不断提高，目前在台北101安装了世界上最快的电梯，它们能以每秒16.8米或每小时60公里的速度运行。

如果没有这些技术的进步，出入高层建筑将是不实际的。如果将运行速度每秒0.2米的电梯安装在台北101，假设电梯中途不停，到达最高层需要40分钟。而使用现代高速电梯，这一行程只需约37秒。

电梯速度一直是决定人们进出高层建筑难易程度的主要因素。但是客观上电梯的速度和加速度会受到某些限制。因此，为了使建筑物被有效使用，需要提高电梯在其他方面的性能。

电梯交通控制

电梯交通控制已经由坐在电梯里的人用手动控制发展到自动优化服务的控制系统。现代电梯采用先进的控制算法，如全面集体控制，动态分段和人工智能，使电梯使用更容易更高效。

近来一种称为门厅呼梯分配的控制系统被越来越多地得以应用。在用户把自己的目的地输入到安装在大厅的键盘后，这种控制系统会通过呼梯分配和目的地派梯，分派一部电梯带用户前往他们的目的地。这样，每位用户都能进入一部分派给他的电梯去他的

Figure 3. 488 Broadway (Source: http://commons.wikimedia.org/wiki/File:E.V._Haughwout_Building.JPG)
图3: 百老汇爱488 号 (来源: http://commons.wikimedia.org/wiki/File:EV_Haughwout_Building.JPG)

Elevator Speed

The world's first Otis elevator was installed at 488 Broadway, New York in 1857 (see Figure 3). It was steam powered and operated at a speed of 0.2 m/sec. Elevator speeds have increased progressively with technology to the world's current fastest elevators at Taipei 101 which are capable of travelling at a speed of 16.8 m/sec, or 60km/h.

Without these technological advances, access to tall buildings wouldn't be practical. If 0.2 m/sec elevators were installed in Taipei 101, it would take around 40 minutes to reach the highest occupied level, assuming the elevators didn't stop. The same journey in the building's modern high speed elevators takes around 37 seconds.

Speed has been a major factor in allowing people access to tall buildings, but there are practical limitations to elevator speeds and accelerations. As a result, development of other aspects of elevators will be the catalyst for further improvements in building efficiency.

Elevator Traffic Control

Elevator traffic control has evolved from early elevators which were manually controlled by an attendant seated inside each car, to modern controls which automatically optimize the operation of the service. Modern elevators use sophisticated control algorithms such as full collective control, dynamic sectoring and artificial intelligence to make elevators easier to use and more efficient.

A recent elevator control system being installed increasingly is hall call allocation. With hall call allocation or destination dispatch, users enter their destination at a keypad installed in the lobby, and the system assigns an elevator for them to travel to their destination. Each passenger then enters the elevator assigned to them for the journey to their floor.

With this system, elevator users with the same destination are grouped to the same car. As a result, each elevator car typically makes less stops through its round-trip journey, reducing the journey times and increasing the handling capacity of the service.

Hall call allocation controls provide improved performance and, in some applications, can reduce the number of elevators required in a building. Hall call allocation is effective in applications such as office buildings, where a high proportion of the buildings occupants require a service from the main foyer to their destination floor during peak times.

Energy Efficiency

Elevators can be significant energy consumers in buildings. Hutt, B. et al (2004) suggest that elevators consume between 5% and 15% of a buildings energy usage. Increasing the efficiency of the drive systems using modern drives can have a significant impact on the buildings carbon footprint.

Early steam powered, and hydraulic elevators consumed significantly more electricity than today's modern elevators. Modern variable voltage, variable frequency drives consume less than one quarter of the energy consumed by hydraulic motors.

Regenerating drive systems return the energy of an elevators downward journey back to the electricity supply, and can significantly reduce the overall elevator energy consumption. KONE estimate that their regenerative drives can return as much as much as 30% of the elevators energy consumption back to the grid.

目的楼层。

有了这个系统，目的地相同的乘客就被分配到同一电梯。电梯在其往返行程中减少了中途停梯，从而减少了每次载客所需的时间，增加了运客能力。

门厅呼梯分配控制系统提高了电梯的服务能力，在一些情况下，还可以减少建筑物内需安装电梯的数量。比如在办公楼里，大部分用户都是在同一个时段 (高峰时间) 要求电梯从一楼门厅带他们到目的地楼层，采用这种控制系统就很有效。

电梯节能效率

电梯可成为建筑物中的用电大户。B•赫特等 (2004年) 建议，电梯的耗电量占整个建筑物耗电量的5 %至15 %。使用驱动效率高的现代驱动装置可以显著改善建筑物的碳足迹。

早期的蒸汽动力和液压电梯比现代电梯消耗更多的电力。现代的可变电压，可变频率驱动器能量消耗不到液压马达的四分之一。

能源再生驱动系统会把电梯在向下运行中产生的能量返回到电力供应系统中，显著降低电梯的整体能耗。通力估计，他们的能源再生驱动装置可以将高达30%的电梯能耗回馈给电网。

巴尼 (2006年) 建议了一些提高电梯节能效率的实用方法，如在电梯不被使用时关掉电梯轿厢照明和辅助装置，在用梯需求低的时段，关停部分电梯。

能源通过以最短行程、最少停靠方式运送乘客的高效运输控制系统，结合现代的变压、变频驱动系统，以及实用的节能措施，正使得电梯的能效更高，可持续性更强。

建筑节能

随着土地价格及建筑成本的上升，提高建筑节能成为建造在经济上可持续的现代化摩天大楼的关键。这意味着需要降低建筑物核心筒和设备机房的面积来提高大楼的经济产出。

由于电梯占据最大的楼层空间，电梯设计的优化能给节省空间和提高效率提供最大的机会。在高层建筑中，仅仅节省一个电梯井就会对建楼的可行性和建筑节能有着显著影响。最新电梯技术能在减少电梯井的情况下仍保持电梯的服务水准，为提高建筑节能效率提供了更多机会。

双层轿厢电梯

双层轿厢电梯由连接在一起的两个轿厢组成，一个轿厢被安置在另一个轿厢的上面，使电梯能同时服务两个楼层。双层轿厢电梯需要一个二层高的主门厅，使乘客可以同时进入上层和下层轿厢 (见图4) 。

双层轿厢电梯已被使用了很多年。他们基于奇偶数服务的原理，由一个轿厢给奇数楼层提供服务，而另一个轿厢给偶数楼层提供服务。这要求楼梯或自动扶梯连接上下二个主大厅，让乘客可以在上下二个大厅之间移动以到达那个适合的大厅，进入去奇数或偶数楼层的轿厢。从历史上看，由于乘客对在上下大厅间移动不满，双层轿厢电梯已经失宠。另外一个双层轿厢电梯失宠的原因是很少会出现二个轿厢需要一起停止的情况。当电梯停在某一楼层时，一轿厢内的乘客离开或等在那一楼层的乘客进入这一轿厢，而另一轿厢内的乘客虽无需离开轿厢，也没乘客要求进入这

Barney (2006) suggested practical methods of improving lift energy efficiency such as: switching off lift car lighting and auxiliaries when lifts aren't being used, and shutting down lifts during periods of low traffic demand.

Control systems which transport passengers efficiently to their destination with a minimum number of journeys and stops, combined with modern variable voltage, variable frequency drive systems, and practical energy conservation measures are making elevators increasingly energy efficient and sustainable.

Building Efficiency

With increasing land and construction costs, the key to building a modern skyscraper that is economically sustainable is increasing the building efficiency, which means reducing the size of the building core and plant spaces to optimize the yield.

As the service which occupies the most floor space in a building; elevators provide the greatest opportunity for space savings and efficiency improvements. In tall buildings, saving just one shaft can have a significant impact on the building efficiency and the feasibility of the development. Recent elevator technologies offer further opportunities to improve building efficiencies by allowing the installation of less shafts while still achieving the same level of performance.

Double-Deck Elevators

Double-deck elevators comprise two decks attached together, one on top of the other, allowing the elevator to serve two floors at the same time. Double-deck elevators require a double height main lobby so that passengers can load the upper and lower decks simultaneously (see Figure 4).

While double-deck elevators have been available for many years, they have traditionally operated on an odd/even basis, with one of the decks serving the odd numbered floors and the other deck serving the even floors. This required stairs or escalators at the main lobby so that passengers could move between the upper and lower level lobbies to get to the appropriate main lobby for their destination floor. Historically, double-deck elevators fell out of favor because of passenger dissatisfaction with having to transfer levels at the main lobby and due to non-coincident stops. These are where the elevator stops at a floor to allow passengers of one of the decks to enter or exit the elevator while there is no one entering or exiting the other deck, even though it is stationary.

Figure 4. Double-deck Elevator (Source: http://ottawaphotography365.com/wp-content/uploads/2012/12/Blog-Posts-Photos-168.jpg)
图4: 双层轿厢电梯 (来源: http://ottawaphotography365.com/wp-content/uploads/2012/12/Blog-Posts-Photos-168.jpg)

一轿厢，但它仍要静止等待。

但是，如果双层轿厢电梯运用了门厅呼梯分配系统，乘客就可被分配到能最有效地带他们到目的楼层的电梯。知道乘客的目的楼层让系统能够战略性的分配电梯及轿厢给乘客，让乘客在上下层大厅都可搭乘电梯，提高了电梯的整体服务水平并最大程度地减少了不重合停止。

运用门厅呼梯分配系统，双层轿厢电梯提高了载客能力。采用这一系统既减少了占用核心筒的面积又能在一定时间内为大量乘客提供服务，提高了核心筒的使用效率。为了减少电梯井的总数，伦敦的布罗德盖特塔率先安装了运用门厅呼梯分配系统的双层轿厢电梯，这种电梯系统就是通力的双层轿厢目的地分派电梯。

一井双梯

蒂森克虏伯电梯开发了共用一井的双梯产品。图5显示了安装在德国法兰克福主三角大厦的一井双梯。

一井双梯是两个完全独立运行的电梯，每部电梯都有自己的机器，配重和导轨等等。一井双梯系统有多个安全装置，以保证两个轿厢在运行期间不会靠得太近。门厅呼梯分配是这些安全装置的一个关键组成部分，因为它可以把乘客战略性地分配在上面或下面的电梯轿厢，并确保两个轿厢在一个井内安全运行。

首选的设计是建一个双层高的主大厅，类似于双层轿厢电梯所需的大厅，使乘客能够同时进入上面和下面的电梯轿厢。一井双梯也可以在主大厅只有一层高的情况下工作。

采用一井双梯可有效减少办公楼，酒店及多用途高层建筑内电梯井的总数，同时保持同等的服务水平。

案例分析

下面的案例分析说明了在现代建筑中如何策略地使用这些技术去提高效率，并为我们带来益处。

案例1：澳大利亚墨尔本，里亚托南塔
里亚托塔是位于墨尔本柯林斯街上的高档办公楼。30年前迈进的工程师为这座地标性的建筑进行了创新的结构设计。这座建筑于1986年落成。如以屋顶为最高点，里亚托南楼 (见图6) 至今仍是澳大利亚最高的办公楼。

现有的里亚托南塔提供四个楼层段的电梯服务，共用了以下的20部电梯:

- 低层电梯 (服务楼层: 1楼至12楼)
- 中层电梯 (服务楼层: 12楼至24楼)
- 高层电梯 (服务楼层: 24楼至37楼)
- 超高层电梯 (服务楼层: 37楼至54楼)

另一种设计则是利用二排双层轿厢目的地分派电梯。在这种设计中，低层电梯的服务楼层是从2楼至30楼，需使用6部载重1800公斤的双层轿厢目的地分派电梯。高层电梯的服务楼层则从31楼至55楼，需使用6部载重1600公斤的双层轿厢目的地分派电梯。一个夹层电梯厅需被设置在主入口处。

图7采用双层轿厢目的地分派电梯的核心筒平面设计与现在的核心筒平面设计进行比较。

由以上设计所提供的电梯服务能够达到原设计电梯服务水平。然而，以上这种设计只需要12部双层轿厢电梯，而原来的设计共用

However, with the addition of hall call allocation to double-deck elevators, passengers can be assigned the most efficient elevator selection. Knowing each passengers' destination enables the system to allocate passengers to elevator decks and cars strategically, allowing passengers to catch their elevator service from either the upper or the lower lobby, improving the overall performance of the service and minimizing non-coincident stops.

Double-deck elevator cars boost the effective handling capacity of the system and provide the ability to allow a large number of passengers to reach their destination floor with a reduced number of shafts, providing more efficient building cores. This arrangement was pioneered in Broadgate Tower in London, where KONE double-deck destination dispatch elevators were installed to reduce the total number of elevator shafts in the building.

Twin

This product was developed by ThyssenKrupp Elevator and comprises two elevators within the same shaft. Figure 5 shows the Twin installation in the Main Triangel building, Frankfurt, Germany.

The two elevators are completely independent in operation, and each comprise their own machine, counterweight, guiderails etc. The systems are provided with a number of safety devices to ensure that the cars do not come too close together during operation. Hall call allocation is a critical part of these safety systems as it allows passengers to be strategically assigned to upper or lower cars and ensures that the two cars operate safely within the single shaft.

The preferred design arrangement is a double height main lobby similar to that required for double-deck elevators, to enable the passengers to simultaneously load the upper and lower cars. Twin can also operate with a single level main lobby.

Twin can effectively be used to reduce the overall number of shafts in a wide range of tall buildings such as offices, hotels and mixed-use towers, while maintaining an equivalent level of service.

Case Studies

The following case studies demonstrate how these technologies can be used strategically in modern buildings and the benefits and efficiency improvements which they can make possible.

Case Study 1: Rialto South Tower, Melbourne Australia

The Rialto Towers are premium grade office towers located in Collins Street, Melbourne. Meinhardt engineers undertook the innovative design of the structure of these landmark towers over 30 years ago, the construction of which was completed in 1986. The Rialto South Tower (see Figure 6) remains the tallest office tower in Australia when measured to its roof.

The existing South Office tower utilizes 4 passenger elevator services, comprising a total of 20 passenger elevators as follows:

- Low rise elevators (serving L1 to L12)
- Mid rise elevators (serving L12 to L24)
- High-Rise elevators (serving L24 to L37)
- Sky rise elevators (serving L37 to L54)

An alternative elevator design was considered for the tower utilizing 2 banks of double-deck destination dispatch elevators. For the

Figure 5. TWIN (Source: http://davieselevator.com/2011/06/21/thyssenkrupp-elevators-twin-elevator-system-breaks-through-to-the-chinese-market/)
图5: 一井双梯 (资料来源: http://davieselevator.com/2011/06/21/thyssenkrupp-elevators-twin-elevator-system-breaks-through-to-the-chinese-market/)

Figure 6. Rialto South Tower (Source: https://www.flickr.com/photos/13994192@N07/2493992979/)
图6: 里亚托南楼 (来源: https://www.flickr.com/photos/13994192 @ N07/2493992979 /)

alternative design, the low rise service would comprise 6 No. 1800kg double-deck destination dispatch elevators and would serve levels 1 to 29. The high-rise service would comprise 6 No. 1600kg double-deck destination dispatch elevators and would be configured to serve levels 30 to 54. A mezzanine lift lobby would be provided at the main entry.

The service core for alternative double-deck destination dispatch design is compared with the original core design in Figure 7.

The alternative services have been selected to achieve an equivalent level of performance to the original elevator services. However, the alternative passenger elevator design requires 12 double-deck elevators, while the original design utilizes 20 passenger elevators. As a result, there are 8 less elevators and 8 less elevator shafts. Installing less elevator shafts provides the opportunity to gain floor area in the building. The alternative design would allow an additional 2850m^2 of floor area for tenants of the building, which is the equivalent in area of almost 3 floors of the building. With premium Melbourne CBD office space rental currently at \$475/m^2 per annum, this extra space could provide an additional AU \$1.35M in annual rental income.

Premium Collins Street office space in Melbourne is currently valued at around AU \$10,000 per m^2, making the additional value of the building due to the extra floor space of the order of AU \$28 Million.

Double-deck destination dispatch can provide substantial reduction in the number of elevator shafts in office tower developments, increasing the usable area and potentially the value of the building.

Case Study 2: Pudong Kerry Centre Hotel, Shanghai

The Pudong Kerry Centre Development in Shanghai is a mixed-use development which comprises a hotel, office building and serviced apartments in 3 separate towers. The 31 story hotel building (see Figure 8) comprises the following:

- Ground floor lobby
- Level 2 Restaurant
- Level 3 Function Rooms
- Level 4 Hotel facilities
- Levels 7 to 31 – 600 luxury hotel rooms.

The hotel passenger elevator service comprises 6 elevators.

An alternative passenger service comprising Twin elevators (2 elevators in a single shaft) was considered, based on Twin elevators in a total of 4 shafts. The lower Twin cars have a speed of 3.5 m/s, while the upper Twin cars have a speed of 5 m/s.

The alternative Twin design arrangement requires 2 less shafts. The reduction in the number of elevator shafts allows a reduced core size.

The overall floor area saving from installing 2 less elevator shafts and a smaller lobby on each floor is more than 830m^2, which is equivalent in area to 20 hotel rooms.

Twin elevator designs can provide floor space savings in a range of different building designs by reducing the required number of shafts.

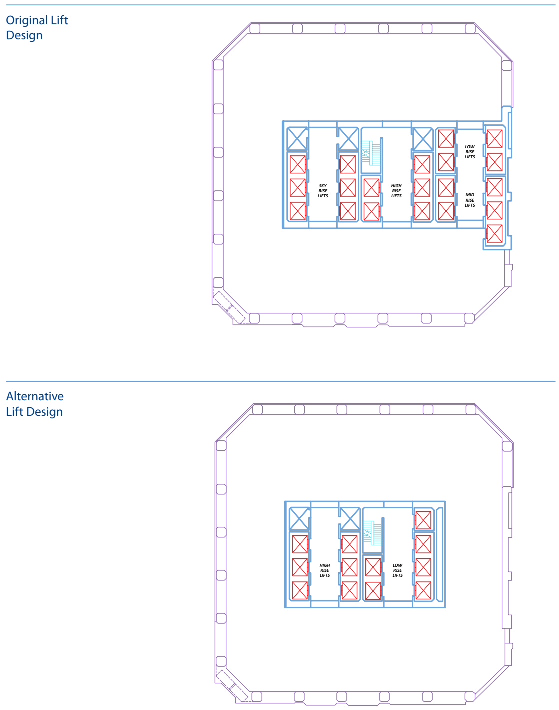


Figure 7. Rialto South Tower Elevator Core (Source: Meinhardt Pty Ltd)
图7: 里亚托南塔电梯核心筒 (来源: 迈进澳大利亚)

Figure 8. Pudong Kerry Hotel (Source: http://www.flickriver.com/photos/businesstraveller/sets/72157627579874581/)
图8: 上海浦东嘉里大酒店 (来源http://www.flickriver.com/photos/businesstraveller/sets/72157627579874581/)

Case Study 3: Mixed-Use Building

This study considers a 53 story mixed-use development as shown in Figure 9.

The building comprises a 5 Star Hotel on levels 1 to 34 and Grade A office accommodation on levels 36 to 50.

The building has a hotel foyer at lower ground level and an office foyer at the upper ground level. The Hotel function rooms are located on Level 1.

Escalator services connect the lower and upper lobbies as well as the level 1 function rooms. Above the function rooms are 800 hotel rooms located over 32 levels.

The 18,750m^2 of office space are located in the upper 15 levels of the building.

The service core for this building as it would be designed using traditional elevators and for the alternative Twin arrangement are compared in Figure 10. The traditional design requires 21 elevators; while the alternative Twin arrangement requires 12 elevator shafts, with the hotel and office passenger elevator cars located in common Twin shafts. Two of the hotel service elevators are configured in a Twin arrangement with the office service elevators.

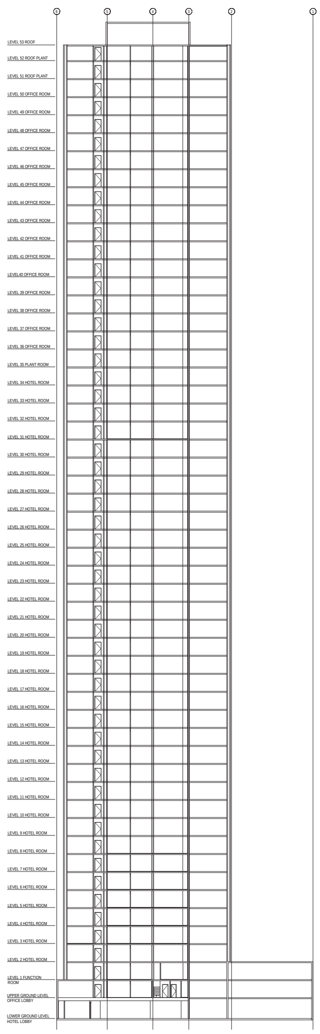


Figure 9. Mixed-Use Tower (Source: Meinhardt Pty Ltd)
图9: 多用途大厦 (资料来源: 迈进澳大利亚)

了20部电梯。以上采用双层轿厢电梯的设计可减少8个电梯和8个电梯井。减少电梯井可为获得更多的楼层面积提供机会。以上减少电梯井的设计可带给大楼额外的约2850平方米办公出租面积，这相当于三个标准层的面积。根据目前墨尔本中央商务区高档办公楼每平方米475美元的年租金，这些额外的面积可每年提供135万澳元的租金收入。

目前在墨尔本的科林斯街，高档办公楼的价值约每平方米一万澳元。以上额外的办公出租面积可以给这栋大楼增加二千八百万澳币的价值。

双层轿厢目的地分派电梯可以大量减少电梯井的数量，增加使用面积和建筑物的价值。

案例2：上海浦东嘉里中心大酒店

上海浦东嘉里发展中心是一个多用途发展项目。整个项目由三个独立的塔楼组成，它们分别为酒店，办公楼和服务式公寓。高31层的酒店大楼 (见图8) 由以下部分组成:

- 1楼大堂
- 2楼餐厅
- 3楼多功能厅
- 4楼酒店服务设施
- 7楼至31楼是600间豪华客房。

酒店客用电梯共有六台。

如果采用一井双梯 (两部电梯共用一个电梯井) 的设计，共需4个电梯井。轿厢在低位的电梯可以每秒3.5米的速度运行，而轿厢在高位的电梯则以每秒5米的速度运行。

这种一井双梯的设计可减少两个电梯井，从而减少了大楼核心筒的面积。

由于少建二个电梯井和在每层都安排一个较小的电梯厅，整个建筑的使用面积可增加830平方米以上。这一增加的面积相当于20个酒店客房。

在一系例不同的建筑设计中，采用这种一井双梯的设计能减少电梯井的数量，从而减少电梯所占用的空间。

案例3：多用途建筑

这一案例分析了一个53层高的多用途建筑，如图9所示。

该建筑的2层至35层是五星级酒店，37至51层为A级办公楼。

该建筑的酒店大堂位于低1层而办公室门厅位于高1层。酒店多功能厅位于2层。

自动扶梯连接低一层和高一层两个大厅，以及二层的多功能厅。二层多功能厅以上的32层是800间酒店客房。

18750平方米的办公面积都位于建筑最上面的15层。

图10以这一建筑为例，将现在的传统电梯设计的核心筒平面布置和采用一井双梯设计的核心筒平面布置做了比较。传统设计需要21部电梯，而一井双梯设计可以把服务于酒店和办公楼的电梯轿厢安置在一个井内，使得整个建筑只需要12个电梯井。具体安排是让两部服务于酒店的电梯与服务于办公楼的电梯在一井双梯的组合中运行。

与传统设计相比，以上一井双梯的设计能够节省约4200平方米的面积，这相当于三个楼层的面积。而且由于写字楼及酒店的使用高峰不在同一时段，这种设计可提供优良的的电梯服务。例如，早上是办公楼工作人员的高峰使用期，却不是酒店客户的高峰使

The alternative design provides a floor area saving of approximately 4200m^2, which is equivalent to more than 3 levels of the building when compared with the traditional arrangement. The alternative service provides a high level of service because the peaks for the office and hotel do not occur at the same time. For instance, during the office morning up-peak there are more than the required 8 passenger elevators available for use by the office staff, because the office morning up-peak does not coincide with a peak for the hotel service. Similarly, during the hotel's evening peak the office levels are largely unoccupied, allowing many of the elevators to be available for the hotel guests.

Twin elevators can be very effective in saving space in mixed-use buildings because of the benefits of boosted performance due to non-coincident peaks of the building uses to provide an excellent level of service.

Conclusion

Developments in elevator technologies including elevator speed and controls have made tall buildings accessible and have enabled the growth of modern cities like Hong Kong. Technologies such as regenerating drive systems, hall call allocation, double-deck destination dispatch and Twin allow tall buildings to be constructed more efficiently than ever, making high-rise development economically sustainable. The elevator safety device allows people to travel vertically through buildings safely and efficiently every day.

That day in 1851, Otis may have felt differently about his invention if he could have seen today's cities and known that now there are over 250 million elevators in use worldwide.

用期，这样上班的工作人员可使用八部以上的电梯。同样，晚上是酒店的高峰使用期，而办公楼的大部分工作人员已下班，使得许多电梯可供酒店客人使用。

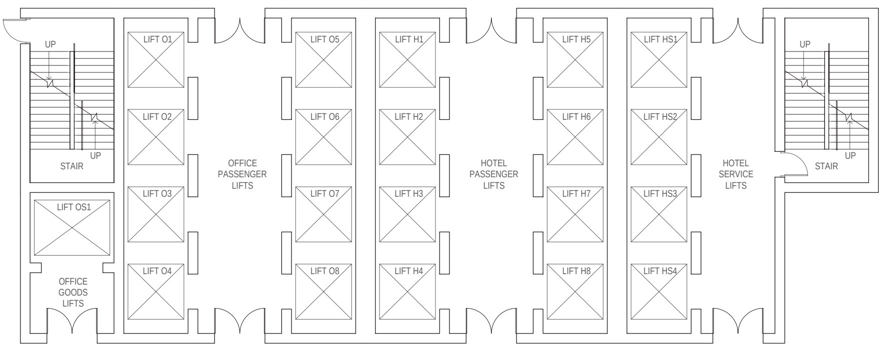
由于多用途建筑中各部分非重合的高峰使用期，一井双梯的设计不但可以节省空间而且使电梯十分有效地被使用，为建筑提供了优良的电梯服务。

结论

电梯技术包括电梯速度和运行控制的发展使得人们进出高层建筑成为可能，并让香港这样的现代化城市发展了起来。能源再生驱动系统，门厅呼梯分配，双层轿厢目的地分派和一井双梯的技术使高楼大厦被更高效地利用起来，让建造高层建筑在经济上具有了可持续性。电梯的安全装置让人们每天可以在高楼大厦里安全有效地垂直移动。

在1851年的那一天，如果奥的斯能看到今天的城市并且知道今天全球有超过2.5亿部电梯在运行，他可能对自己的发明会有完全不同的感想。

Original Lift Design



Alternative Lift Design

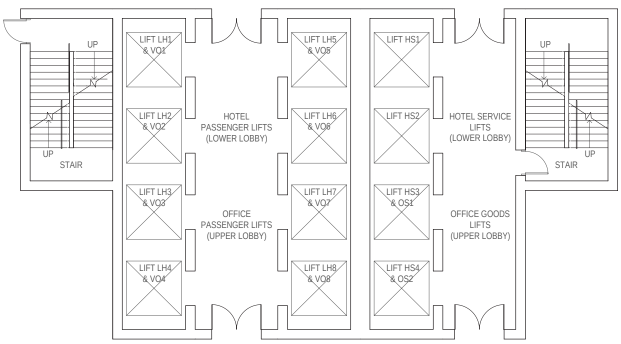


Figure 10. Mixed-Use Tower Elevator Core (Source: Meinhardt Pty Ltd)
图10: 多用途大厦电梯核心筒 (来源: 迈进澳大利亚)

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