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Modernization: Renewing the Lifecycle of Vertical Transportation

旧梯更新改造：延长垂直交通工具的生命周期

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Franz Arnold's footprint in the elevator industry spans over the course of 20 plus years. Franz joined Schindler in 1992, and held various responsibilities within the sectors of engineering and logistics in Hong Kong, Singapore, and Switzerland until becoming head of Schindler Aufzuge Modernization business in Switzerland in 2004. In 2009 he became head of Schindler Aufzuge's Modernization department including the engineering structure and order management for the country. Since 2013 Franz has moved to the global headquarters of Schindler Top Range Division in Shanghai where he leads the modernization and application engineering department.

弗朗茨•阿诺德 (Franz Arnold) 从事电梯行业已有20多年。弗朗茨1992年进入迅达，曾在香港、新加坡和瑞士的工程和物流部门担任过多项职位，后于2004年成为迅达电梯瑞士旧梯更新改造业务负责人。2009年，他成为迅达电梯旧梯更新改造部门主管，管理范围包括全国的工程结构 (engineering structure) 和订单管理。2013年，弗朗茨来到位于上海的迅达全球总部 (Top Range Division)，领导旧梯更新改造和应用工程部门。

Abstract

Traditionally much of the focus in the tall building sector has been centered on the ground breaking technology being put in place for the pioneering "Skyscrapers of Tomorrow." However, as these landmarks continually develop the ranks of "yesterday's skyscrapers" is increasingly being overlooked despite their quantity swelling.

The vertical transportation industry has continually been researching ways to tailor specific tall building solutions for this sector. To this day, this has largely centered on upgrading specific components, to improve performance or newer decoration to revamp the user's ride experience. Destination Control systems have become a game changer.

This paper seeks to prove that the development of traffic management systems and expertise for building modernizations should no longer be considered as pure component replacements for material renewal. Rather, these control aspects need to be concentrated on for the optimized function of tomorrow's passenger locomotion.

Keywords: Vertical Transportation, Modernization, Destination Control

摘要

在高层楼宇领域，运用史无前例的技术建造具有开创性的"未来摩天大楼"往往会更受世人瞩目。然而，随着这些地标性建筑的不断发展，"昨日的摩天大楼"数量持续增长，而我们对它们的关注却日益减少。

垂直交通领域的不断探索，以求为高层楼宇细分市场定制解决方案。时至今日，这项工作很大程度上仍侧重于升级特定部件以提高性能，或者更新装潢以提升用户的乘梯体验。而目的地控制系统则是对传统的颠覆。

本文尝试论证了垂直交通系统和大楼更新改造专业技术的发展不应局限于单纯地更换部件和更新材料。而是应将这些视为促进乘客移动性的未来发展有利因素。

关键词: 垂直交通; 旧梯更新改造; 目的地控制

Modernization: Renewing the Lifecycle of Vertical Transportation

Last year 829 skyscrapers over 200[1] meters were built around the globe to fulfill the continuing of the global population's ambitious urbanization needs. The growing pressure from populations relocating from the countryside to cities is no longer a factor limited to Western Countries, but a growing concern for the bulk of the global population situated in the Far East namely China and India. In 2013 China surpassed the symbolic 50%[2] urbanization rate leading to an exact balance equating to 650 million people living in the country's urban dwellings. Comparatively speaking, Europe's urban population remains at 80%[3], meaning that approximately 390 million people are still to be potentially relocated. Although this is

[1] CTBUH (2014) www.skyscrapercenter.com
[2] (2014) www.wikipedia.com
[3] (2014) www.wikipedia.com

旧梯更新改造: 延长垂直交通工具的生命周期

去年，全球新建了829幢200[1] 米以上的摩天大楼，以满足全球人口持续攀升的城市化需求。人口从乡村迁往城市，带来越来越大的压力，这已不再仅仅是"西方国家"所面临的问题，它也日益成为远东地区中国和印度这样的人口大国所必须应对的难题。2013年，中国的城市化率超过50%[2]，全国有6.5亿人居住在城市，象征着其城市化水平达到了平衡。相对而言，欧洲的城市人口占比仍保持在80%[3]，意味着若与欧洲城市化率相比，中国仍有3.9亿人为"潜在"城市化人口。虽然这个例子略显极端，但也准确概括了城市对高层建筑的需求，体现了为全球摩天大楼定制新型、可持续解决方案的需求。

这些主题仅在过去5-8年内才逐渐显现，并成为世人瞩目的焦点: 过去几十年所建的摩天大楼的未来命运将如何呢? 如今，这样的大楼如雨后春笋般大量涌现，这一突出问题便引出了"摩天大楼的寿命"这一命题:

a slightly extreme example, it encapsulates exactly the need for the high-rise buildings to find new and sustainable solutions for urban skyscrapers globally.

These subjects have been in the limelight only within the last 5-8 years: What about the previous generations of skyscrapers erected over the past decades? This issue remains outstanding; posing the question of the longevity of skyscrapers particularly at the current volume they are being produced. Can the industry sustain and responsibly commit to the development, and more importantly maintenance of the past structures as the Empire State building or the Rockefeller Center in New York? Last year 314 buildings over 200 meters were constructed in China[4]. These structures continually transform the local skylines, soon to be dwarfed by higher structures yet to come. The responsibility of ensuring these buildings remain relevant not only from a financial perspective but also from a technological sense falls under building owners and city officials. During the construction of such iconic buildings, rarely is the demolition considered, mostly on the basis that deconstruction and reuse is not economically viable. Hence, the growing role of building refurbishment and modernization becomes the only solution to prolonging the relevance of an aging skyscraper, aside from its architectural contribution.

Buildings Developing the Need for Modernization

An 8 elevator group installation serving 20 floors averages over 3,000 trips[5] every day. The wear and tear of the mechanical components and interior decoration becomes inevitable as passengers take their journeys day in and day out. Like all mechanical components (and high-rise buildings themselves), components need replacement through module refurbishment to bring them up to date. Furthermore, the continual development of elevator standards and evolution of vertical transportation codes entails the equipment sold over a decade ago are outdated, leading to necessary refurbishment to comply with up to date with local laws and regulations. Finally, the economic viability of a high-rise building and the reality of attracting high level office tenants with state of the art technology and efficient vertical traffic management tools and processes are essential to ensure the survival and function of such structures.

Destination Control, the Game Changer

The advent of Destination Control has not only symbolized a revolution from a technological perspective but also from a manner in which the vertical transportation industry approaches buildings and their passengers, inventing new terminology such as crowd control. Rather than looking at a mass of people who wish to move from one floor to another as a subtext of a larger building transit requirement, but instead taking the responsibility for the entire journey from its inception to its conclusion. By integrating all of these journey's achieves a stepwise improvement in equipment utilization and, by extension, not only customer satisfaction but the very design possibilities of the building itself.

Destination Control enables the flexibility both technically and esthetically for building owners and managers to further fulfill their ambition of taller structures. The enablement of this is largely due to the transformation of traffic simulation which has brought this to

该行业能否继续潜心致力于发展及维护诸如纽约帝国大厦或洛克菲勒中心等历经风霜的建筑? 去年，中国新建了314幢超过200米的大楼[4]。这些建筑不断为当地的天际线添彩，但很快又将会有更高的建筑出现，使其相形见绌。如何从财务和技术方面确保这些建筑不致落伍，这一责任落在了大楼业主和市政官员肩上。在建造这些大楼的时候，一般不会考虑到这些标志性建筑会被拆除，或者会因经济可行性不高而遭弃。因此，日益盛行的建筑翻新或更新改造技术成为了延长摩天大楼使用寿命的唯一解决方案。

楼宇旧梯更新改造的需求

以安装8台电梯群为例，其服务楼层为20层，平均每天运行3,000次[5]以上，随着乘客使用次数的增加，电梯机械部件和内部装潢的损耗在所难免。如同所有机械部件 (以及高层建筑本身)，电梯也需要更换新模块。此外，随着电梯标准的持续发展以及垂直交通规范的演变，十几年前售出的电梯必须进行更新改造，以符合最新的电梯标准规范及实践需求 (以当地法律法规为准)。最后，高层建筑的经济可行性，以及凭借一流的技术、高效的垂直交通管理吸引高水准办公租户的能力对确保这些建筑的发展和顺畅运行至关重要。

目的地控制技术——传统颠覆者

目的地控制技术的实现不仅象征着技术层面的革新，同时也体现了垂直交通行业对待大楼及其乘客需求的不同方法，此外，它还催生了人群控制等专业术语。庞大的楼宇交通需求不再意味着坐视一大群人想从一个楼层前往另一个楼层，而是贯穿始终，关注乘客乘梯的全过程，并整合所有旅程，逐步改善设备利用情况，进而提升顾客满意度、拓展建筑本身的设计可能性。

这样，大楼业主和管理者能够从技术层面和审美角度出发在建筑翻新工作中增添更多灵活性，并与目的地控制技术相得益彰。这在很大程度上得益于交通模拟技术的更新换代，而这一技术在十几年前建造这些大楼之时尚未普及。

交通模拟模式定义回顾

在电梯行业，通常会根据相对简单的计算在早期确定为满足特定交通规范所需的安装量级。最近，通过 (计算机) 模拟，对这些粗略的计算结果进行了进一步提升，从而可以为特定楼层选择合适的布置 (如: 咖啡厅)。然而，确保模拟的高品质非常重要。Lukas Finschi博士已经指出过于简单的建筑交通模拟方法存在的风险。

"当今，模拟作为一种公认的必要手段在交通分析领域使用广泛。然而，模拟方式的应用通常很不到位。其主要问题在于，所得出的结果往往缺乏统计支撑，也就是说，评估中所使用的数据不够充分。尽管人们早已认识到这个问题，电梯行业也不例外，但这个问题却并未得到重视……电梯群控系统对运载能力及服务质量具有重大影响。因此，具有现实意义的交通分析必须能够反映真实的电梯群控系统: 使用电梯群的实际控制算法进行模拟便是不二之法。而且，交通分析的结果必须可靠，意味着这些结果必须可再现、无偏颇。随机性是模拟中的一项重要因素，它会对结果的可再现性构成挑战。我们将会意识到，一旦我们对它有了充分了解，这一问题也就不难应对了。简言之，必须通过充足的样本数据来对变量加以控制，从而达到平衡[6]。"

[4] CTBUH (2014) www.skyscrapercenter.com
[5] WeiLiu, C (2014) *Schindler R&D Research*

light, which was largely unavailable at the time of construction of buildings over 10 years ago.

The Revision of Pattern Definition in Traffic Simulation

The elevator industry has traditionally relied on relatively simple calculations to determine at an early stage the magnitude of the installation required to meet certain traffic specifications. More recently, these rough results have been further honed by simulations to ensure that specific floor placement choices (for example a cafeteria) were made correctly. It is important to ensure that the simulations which are undertaken are of a high quality. Dr. Lukas Finschi has pointed out the risks associated with an over-simplistic approach to building traffic simulation.

"Today, simulations are widely used for traffic analyses, as it has more generally been recognized that this is necessary. However, simulation methods are often very poorly applied. The main problem comes from the fact that results often completely lack statistical relevance – just not enough data points are being considered for evaluation. Although this problem is known for a long time in general and also specifically in the elevator industry, it is widely ignored….. elevator group controls have a big impact on handling capacity and service quality. Therefore, a realistic traffic analysis must reflect the actual elevator group control: There is no other way as to run simulations which use the actual control algorithms of the elevator group. Furthermore, results of a traffic analysis must be reliable, which means that the results are reproducible and unbiased. Reproducibility is challenged by randomness, which is an important element in simulations. We will see that it is not so difficult to cope with this, once the problem is understood. Simply speaking, the variation must be averaged out by considering a sufficiently large set of sample data points[6]."

Office Population Development

As offices evolve so does the space allocation per square meter dedicated to each employee, in the past square space meter allocation was space allocations were 18-20 compared per person to 12-15 per person today[7]. The evolution of the office landscape has moved towards a strengthening and development of individual islands/ cubicles rather than towards individual cellular offices. Meaning the capacity of population per floor has increased dramatically over the past 10 to 15 years. Furthermore the absence of modern traffic simulators during the design phase of the buildings may have only allowed for a rough estimation of passenger requirements. The lack of data and of computer power available previously to devise specific algorithms based on thousands of previous high-rise operation observations will ultimately affect the manner in which the elevator system requirement of the building system will be calculated. Finally as with all structures and elements buildings evolve and so consequently does their usage; the differing amount of tenants occupying office space within a high-rise building can change dramatically over the course of its life span. For example the needs of an advertisement agency versus an accounting firm vary to great significance in terms of space allocation and company culture.

Within this continually changing landscape of building development,

[6] Finschi, L. (2010) *State-of-the-Art Traffic Analysis*
[7] Studly, P and Foster, K (2013) *The impact of changing workplaces*

办公室人口发展

随着办公室环境的变化，每位员工所拥有的每平方米的空间分配也在变化，过去，每平方米空间分配是每人18-20，而如今则是每人12-15[7]。办公室格局朝不断优化的个人岛/小隔间而非分格式的方向演变。这意味着在过去10到15年间，每一楼层的办公人员容量急剧增长。此外，正如前文所述，相对应现代交通模拟技术的不断发展，由于当初在大楼设计阶段未曾采用交通模拟，因此对乘客需求仅作了粗略预估。以前，数据匮乏，可加以利用的计算机技术也不完善，我们根据先前参与过的高层建筑项目以及我们在电梯行业积累的经验，精确计算用户的需求，并最终影响大楼电梯系统需求的计算方法。最终，像所有结构及元素一样，建筑在不断演变，其用途也会不断变化，高层建筑内办公空间所能容纳的租户数量在大楼生命周期中会发生急剧变化。例如，广告公司和会计师事务所有着不同的需求，其空间分配乃至公司性质存在着巨大的差异。

由于建筑发展格局日新月异，目的地控制仍然是可行性最高的选项，这一技术能够显著提升交通性能以满足办公空间使用需求的骤变。候梯时间/运行时间 (在门厅以及在轿厢中) 已经成为影响高楼租户日常工作效率的关键要素之一。若能把高层建筑日常"体验"中的这部分时间缩至最短，这将成为吸引潜在租户的一项关键因素。

个性化服务和追踪能力

开创性技术控制系统的发展对用户的个人和职业生活各方面均产生影响，这一领域正朝向个性化服务方向自然演进，从手机到个人电脑，这些产品不断创造着独特的用户体验。然而,更重要的还是满足来自公众的各方面需求和期望。由于这种需求的存在，高层建筑业主和现场经理需要为所有长时间工作的租户提供独特的用梯体验，无论是通过为租户提供特定服务,还是通过改进技术来达到吸引最合适租户的目的。凭借这一步，垂直交通目的地控制系统的供应商满足了市场和租户的需求。个性化技术使每位用户的每次乘梯都成为一次个性化旅程，这是技术层面的一大重要成就，乘客在日常使用中不会感觉到任何不利影响。旅程个性化的最大影响在于，每位用户在读卡器上刷识别卡后，目的楼层控制终端将为其提供个人识别功能。个人识别介质可能是一张显示姓名的简单图片或者是生日确认，用户可以在乘梯前就开始享受无与伦比的个性化服务。此外，这一功能算法还能够"学习"某个租户的移动情况和偏爱路线，并能根据其偏好显示这些选项服务，相比传统电梯系统，这样的功能凸显了个性化服务的额外优势 (见图1) 。

此类个性化服务也有利于大楼管理，因为它能追踪大楼内所有租户任何时候的乘梯记录。若能了解大楼租户的所有个人移动，并配合以紧急疏散和安全监管制度，可将这一功能进一步运用至老旧建筑的管理中，发挥其特有优势。通过这一功能查明每一楼层的撤离者数量，可以在灾难事件中大幅节省时间和资源。由于消防规范越来越复杂，要求也越来越严苛，今后，是否符合撤离者追踪规范将成为高层建筑更新改造要求中的一项关键指标。

成本和人力

此类技术的超高效率无疑将对大楼管理的人力要求产生影响，通过中央控制屏，管理员能随时全面监视整个电梯交通系统，看到所有乘客的乘梯情况，电梯功能以及乘客监视效率得以显著提升。因此，与过去相比，也将显著减少监视和排除运行故障所需的人力。除了提供监视功能外，目的地控制系统也会根据对业主或租户的判断来管理每一楼层的安全门禁，减少之前安保人员为

Destination Control remains the most viable option to induce significant increase in traffic performance to accommodate such a radical evolution of office space usage. Elevator waiting times/journey times (in the lobby and in the car itself) have been singled out as one of the key points within tall building tenants work life, minimizing this aspect of a high-rise "experience" in everyday life is a key factor towards the foundation of attractiveness for prospective tenants.

Individual Personalization and Traceability

Within the development of pioneering technology control systems affecting all aspects the user's personal and professional life, the natural evolution has come towards the personalization of services ranging from mobile phones to PCs creating unique user experiences. This demand has now materialized into high-rise owners and site managers needing to offer a unique experience to all tenants working extended hours in their locations, be it through tenant specific services or technological perks, in order to attract the most suitable occupancy. With this natural step vertical transport Destination Control system suppliers have followed suit to market and tenant request. The advent of personalized technology has allowed for every elevator ride undergone by each individual to be a personalized journey calculated on an individual basis. Although this from a technical standpoint is an achievement, it heeds little effect on the day to day passenger's impression. The furthest impact measurement towards the personalization of the journey has been through individual recognition the Destination Control terminals provided to each user when swiping their identification on the reader. Whether this could be a simple picture display name, or birthday acknowledgement, the sentiment of an individualized service provided ahead of the journey is unparalleled. Further to this ability of the algorithm to "learn" a tenant's movements and preferred routines and to display these choices in accordance to their preference gives the extra edge of individuality over traditional sense of conventional elevator control systems (see Figure 1).

This individuality also plays into the favor of the building management as it allows an overarching approach towards the traceability of all building occupants at all times. Knowing all personnel movements of building tenants is an unprecedented advantage for emergency evacuation and safety regulatory systems which can be included with the analysis of aging structures. Being able to pinpoint the amount of potential evacuees per floor can significantly save time and resources in case of a catastrophic event. As fire codes further develop complexity but also require compliance with evacuee traceability, Destination Control will become one of the essential future trends of high-rise modernization requirements.

Costs and Manpower

The efficiency of such technology inadvertently affects manpower requirements for building management. Having a central control system enabling full traffic vision and surveillance of all passenger journeys at all times, elevator function and passenger supervision is improved dramatically. This consequently requires significantly less manpower for supervision and operational troubleshooting than in the past. As well as providing supervision, Destination Control also manages secure access to each floor as per the owner's or tenant's discretion, saving precious time of security personnel of needing to follow unwelcome guests throughout the structure . These "smart" systems can save costs through personnel and also through energy efficiency. By improving traffic performance elevator usage will be

跟随进入大楼的不速之客所花费的时间。因此，这些"智能"系统不仅可以节省人力，还能提高工作效率，进而节约成本。这一系统可间接提升交通性能，并对电梯使用产生影响，不仅使更多乘客能够及时到达目的楼层，而且其他在用电梯所需运行的次数也将减少。目的地控制系统制造商为大楼和乘客量身定制贴心服务。目的地控制系统能适应早间和午间用梯高峰时段变化无常的交通环境。目的地控制系统能够根据在运电梯的数量，将未使用的电梯调至休眠模式。顺带提及，迅达的ECO模式使电梯能耗降低10%，而无需关闭整个系统。此外，在无需任何大楼管理的周末等停机交通状况下，使用目的地控制系统能节省10-20%[8]的能耗。此外，当交通高峰再次到来，目的地控制系统将重新适应高负荷交通。在旧梯更新改造布置过程中，除了电气元件，机械装置对实现大楼系统能量再生、节约成本也起到决定性作用。能量再生技术的关键演进之一在于上一代电梯中引入了永磁电机，电梯移动因而能够实现更多能源反馈，然后传输回大楼的电力能源网络。

循序渐进的电梯系统置换

如上所述，办公地产领域的竞争程度异常激烈，因而不容存在电力低效使用的情况。如今，大楼业主再也无法承受在大楼更新改造期间关闭全部建筑区域，也无法接受其大楼功能完全受阻。垂直交通行业深知这一点，因此为其提供逐步进行的更新改造方案，确保将旧梯更新改造每个阶段对大楼功能的干扰降至最低，具体分为以下阶段:

Figure 1 PORT Destination Control System (Schindler Internal)
图1 PORT目的楼层控制系统 (迅达内部资料)

affected aside from more people getting to their destination in a timely fashion, the rest of the elevator usage group will be under less trip cycle requirement. Destination Control Systems manufacturers tailor their services to buildings and passengers alike by being able to constantly adapt to the continually changing traffic circumstances of morning and lunch rush conditions. The Destination Control systems are able to adapt to the number of elevators in service and place the unrequired units in a hibernation mode. With Schindler's ECO mode reduces elevator power consumption by 10% without shutting down the whole system. Furthermore this enables up to 10 to 20%[8] of savings on severe downtime traffic situations such as weekends, without any need of action from the building management. In addition to this the Destination Control system re-adapts to high traffic situation as soon as traffic peaks again. Aside from the electrical element of the modernization replacement the mechanical devices plays a decisive role within the contribution of energy regeneration towards the building systems achieving costs savings. One of the key evolutions of regeneration technology has been the introduction of permanent magnet motoring within the lastest generation of elevators, allowing for a greater recuperation of energy from elevator locomotion to be retransmitted back into the building.

Elevator System Replacement Step by Step

As elaborated, the degree of competitiveness within the office real estate sector is intense, thus allowing little tolerance of powers maneuver for inefficient use of real estate space. Building owners can now no longer afford to shut down full building sections or completely impede the function of their property during a phase of building modernization. The vertical transportation industry has understood this and now offers the step by step modernization process allowing for specific phases of elevator modernization to take place whilst causing minimal disturbance to the building function, through the following phases:

1. The upgraded overlay cabinets and interface boxes are installed in the machine room (see Figure 2).
2. The cabling to the landings and cars is installed one elevator at a time and prepared for later connection to the new control fixtures (see Figure 3).
3. The old landing and operating panels are removed, whilst the new car operating panels, destination indicators, car door frames, floor terminals, and designation plates above the landing doors, are connected to the wiring setup previously (see Figure 4).
4. The interface boxes are then connected to the upgraded cabinet and new control systems (see Figure 5).

These 4 elaborate yet direct steps can take place over a single time frame, either overnight or over the course of a weekend depending on the amount of floors and elevator groups needing refitting. The traffic performance will be improved whilst minimally disturbing the function of tenants.

Figure 2 Modernization Installation Guide (Schindler Internal)
图2 旧梯更新改造安装指南 (迅达内部资料)

Figure 3 Modernization Installation Guide (Schindler Internal)
图3 旧梯更新改造安装指南 (迅达内部资料)

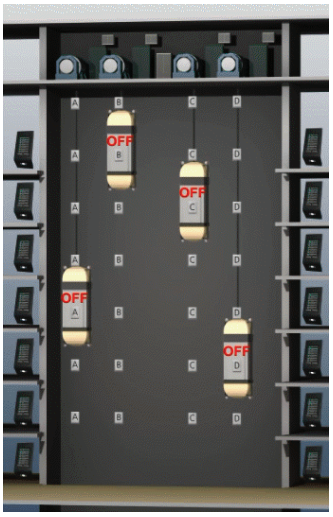

Figure 4 Modernization Installation Guide (Schindler Internal)
图4 旧梯更新改造安装指南 (迅达内部资料)

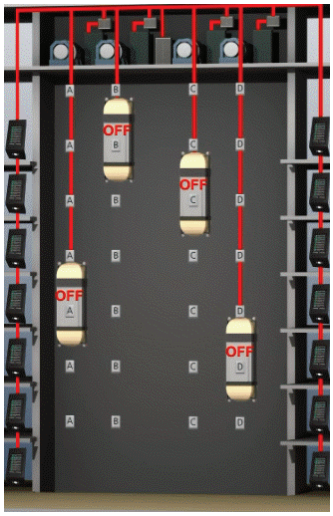

Figure 5 Modernization Installation Guide (Schindler Internal)
图5 旧梯更新改造安装指南 (迅达内部资料)

1. 升级的电梯控制柜和接线盒在机房内安装完毕 (见图2)
2. 一次安装一部电梯的层站及轿厢布线，以备后续连接新的操纵盘 (见图3)
3. 移除旧的层站和操作面板后，预先将新的轿厢操作面板、目的楼层显示器、轿厢门架、楼层终端以及层站门上方标示板连接至布线设置 (见图4)
4. 然后，将接线盒连接至升级后的控制柜和新的控制系统 (见图5)

以上四步说明，每一步骤可在单一的时间范围内完成，它可以是在夜间，也可以是在周末，取决于需要重装的楼层数和电梯群数量。在这一过程中，交通性能也将得到提升，同时会将对租户的影响降至最小。

[8] WeiLiu, C (2014) *Schindler R&D Research*

Conclusion

As newer and taller buildings grow in consequence and numbers globally, the question of the longevity and lifespan of these structures is a topic which can no longer be ignored. This paper has demonstrated that the vertical transportation industry is aware and focused on these issues at hand. Furthermore, the advent of Destination Control technology has encompassed a revolutionary bid towards the efficient management of building systems and tenant occupancy. Whether this would be from an ecological, efficient, or cost savings perspective, the tools which have up until this point been mostly focused on the proliferation of new installation technology undeniably contribute towards the future of maintaining and prolonging tall building lifespan. After all, there would be no Tall Buildings without elevator systems.

结论

总而言之，随着全球摩天大楼的影响不断扩大、数量不断增加，其寿命及使用期限已成为不容忽视的问题。本文论述了垂直交通行业已意识到这些问题，并予以重点关注。此外，目的地控制技术出现后，该行业也在进一步谋求大楼系统及租户租赁的高效管理。不论是从生态、效率还是从成本节约的角度来看，如今的重点主要集中在新梯技术的推广，这无疑对维持和延长高楼生命周期大有裨益。毕竟，如果没有电梯系统，高层建筑也就无从谈起。