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# Connecting the three Dimensions of Urban Transportation

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**Abstract**

Currently, urban mobility is rather two-dimensional: Connections between transportation solutions like elevators, escalators, moving walks, and metro stations are static. In the future, urban mobility will require a holistic view: Seamless transportation, enabled by innovative IoT technology, is a necessity. A dialogue between the city, its buildings and transportation systems, considering the specific needs and preferences of each and every citizen, must be adopted. Travelling through the city will become a lot more individualized, interactive and customized to specific requirements.

**Keywords:** MULTI, Smart Cities, Urban Mobility, High Rise

## 1. Introduction

### 1.1 our urbanizing world

In 1950, rural populations accounted for 70% of the global population. By 2050, urban populations will account for nearly the same percentage. With half of the world's population already living in cities, we are in the midst of the most significant demographic shift in modern history. The swiftest growth rates can be found in Africa, Asia, the Middle East and Central America. However, Europe and North America are also strongly affected by the trend. On a global scale, builders are constructing the equivalent of a one-million-person city every day. Based on projections of average household sizes and increases in city populations, an estimated 250 million additional housing units will be required by 2030 across the 12 countries that account for 61% of the global population (excluding demands for refurbishment and replacement).

Outward expansion, also called urban sprawl, is not the answer. By expanding cities on the horizontal plane, we would destroy natural environments, increase the number of cars on the streets (increasing pollution and commuting times) and reduce quality of life. Many global cities, such as Hong Kong, face natural or political barriers that completely prevent urban sprawl.

Current urbanization trends need to find solutions that allow city dwellers to live comfortably, while accommodating the increasing population density. This means that cities must use the space they have more effectively. The rising density of urban areas requires the development of more mid to high-rise buildings, which allow for the most environmentally friendly and cost-effective usage of space. Tall buildings occupy less ground space, which is essential to securing green areas for the city, and allowing for the centralized and intelligent control of energy. Skyscrapers can also become part of the solution. According to the Council on Tall Buildings and Urban Habitat, the number of buildings over 200 m has gone from about 260 in the year 2000 to more than 1,300 today, and there are more than 400 buildings of over 250 m in height currently under construction. When it comes to the construction of supertall buildings, the Middle East and Asia are clearly in the lead.

Tall buildings are becoming more like vertical cities, providing office, residential and commercial space within a single structure. Sometimes they are even interconnected with one another. Just like any other place in a city, every location within a building needs to be well connected if it wants to attract commercial investors, tenants, or even casual shoppers. To achieve this level of connectivity, buildings - tall buildings in particular - need a flexible transport system similar to a metro.

Therefore, the transportation system of the future has to go one-step further. Smart mobility must go even further than predicting malfunctions in real time, or allowing passengers to call an elevator before they reach it. Looking ahead, we should understand mobility as a service. Urban mobility influences the most diverse areas of life, and it should therefore be individualized for passengers. This applies not only to smart modes of transportation, but also to smart buildings and smart cities.

## 2. The three Dimensions of Urban Transportation

### 2.1. The first Dimension - The Transportation of People within Buildings

As a first step, it is necessary to fully comprehend the

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transportation of people within a building. In times of urbanization, buildings are getting higher and people's daily lives are moving away from the street level. Living and working spaces are moving to the upper floors of buildings. Therefore, future transport systems within buildings need to adapt to the new requirements of respective residents.

It is becoming more common for buildings to reach heights of 300-500 meters. Urbanization and the resulting lack of space in the horizontal plane necessitate a rise in height for buildings. Unfortunately, it is precisely at this height that conventional elevators reach their limits. Using only one car in a single vertical shaft not only restricts mobility; it also takes up too much precious space within the building. That could be bypassed by using smaller shafts or putting more cabins into the systems. The space that would then become available could be offered for rent or sale, which would increase the building's profitability.

In order to work around height limitations, sky lobbies are built so that passengers can change into different elevators. However, this is not a sufficient solution as the problem of space remains. In fact, sky lobbies further exacerbate the issue by occupying even more valuable space. All this space is lost and affects the economic efficiency of the building. Moreover, the use of sky lobbies increases passenger travel times significantly, as they often have to wait to change the elevators. Particularly in buildings beyond the 500-meter mark, several stopovers in sky lobbies become more and more likely when conventional elevators are used. In times of demand-driven mobility, this should be prevented. Artificial intelligence and algorithms could help in finding a solution, as they can calculate peak times and show how to bypass them deliberately, thus reducing waiting times and optimizing travel inside and outside the building.

In times of climate change, the energy efficiency of buildings will also play an increasingly important role. Here, too, conventional mobility solutions have significant disadvantages. For example, the initial power consumption of elevators during their start phases is very high. Most of them are not able to predict the number of passengers, so empty runs are likely. This results in significant energy consumption. Such energy peaks could be avoided with multiple cabin systems, where cabins could regenerate energy while moving down, immediately feeding that energy back to other cabins as they move up. Continuous energy consumption, as opposed to several energy peaks, is necessary for smart grids of the future.

### 2.2. Second Dimension – Interconnectivity of Buildings

When talking about the mobility of the future, not only individual buildings but also entire housing blocks play an important role. In vertical cities of the future, there is the possibility to connect buildings. An attractive option for this is the introduction of skybridges in buildings. Skybridges can facilitate social networking that is normally only possible at the street level - with shops, parks, and cafés accessible from several buildings. With the right elevator technology, skybridges could also enable passengers to move from the top floors of one building to another without having to go down to the ground floor.

However, the connectivity will go even further. Buildings will not only be connected through skybridges; they will also have systems that enable them to communicate with each other. By exchanging data streams and using the Internet of Things (IoT), other means of transport, such as air taxis, drones, metros, and elevators, will be synchronized. As a result, resources can be shared and used much more efficiently. Currently, great benefits are lost because different systems do not exchange data with each other. To achieve this, however, buildings need a technology that allows the different devices and means of transportation to communicate with each other. There must be a constant exchange and analysis of data to understand and realize mobility as a service.

### 2.3. Third Dimension - Connecting Private and Public Life

The third dimension of people's transportation focuses on life within future cities. Life has to be safe, efficient and sustainable. Therefore, solutions are needed that pave the way for innovation and economic growth. A data-based mobility infrastructure is one example that can supplement new services, such as car-sharing or neighborhood logistics services.

These require not only conventional public transport systems, electric vehicles and charging technologies, but also booking, routing and information systems that make public mobility more attractive for users - thus helping to make the private car obsolete for urban transport. To make this possible, it is necessary for public and private transportation systems, such as elevators, escalators or metros, to communicate with each other. Only if this smart connectivity is established will it be possible to travel seamlessly through the cities of the future. We therefore need interoperable software platforms that can combine, analyze and process different streams of data to improve and introduce new urban services.

## 3. Introducing MULTI

With all this in mind, it is clear that efficient mobility in buildings is no longer a luxury, but an absolute necessity. MULTI is thyssenkrupp Elevator’s solution to meet that need and more.

MULTI is a next-generation elevator system that can put multiple cabins in one shaft - but it does not operate in a single shaft alone. MULTI cabins operate in a circuit, traveling up one shaft and down another. And since there are no ropes, MULTI systems can even travel sideways to connect with different buildings or adapt to buildings with innovative new geometries and formats.

In most cases, MULTI follows the basic premise of a

**Figure 1.** Rendering of MULTI in action.

circular system, much like a paternoster. MULTI uses ropeless, linear drive technology, which means that multiple cabins can be incorporated in a single loop. With a targeted speed of 6 meters per second, this system will enable near-constant access to an elevator cabin every 15-30 seconds. Passengers will benefit from reduced waiting times, and the option to simultaneously access two elevators via two separate doors on the ground floor improves the flow of people in large buildings. By removing the suspension cables and leveraging expertise in maglev technology, the MULTI can function like a mass transit system, increasing transport capacities by 50 percent, while also reducing the elevator footprint by 50 percent.

MULTI takes advantage of the linear motor technology developed for the German Transrapid magnetic-levitation train and applies it to elevator cabins. This enables them to move in shafts in the same way that trains move in rail systems, with various independent cabins per shaft that can move vertically, horizontally and even diagonally. Safety is ensured by the multi-propulsion and braking systems in cabins and by the proven safety control system developed for TWIN elevators that prevents cabins from getting too close to one another.

MULTI offers much higher capacities, as well as faster and more comfortable movement when compared to high-speed elevators, which are limited by the effects of pressure on the human body, with many people experiencing discomfort at speeds higher than ten mps.

300 meters or higher is the ideal building height for MULTI installations using the paternoster-style, dual-shaft circuit. Yet the system is not dependent on a building's height. With no ropes, a multilevel brake system and wireless power transfer from shaft to cabin, adopters of MULTI will also benefit from smaller shafts of six square meters, compared to other technologies that occupy a space of nine square meters. The overall increase in efficiency also translates into a reduced need for elevator shafts, thereby decreasing a building's elevator footprint and providing further usable floor space and revenue to building owners.

### 3.1. MULTI - the Heart of a Smart City

Digitalization and the Internet of Things (IoT) are very important topics today, and MULTI is designed to use their every advantage. One example is MULTI's digitalized interface, a state-of-the-art building facilities management system. The tool integrates hundreds of data sources to streamline building performance and efficiency - from maintenance, resource utilization, and energy efficiency - to improve the "user experience" for building tenants and visitors. Naturally, that includes elevator operations.

The Digital Twin collects and integrates hundreds of data streams from individual proprietary systems to provide a single overview, creating actionable insight through a visually intuitive software platform, accessible by all levels of asset management in real-time. It also uses the data collected by MAX, the predictive maintenance system that is already connecting and analyzing data from over 120,000 elevators around the world to reduce elevator downtime by half. With this system in place, elevators can be fixed before an error ever occurs.

Together with the data collected by the existing MAX predictive maintenance service, the Digital Twin creates a living system that allows asset managers and owners to build a digital picture of how tenants are experiencing a building. This intelligence helps to improve facilities management and provides insight into how occupants and visitors use the building.

However, the MULTI goes one-step further. In the future, intelligent algorithms based on artificial intelligence will help to reduce waiting times to a minimum. The artificial intelligence used in MULTI not only enables the elevator control system to intelligently direct the flow of traffic through the building; it also provides a learning effect. For each activity, the system registers positive or negative findings and then attempts to consider them in the future. While conventional elevators can stand by on call-up to transport people to their destinations, the MULTI uses previously-stored and analyzed data to predict which destination passengers want to go to and then find the most effective transport route, thus combining machine-learning technology with the Internet of Things.

The use of MAX offers even more advantages. Since conventional elevators and escalators, along with MULTI, can use MAX, the units can share data to make customized passenger transportation adjustments. If the cities of the future were to rely on intelligent solutions in public areas, such as traffic light systems, the means of transport could then be able to harmonize the entire inner-city transport system. In this way, traffic jams could not only be avoided but also be prevented completely using intelligent transport systems.

### 3.2. MULTI - New Possibilities for Future Cities

As outlined above, MULTI can be understood as a vertical mass transit system, with parallel tracks and independent "trains" (i.e. cabins). That means that any

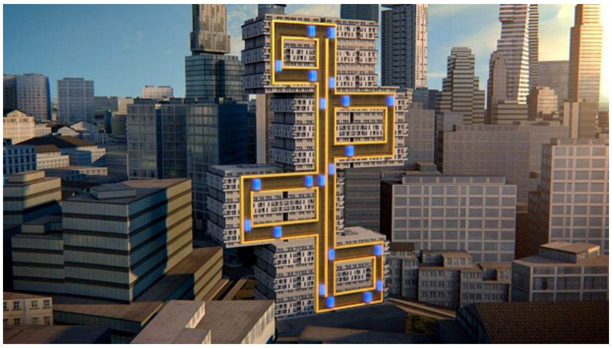

**Figure 2.** The only limit: your imagination.

two points on a vertical plane can be connected with one another just like with a metro.

Looking beyond applications to improve passenger throughput and elevator efficiency in singular tall buildings, MULTI's mass-transit approach means that multiple buildings and structures can be connected across skybridges or via underground tunnels. This could be an attractive option for unprecedented accessibility and connectivity within low-rise building complexes or buildings with unique geometries, such as the Dubai Frame (UAE), the Interlace (Singapore) or so-called "landscrapers".

### 3.3. MULTI Underground

Inspired by the design options offered by MULTI, architect Chris Williamson (Founding Partner at Weston Williamson+Partners and specialist in public transport station design) came up with several ways that MULTI could enhance the accessibility of underground stations and solve the limitations caused by our current dependence on escalators for reaching underground platforms.

Today, people who travel on subways must often descend several levels, passing through long corridors and going down multiple escalators before they reach a train. If there is an elevator, it has limited handling capacity. Both of these options can be time-consuming and stressful for commuters. This, however, can be changed.

Since MULTI significantly increases handling capacity and reduces the waiting time for elevators, it would be possible for many more people to use elevators instead of escalators. Furthermore, due to the speed and handling capacity of MULTI, it would be possible to build deeper metro lines that could bypass the complex infrastructure underground. Seamless connections between buildings and metro lines would also be feasible.

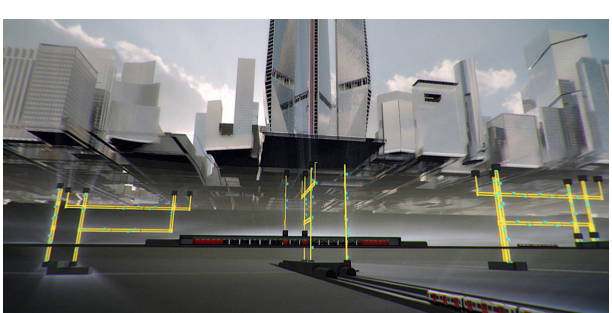

**Figure 3.** Quick, high-volume connections between metro, land & building

### 3.4. Higher levels of connectivity - MULTI and skybridges

Skybridges between buildings have existed for years, but they have recently moved beyond simple architectural novelties. Now, they are widely seen as part of a new revolution in urban connectivity. That is because new thinking and technologies dramatically expand the practical potential of skybridges - making them multi-functional architectural components that promise exciting design opportunities. Skybridges may soon become expected and indispensable features of any new building.

The benefits are obvious. Urban real estate is expensive. The empty spaces between buildings can be profitably used, providing additional amenities for residents and tenants. They offer a new plane for social interaction and communal spaces at the upper levels that are normally only possible at the street level. Furthermore, skybridges offer better integration of electrical, water, HVAC and building management systems, and can provide fail-safe system redundancies and alternate emergency escape routes.

Skybridges also offer benefits for mobility, saving time for people who need to move between two (or more) buildings. The MULTI system provides designers with their first major tool in using skybridges to seamlessly bridge the gap between buildings. Architects may even be encouraged to rethink the entire architecture of buildings. In the meantime, skybridges are putting significant horizontal urban habitat in the sky within reach. Using skybridges, MULTI will provide the connection between buildings, streets and sky - as well as between people.

**Figure 4.** Building-to-building travel via skybridge.

## 4. Conclusion

We currently remain in a phase of two-dimensional urban mobility. This is because, so far, there are only a few possibilities to connect people, buildings, and cities efficiently. The future of urban mobility must establish a dialogue among city, buildings, transport systems and inhabitants. Only then can a sustainable and forward-looking transport system work, which has a lasting impact on the everyday life of people in cities. With customized passenger transportation, more sustainable solutions can offer a real alternative to cars and thus facilitate shift from road to rail.

MULTI from thyssenkrupp Elevator has the potential to play a significant role. Not only can building shapes be completely re-imagined, but the use of artificial intelligence and algorithms will also allow MULTI to communicate easily with the cities of the future. This can revolutionize transportation within cities - because MULTI is truly digital and can become the heart of a smart city.

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