

MAXIMIZING CITY EFFICIENCY

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IN A **MAX CONNECTED CITY**,
ELEVATORS WILL RUN **MORE
CONSISTENTLY**, OFFERING
ADDITIONAL AVAILABILITY,
MEANING MINIMAL STRESS
AND **MORE QUALITY TIME**.

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CHAPTER 1 FOREWORD



By the end of the century it is estimated around 70 percent of the global population will be living in urban areas. In this century of cities and age of smart technology, companies must play an intrinsic role in shaping urban landscapes to ensure cities of the future are as efficient and sustainable as possible.

thyssenkrupp Elevator joined forces with Microsoft to create MAX, a game-changing predictive and pre-emptive maintenance service solution to revolutionize the elevator industry. By tapping into the Internet of Things (IoT), MAX is capable of identifying in real-time the need for replacements in components and systems before the end of their lifecycles.

MAX will therefore help play a pivotal role in keeping our cities moving more efficiently, and improving the safety of the 12 million elevators worldwide that perform 7 billion trips, and transport more than a billion people each day. In a MAX connected city, elevators will run more consistently, offering additional availability, meaning minimal stress and more quality time.

MAX will also act as a wingman to elevator service engineers, effectively telling them the elevators' service needs - which is a huge step from today's remote monitoring - and informing building owners in advance when key systems need to be repaired or replaced.

This report provides more background on why and how MAX was created, as well as offering views on how this technology has the ability to transform other industries.

We will also explain where MAX is currently being installed and plans for global roll-out, in line with our aim for MAX and other data-driven technologies to be available to 80 percent of elevators worldwide in the near future.

Our aim is to revolutionize an industry that has not generated truly game-changing technology in more than a century. Through this partnership with Microsoft and unique technology MAX, we are taking the elevator industry into the digital era and transforming the way it offers maintenance to benefit people's daily lives.



Andreas Schierenbeck
Chief Executive Officer
thyssenkrupp Elevator

CHAPTER 2 THE THINKING BEHIND MAX

CONVENIENCE AND THE EXPECTATION OF IMMEDIACY

Today's world operates at a fast pace. The internet has revolutionized the way we live our lives, and - accompanied by ever-advancing developments in the field of technology - has established a global culture of convenience that has made immediacy not just a possibility but an expectation in almost every aspect of our daily routines. Time has become a more valuable commodity than it has ever been before.

In the elevator industry, wasted time is a global issue, and one that has an impact that reaches far beyond people's daily lives. A study undertaken by Columbia University students found that in 2010 alone, New York City office workers spent a cumulative 16.6 years waiting for elevators to transport them around buildings. These redundant hours can not only trigger detrimental health and emotional effects, such as increased stress and anxiety levels, but also significantly impact the efficiency of the businesses they work for, and the cities in which they are located.

According to a recent economic report, for office workers, just 49 minutes of wasted time each day equates to a massive £26 billion loss to the UK economy over the year. Even spending just five minutes of this time waiting for elevators would have a significant impact.

The consequences of wasted hours are amplified when applying these statistics at a global scale. There are currently 12 million elevators in operation across the world transporting more than one billion people every day. The elevator is the most used (and safest) method of transport, but in just one 12-month period, it is estimated they are rendered unavailable or out of service for an average cumulative total of 190 million hours – the equivalent of 108 centuries. This figure is so large it is almost intangible, but the negative effects on efficiency are in fact very real. Finding a means of increasing the availability and efficiency of elevators is an urgent priority, to give city buildings, plus the people and businesses inside them, the best potential for optimum productivity.



CONSIDERING THE CAUSE

When addressing a problem it is important to consider its cause. In the case of elevator inefficiency it is the disconnect between traditional elevator maintenance procedures and the everyday needs of the modern urban environment. As our cities have expanded and evolved, the services and processes demanded to operate them properly have changed. Since 2000, the number of high-rise buildings (>200m) has tripled and over 180 buildings currently under construction are more than 250m tall.

The average height of buildings is also surpassing past expectations. In 2000, the average height of the world's 50 tallest buildings was 315m (approximately 90 stories), while in 2013, that same average reached 390m (approximately 111 stories); a 25 percent increase in just one decade.

Increased traffic places greater strains on building services, and unfortunately elevators have not developed at the rapid pace to accommodate these demands. The gap between what is needed and what is being delivered has made optimum building performance nearly impossible.



TRADITIONAL ELEVATOR MAINTENANCE

That is not to say, however, that elevator maintenance has not changed at all over time. The Equitable Life Building completed in 1870 in New York City was the first office building to have passenger elevators, and for a long time since then maintenance services were only provided in reaction to a breakdown. Technicians would be called to fix an elevator when it had a fault or stopped working.

Recognising the limitations of this responsive approach, the industry shifted tact in the 1950s and established preventative maintenance practices to try and ensure elevators were fixed before they broke down. With the ambition to lengthen the service life of elevators across the world, more and more building developers commissioned remote monitoring services to alert the elevator company when a breakdown had occurred. Yet while setting the scene for more proactive repair solutions, this system did not achieve the level of efficiency the elevator industry could offer if applying the most advanced digital technologies.

Remote monitoring of elevators and escalators appeared in the late 1980s. While remote monitoring would alert the lift company when a lift had a breakdown, it did not in and of itself reduce the number of breakdowns.

A decade later in the 1990s, the model evolved to usage-based maintenance – a concept based around adjusting the level and frequency of repairs dependent on each elevator’s usage. This method had been adapted from the automobile industry, where motor oil was often changed based upon distance travelled. In the elevator industry this paved the way for gradual progression towards more condition-based repairs.

Each of these developments demonstrated the ongoing industry intent to increase elevator efficiency levels and develop better customer service. While these systems were in line with the services and technology available at the time in which they were introduced, fast forward 20 years and the evolution of cities has rendered these methods ineffective and unsuitable for modern-day building needs. A new methodology with the power to take the learnings of these earlier maintenance systems and incorporate the benefits of the new systems and technologies we now have access to, was needed to create a new efficient and effective practice for elevator repairs to enhance overall building efficiency.

That’s why we at thyssenkrupp created MAX.



Seoul cityscape, South Korea



THE MODERN SOLUTION - MAX

thysenkrupp Elevator's newly-developed data-driven maintenance technology, MAX, incorporates the efficiency targets and operational learnings of previous repairs processes, and amalgamates them with newly available technological solutions to create a modern and advanced system.

Similar to the 1980s approach, MAX is based on remote monitoring reports of the usage and condition of the elevator. However, in a modern twist that combines this traditional approach with 21st century functionality, these real-time reports are transmitted to Microsoft's trusted Azure cloud platform, where intricate algorithms apply machine learning. Calculations are made to work out the remaining lifetime of key components and parts, before the flagged issue is then interpreted and translated into a prediction of which specific component will require maintenance, and when. Pre-emptive repair notifications are then flagged to a service engineer, who is better able to schedule and undertake his maintenance duties; minimizing disruption to both the other elevator assets and the passengers using the elevator.

Using data to support original thinking and predict future events is not a new phenomenon. Retailers, technology firms and communications companies have all used this approach. The amount of data available for us to access at any given time is so vast it is almost unquantifiable.

According to IBM, in 2012, 2.5 exabytes – equivalent to 2.5 billion gigabytes – of data were generated every day. This is the same as downloading 500 billion songs.

These colossal figures are being driven continuously higher by what is now an inherent use of internet-based systems in our lives. This would have been simply inconceivable even ten years ago. Scientists, for example, use seismic activity data to predict earthquakes and recommend effective damage limitation activities. Transport authorities use real-time data collection to deliver service notifications and limit passenger disruption. In the elevator industry however, a system that is able to interpret building component data into meaningful information to improve service is unique, and marks a milestone turning point in the future direction of building trends.

The development of MAX means maintenance tasks can be scheduled ahead of elevator breakdowns; increasing what is known in the industry as Mean Time Before Failure (MTBF). This data-driven approach also enables a recommendation for pre-emptive action that if taken can ensure continuity of service.

MAX IN ACTION

As an example, if the remote monitoring detects a repetitive increase in door motor current, then MAX can recommend additional door maintenance services are delivered during the service engineer's next visit to the building. If the increase in current is more sudden and unexpected however, MAX will flag the part is likely damaged and requires more immediate and urgent action to fix the issue before the whole elevator system fails.

Elevators already are the safest mode of transport in the world, and MAX can even further improve those statistics. Better maintenance interventions planning can only serve to keep equipment condition always at its best and secure optimized verification on the procedures.

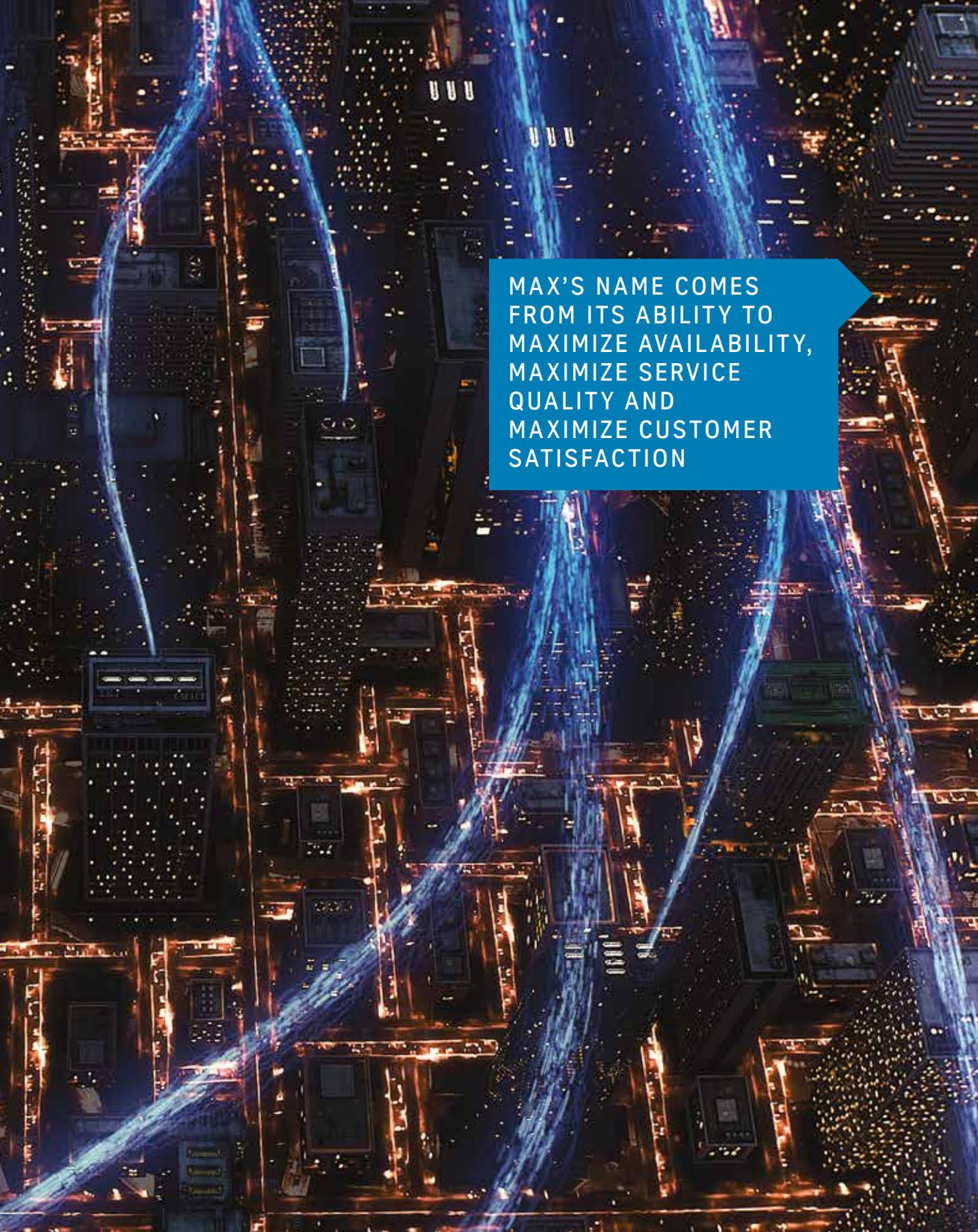
MAX marks the future of elevator maintenance. Facilitating continual elevator usage, this smart technology has the ability to cut elevator downtime by 50 percent. Scaling these individual building savings to match our growing cities allows us to understand the unprecedented impact this technology can have on urban efficiency. Elevator waiting times will dramatically reduce, and time – the holy grail of the busy 21st century world – can be given back to people.



MAX also marks a game-changing moment in the relationship between elevator providers and building managers, transforming sometimes negative, reactive service into a more positive, proactive approach. With MAX, thyssenkrupp's global team of over 20,000 service engineers have a fact-based 'wingman' to alert them in advance to pre-issue repairs.



Sergio Cardoso
Executive Vice President Field, thyssenkrupp Elevator

An aerial night view of a city grid, where the streets are illuminated with warm yellow and orange lights. Overlaid on this grid are several glowing blue fiber optic cables that snake across the city, connecting different points. The cables are thick and have a shimmering, multi-strand appearance. In the center-right of the image, there is a blue arrow-shaped callout box pointing to the right, containing white text.

MAX'S NAME COMES
FROM ITS ABILITY TO
MAXIMIZE AVAILABILITY,
MAXIMIZE SERVICE
QUALITY AND
MAXIMIZE CUSTOMER
SATISFACTION

CHAPTER 3 BRINGING MAX TO LIFE

HOW MAX WAS CREATED

MAX was purpose-built after executives from thyssenkrupp Elevator and Microsoft began a conversation at a conference back in 2013. As their teams met to discuss the Internet of Things, together they realized the potential to incorporate a data-driven approach to thyssenkrupp elevators across the world.

The moment of discovery for MAX came when Microsoft data scientists and thyssenkrupp's elevator experts combined data insights with tactical experience. The result was a team and a platform that utilizes real-time data to transform the elevator industry's approach to service performance and efficiency.

MAX draws on the insights of dozens of Microsoft data scientists and software programmers, as well as thyssenkrupp service and maintenance engineers, to create a game-changing solution capable of turning the elevator industry on its head. The platform also includes the latest technology from Microsoft, the Azure IoT Suite, which is engineered to help businesses roll out IoT solutions even more quickly.

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Collaborating on research and development with thyssenkrupp was a learning process for both teams. The data from thyssenkrupp's vast systems was diverse, challenging our data analysts to draw lines of correlation that would enable meaningful interpretation.

Through a continued process of assessment and evaluation, the team not only applied the power of compute to enable predictive analytics but also to lay the foundation for even more proactive energy - and people-efficient services in the future.

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Sam George

Partner & Director of Azure, Internet of Things, Microsoft



POWERING MAX

Microsoft's trusted cloud platform, Microsoft Azure, provided the ideal support for a personalized cloud infrastructure for MAX.

With tens of thousands of connected elevators and assets collecting data, thyssenkrupp harnesses the power of Data Driven Maintenance to provide actionable insights into their business. Machine learning and advanced analytics allows the MAX algorithm to know why a fault or breakdown took place in the past and also documents the root cause of the issue. From this analysis, the system can independently make a reasoned prediction as to what will happen to the same component in the future.

The level of detail MAX provides to thyssenkrupp's maintenance control hub is vast, yet also specific. For example, MAX shows the type of elevator, such as a freight or passenger cabin. It also shows the model and the real-time data around the landing spaces. It is possible to see which floor an elevator is being called most frequently from and to, as well as real, sensor-level details, such as what the average door-close and door-open time is. All the information that is needed to establish the predictive health of an elevator and its components, and move the thyssenkrupp business model from reactive to proactive, is all there.

It is a milestone development.



MAX represents an opportunity to leverage the power of Azure IoT solutions to transform a business – one that will continue to evolve over the coming years. Data-driven and IoT technologies are creating a new category of best-in-class applications that are going to be born in - and live in - the cloud.



Sam George

Partner & Director of Azure, Internet of Things, Microsoft





MAX is a revolutionary technology in the elevator industry and falls exactly in line with where we believe the elevator, and wider construction industry is headed. The Internet of Things provides a global opportunity to improve service – utilising hard data and proven statistics to support our work. It provides an invaluable monitor for our maintenance workstream and a real step forward.

As the world continues to 'go online', the potential for MAX technology will only increase. With the combined computer power of the cloud, the Internet of Things and data we are at a unique point in time where we are seeing businesses - and lives - transformed. Now is the right time to launch the product to market and we look forward to seeing how it evolves in the coming years.



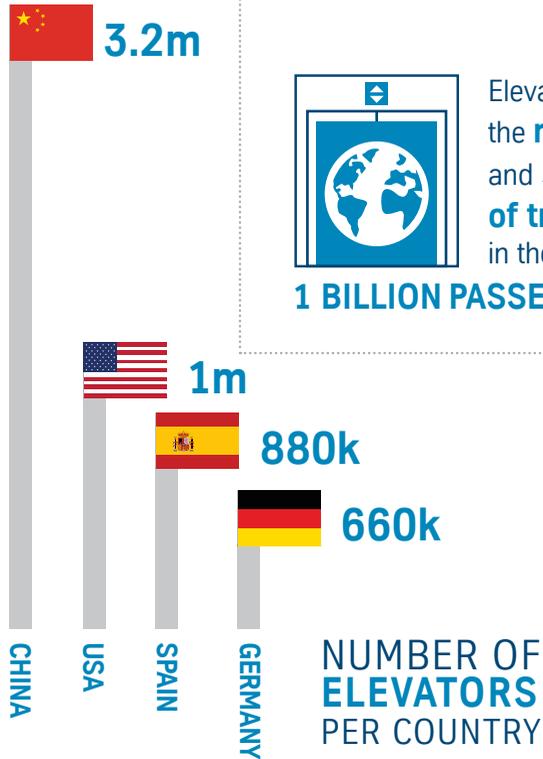
Fabio Speggorin

Executive Vice President of R&D, thyssenkrupp Elevator



CHAPTER 4 MAX FACTS

ELEVATOR MARKET



Elevators are the **most used** and **safest form of transport** in the world

1 BILLION PASSENGERS a day ²

12 MILLION elevators in the world today ³

Number of trips elevators make every day **7 BILLION** ⁴

2+ BILLION motor vehicles in the world today ⁵

4.3M DAILY USERS on NYC Metro ⁶

4 MILLION JOURNEYS EVERY DAY LONDON UNDERGROUND ⁷

BIG DATA BRINGS A GREAT OPPORTUNITY TO IMPROVE EFFICIENCY OF THESE JOURNEYS

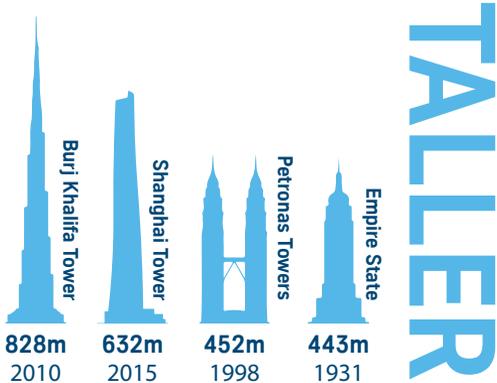
REFERENCES: 1) thyssenkrupp | 2) thyssenkrupp | 3) thyssenkrupp | 4) G. Pederick, How Vertical Transportation is Helping Transform Modern City: CTBUH 2014 | 5) tfl.gov.uk | 6) Navigant Research, 2014 | 7) NY.com

URBANISATION

70% of the global population will be **living in cities** by **2050** ¹

3 BILLION people due to **move to cities** during the next **30 YEARS** ²

BUILDINGS ARE GETTING



THE VALUE OF THE GLOBAL ELEVATOR MARKET IS INCREASING

REFERENCES: 1) UN-Habitat, 2010 | 2) UN-Habitat, 2010 | 3) Tallest Buildings in the World, Wikipedia | 4) thyssenkrupp

CITY EFFICIENCY



BUILDINGS consume **40%** of the world's energy
ELEVATORS = 10% of this ¹



190 MILLION HOURS cumulative time the world's elevators are **'unavailable'** due to service maintenance ²

16.6 YEARS cumulative time wasted by New York City workers waiting for an elevator in 2010 ³

MORE EFFICIENT ELEVATOR SERVICE PROVISION AND MAINTENANCE WILL LOWER CO² EMISSIONS

REFERENCES: 1) B. Nemeth, Energy-Efficient Elevator Machines; thyssenkrupp Elevator 2011 | 2) thyssenkrupp | 3) IBM Smarter Buildings Study, 2010

CHAPTER 5 MAX THE WINGMAN



thyssenkrupp Elevator technicians

thyssenkrupp's global team of 20,000 service engineers will benefit from MAX's ability to predict maintenance issues before they occur and minimize any disruption caused within a building. With MAX on their side, engineers will be able to offer a more predictable and streamlined service to minimize elevator downtime and the stress that accompanies it.



As a service engineer, we are working on what is in effect the front-line of service. To our customers, we are the face of the thyssenkrupp Elevator brand, and our ability to build rapport and a strong relationship with customers is critical in both maintaining and growing our business.

As you will know from your own personal experience, elevator faults and failures are incredibly frustrating for all involved and can cause disruption, discomfort and inconvenience. As these affected individuals field their complaints to building staff, such as receptionists or building managers, these people - our customers - are often unhappy when we arrive to undertake maintenance.

MAX is an innovation that has the ability to transform our relationships with clients into more positive interactions. By anticipating problems in advance of them actually happening, we will be able to more accurately schedule maintenance work to ensure minimal customer and building user disruption. This will also enable us to positively re-frame our customer engagement – showing up at our customer sites as pre-emptive help, rather than when a problem has occurred.

MAX will also be particularly effective as a training tool. Service engineers like myself require a great deal of knowledge not just about the operational functions of an elevator, but also about the user patterns and requirements of the buildings they are responsible for. This learning requires a significant time investment, and as the urban world continues to grow at a rapid rate, we are at risk of falling short of the amount of fully-trained engineers required to service the growing elevator market worldwide.



Jeff Buntin
Elevator Technician, thyssenkrupp Elevator



This is a particular threat in regions where construction booms are driving up demand for elevator services. China, for example, is becoming more urban by the day, and its buildings are also getting increasingly taller. A recent report by the Council on Tall Buildings and Urban Habitat revealed that in 2014 China completed 58 skyscrapers; more than any other nation. To put this into perspective, the runner-up to China was the Philippines, which completed just five structures. The next decade is predicted to see further unprecedented growth in high-rise buildings in the country, spurred by the success of the recently completed projects.

Even in other markets where lower-rise buildings are the norm, elevators are quickly becoming the status quo in in-building design. The United States is one such example, where the demand for engineer staff is going to keep growing.

MAX will help service engineers like myself enhance our skills more quickly – providing the statistics to support and justify some of the maintenance predictions that many of us have been making for years. There is no replacement for the personal touch of an engineer, but now we have the ability to take the in-depth knowledge of elevator performance we already have and use MAX as a helpful reference point to ascertain the proactive repairs work we need to undertake.

MAX presents a great opportunity for us to sharpen our skills and reinvigorate our customer relationships. As one of the front-line faces installing future technologies like MAX and MULTI – I'm excited to see more and more of the technology introduced in the coming months and proud to be part of the team to change our industry for the better.



Jeff Buntin

Elevator Technician, thyssenkrupp Elevator





Shanghai World Financial Center, Shanghai, China

CHAPTER 6 BRINGING MAX TO MARKET



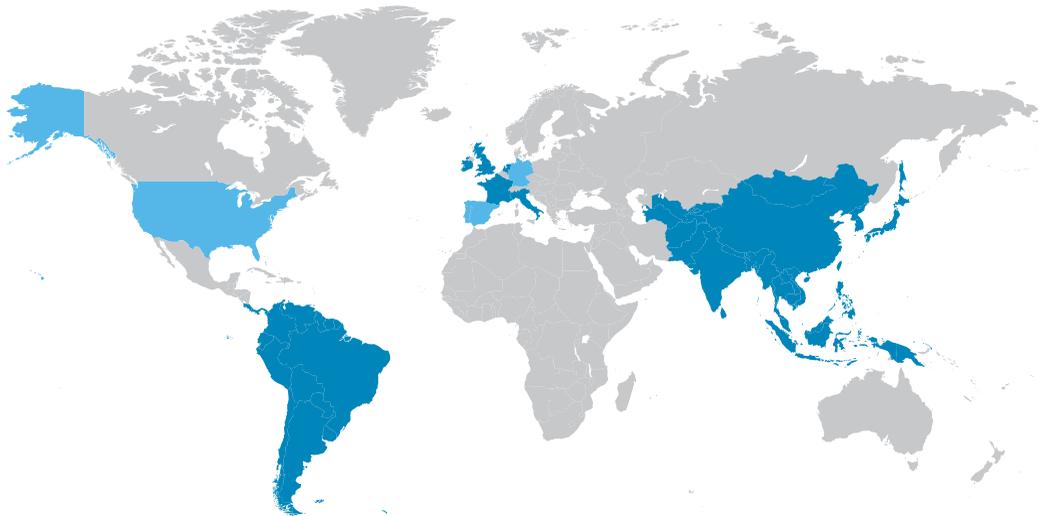
MAX is a key business growth strategy for thyssenkrupp Elevator and we are confident that during the coming months and years this innovative technology will become an integral part of elevator markets across the world. The phased launch approach allows us to introduce the solution in priority markets first and build its strength incrementally, to enable organic developments to be made in line with the constantly evolving market conditions.



Andreas Schierenbeck
Chief Executive Officer, thyssenkrupp Elevator

By **2017**, the first launch stage will see **180,000** units installed in **North America and Europe**

STAGE 1 ● **STAGE 2** ●



The MAX offering will become available to some **80% of all elevators worldwide** in the near future

Today, thyssenkrupp provides maintenance services at some of the world's most iconic buildings and transport infrastructures, including the newly opened One World Trade Center in New York and Denver Airport in Colorado, USA; the Panama Canal, Panama; the Metro Sao Paulo, Brazil; the BMW headquarters building in Munich and

the European Central Bank in Frankfurt, Germany; the Royal London Hospital in London, UK; the Madrid-Barajas Airport, Spain; the Federation Tower in Moscow, Russia; Dubai Airport, UAE; the World Financial Centre in Shanghai, China; the Shinsegae Centum City, Korea, and thousands of other buildings around the globe.

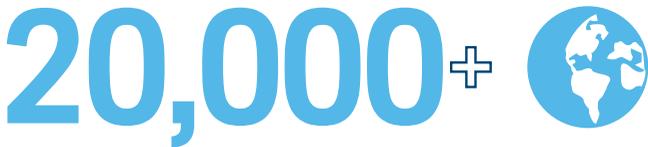


thyssenkrupp + Microsoft ENGINEERS & DATA SCIENTISTS involved in the R&D of MAX



will reduce out-of-service elevators by half

MAX can release 108 centuries in available elevator hours for every year of operation



thyssenkrupp global service engineers who will use MAX

REFERENCES: thyssenkrupp



MAX has the power to transform our cities

CHAPTER 7 MAX AND THE FUTURE

MAX AND THE INTERNET OF THINGS

The success of the internet has exceeded all expectations since its creation, and become so entrenched in our daily lives that transactions and activities that happen solely in the offline world, without any online influence or association, are becoming increasingly rare.

Statisticians have calculated there are approximately three billion internet users in today's world, and within five years as many as 50 billion machines (including computers, mobile phones and tablets) will be connected to the internet. Communication between these portals in the Internet of Things is already happening, however as the world becomes ever more web-driven there will be no limits to its potential to expand. The integration of the internet into business products and practices is therefore a natural step in the digital age.

The elevator industry presents a key commercial group that can harness the power of the internet to modernize its services and deliver results that meet the needs of both current-day and future populations.

The technology for data-driven maintenance has existed for more than a decade. However, until recently, it was cost prohibitive. Today we have fast and low-cost computing, and the cost of data storage is now a fraction of what it was just a few years ago. Low-cost data storage has made Big Data economically feasible. The internet is available almost everywhere in the world where elevators are located, and low-cost wireless data communication is also available globally. Cost and technology have therefore reached a point in time where the economic benefits of data-driven maintenance can more than cover its costs; plus it comes with an improvement in customer satisfaction.

MAX is a game-changing innovation, creating a level of flexibility that has not been an option before and setting the bar for other industries to utilize machine learning innovations to reinvent their operations.

MAX makes elevators and the engineers servicing them more adaptable to different situations, and more able to react in the appropriate way, rather than in off-the-shelf routines. It is a personalized approach that follows in the global trend, and expectation, for more customer-centric service delivery.

Data-driven maintenance such as MAX will change the way maintenance operations are conducted across the sector. More timely information about the performance of lifts will influence product development. For example, if a new component has a higher or lower failure rate than the component it replaces, it will be detected more quickly. If quality is defined by breakdowns per unit per year, then quality should improve. It could even be said that maintenance will evolve to be priced based on up-time. In the elevator industry, if we can achieve machine learning and data-driven maintenance properly, it will revolutionize the way building services are planned from the very early stage of the building process.

Currently, developers and elevator providers have to factor in time and costs for maintenance issues. Machine learning technology allows more prescriptive planning, enabling elevator providers to schedule exactly when and where repair work will be required and ensure this work is undertaken at times of minimal disruption.

MAX AND THE FUTURE: POSSIBILITIES IN OTHER SECTORS

Looking to the future, the drive to make services more reliable and more efficient will dominate all future business strategies and become inherent in every sector. Machine learning, facilitated by the IoT, is central to this plan.

The aviation sector has already established machine learning into its everyday practices, increasing safety and reliability. IoT-based systems will continue to catalyze changes in a number of ways. In buildings for example, air conditioning will be better regulated to prevent temperatures that are too hot or cold. Aside from delivering an optimum environment, this use of IoT data will help make our built environment more environmentally friendly; a key development considering buildings are responsible for 40 percent of the world's total energy consumption.

In the construction industry, it is particularly interesting to consider the potential for MAX as a training aid - especially in developing countries and rapid urban growth countries, where the demand for building service infrastructure is greater than the number of engineers available to do this work. China is a primary example here. In America today, there are one million elevators and escalators in operation. In China, half a million elevators and escalators are installed every year. This almost overwhelming market growth is a real challenge, but in helping to improve understanding and predictive ability for repairs, MAX can serve as a key partner to more quickly up-skill new elevator engineers so they are able to cope with this construction boom.

Re-balancing the supply/demand equation will also allow growth of the wider elevator market – which is not limited to high-rise growth. In the United States, 35-40 percent of new elevators being installed are in low-rise buildings. While efficiency gains will be larger in high-rise structures, MAX will improve efficiency in all markets.

As maintenance is a major source of revenue and profits for the elevator industry, the Internet of Things (IoT) has the ability to change the industry's entire maintenance business model. While improving efficiency will reduce repairs revenues for elevator companies, MAX is a top-line growth device for building contracts; improving customer satisfaction and increasing the potential for greater work retention.

Overall, data analytics will of course deliver unexpected results, and only time will determine how beneficial these results will be. However, there is no denying the potential for MAX to become a leading system in the elevator, construction and wider industries – and I believe it is safe to assume that the results of implementing this technology will benefit service providers and customers alike.



Professor Rory Smith
Director of Strategic Developments Americas,
thyssenkrupp Elevator



FKI Building, Seoul, Korea

To find out more about MAX please visit:
www.max.thyssenkrupp-elevator.com



www.thyssenkrupp-elevator.com
www.urban-hub.com
www.microsoft.com

