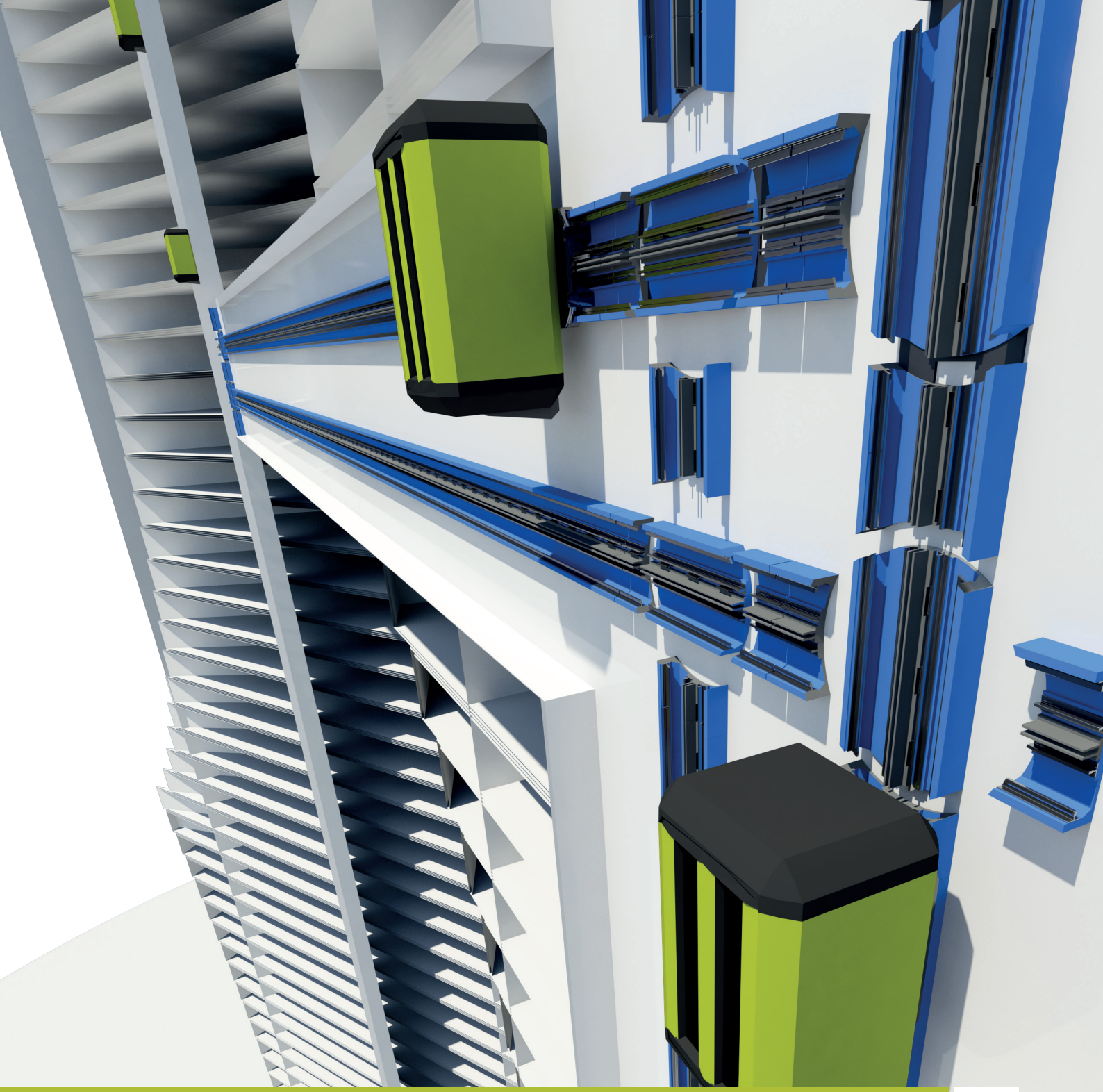


HEIDENHAIN

Traveling Vertically and Horizontally Without a Cable

HEIDENHAIN Measuring Technology for the Elevators of the Future

TECHNOLOGY REPORT

HEIDENHAIN Measuring Technology for the Elevators of the Future

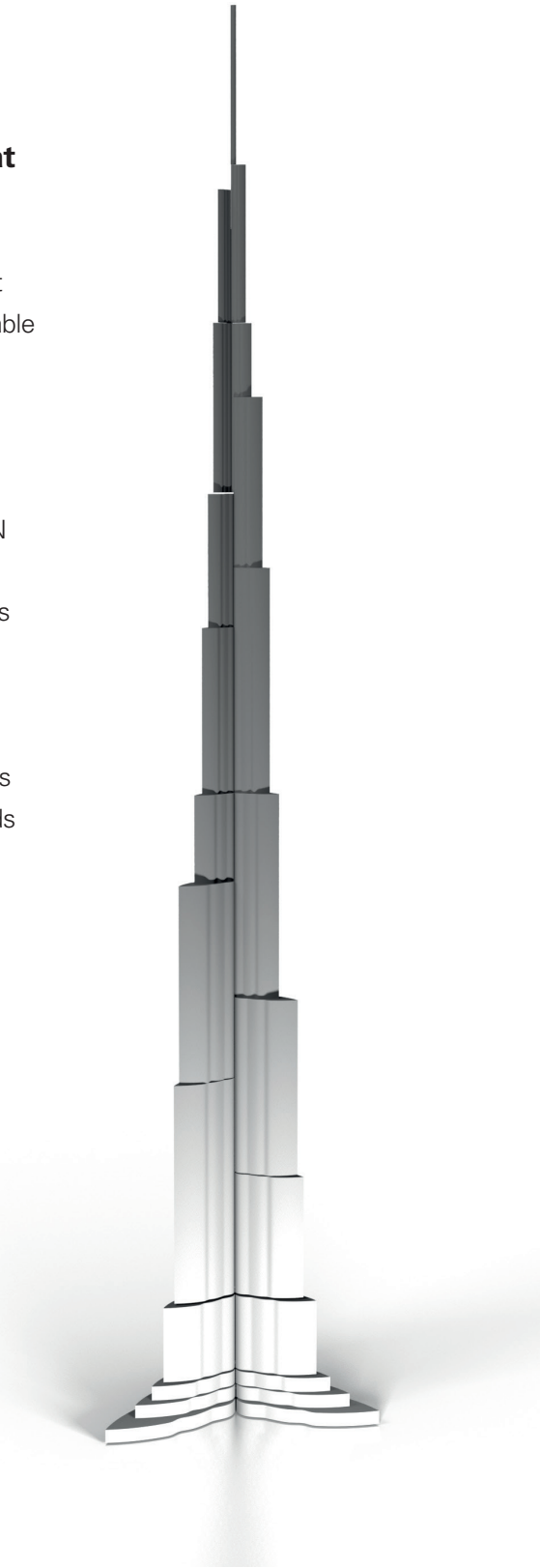
Traveling Vertically and Horizontally Without a Cable

An elevator cab that is not moved by cables—elevator manufacturers are already working on turning this vision into reality. And HEIDENHAIN provides the measuring technology that makes this operation safe and comfortable.

For most people, the term "elevator" means a cab that hangs from a cable and that transports people or freight up or down. This technology has become an indispensable part of our daily lives, and has achieved remarkable standards regarding speed, passenger comfort, and safety. For example, cable-bound elevators in modern skyscrapers move at speeds greater than 10 m/s and reach heights of over 400 m.

Modern measuring and control technology with rotary encoders from HEIDENHAIN that are designed especially for elevator technology ensure particularly pleasant acceleration and braking, a smooth motion, and exact stops. As a result, passengers barely feel the beginning and end of movement.

Also, the elevator stops so that its floor is even with the floor of the selected destination, in order to avoid tripping. In light of the immense number of passengers who ride in elevators every day, cable-bound elevators are one of the safest methods of transport anywhere on the planet. Nevertheless, there are good reasons for improving upon this successful technology.



New elevator designs for increasingly large buildings

Modern cable-bound elevators have two significant restrictions resulting from their design: Due to the weight of the cable itself, it is almost impossible to further increase the travel heights, and as a rule, only one cab can travel up and down an elevator shaft. This strongly limits the number of passengers that can be transported. However, the advances in the construction of large building projects present new challenges: Architects keep striving for ever greater heights and are building increasingly sweeping complexes that are visited by an ever growing number of people—whether for living, working, or shopping, or for spending their free time in fitness studios, movie theaters, restaurants, bars, etc. The elaborate

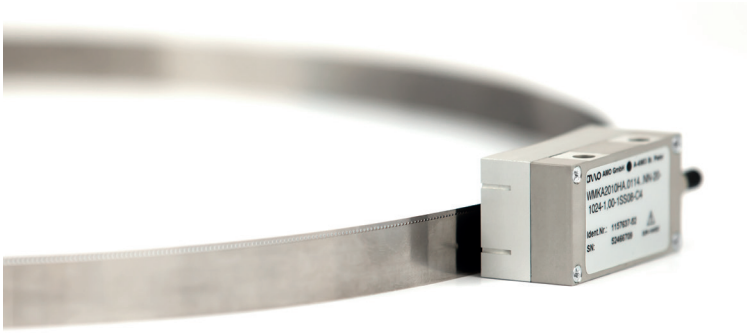
construction methods and structural analysis of such buildings at the same time also drive costs higher, meaning that there should be as much usable space as possible while simultaneously keeping traffic and operational spaces to a minimum.

With increasing passenger numbers, conventional cable-bound elevators require more traffic space in the form of additional elevator shafts, as well as additional elevator systems beyond certain travel heights.

AEF 1323 rotary encoder from HEIDENHAIN, with EnDat 2.2 interface and connections for a motor temperature sensor: dynamic drive control in cable-bound elevators for gentle starting, continuous acceleration, comfortable and stress-free travel, gentle braking, and stopping exactly at the intended position.

In order to realize the necessary performance regarding the number of passengers as well as the distances to be covered in such megabuildings of the future while still using the elevator technology of today, a correspondingly large number of elevator shafts would need to be planned for, as well as additional elevator systems for further travel if the buildings exceed a certain height. This would naturally detract from the very valuable usable space. However, since passenger capacities are calculated based on maximum utilization, the elevators would be severely underutilized most of the time. For example, in an office building there must be enough capacity for the large amount of traffic at the start and end of each work day,

whereas many fewer elevator cabs suffice during the rest of the day. That is why elevator manufacturers are looking for alternative solutions that not only do not limit the travel height, but at the same time also increase passenger capacity and even make it flexible.



Absolute angle encoders like the AMO WMKA with external scanning are suited for particularly precise position measurement on torque motors with large diameters.

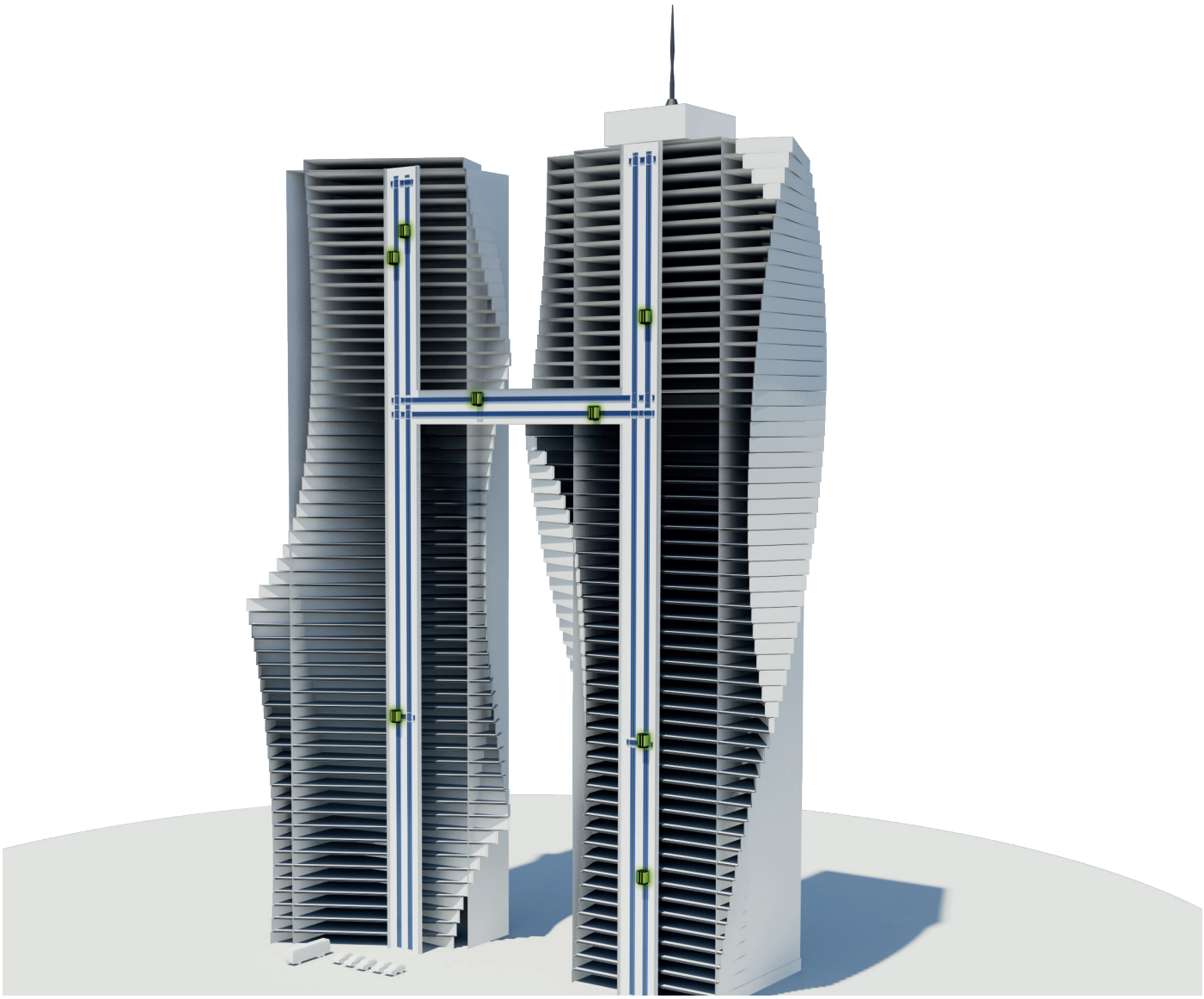
Into the future, without a cable

When looking for new approaches and solutions, one likes to weed out whatever is no longer necessary. Elevator manufacturers are currently considering weeding out the cables in order to build cable-less elevators. This technical idea borrows from the Transrapid, the high-speed magnetic levitation train developed in Germany, since the elevators of the future will be powered with the aid of direct linear-motor technology. The cab is equipped with passive magnets, and the active stator, divided into segments, is located in the elevator shaft. By appropriately providing current to these individual segments, multiple cabs can travel inside a shaft—independently of each other.

In addition to the vertical motion, this drive concept also permits horizontal motion. This horizontal motion makes it possible to use this new technology for the increasingly long level distances in tall megabuildings and in sprawling but connected building complexes. After a horizontal traverse, the cab can then move up or down in the shaft of another part of the building or complex.

Innovative measuring technology must rise to the challenge

This new transportation strategy requires a tailor-made measuring technology—on the one hand to ascertain the position information in order to control the cab's speed, and on the other hand for positioning and controlling a swivel joint when switching between vertical and horizontal travel. The main challenge presented to the motor control during the linear motion is the tolerance required for guideway deviations, since the control must simultaneously provide high signal quality for controlling the direct drive. Only excellent measuring signals reduce vibrations, permit dynamic motions, and significantly increase the speed stability, while at the same time avoiding the generation of additional heat. Passenger comfort is another important requirement, since the desire is for passengers to barely notice that the cab is starting or stopping. Last but not least, the change in direction from vertical to horizontal and back must of course occur exactly, safely, and without any jerk.



Cable-less elevators can move multiple cabs within an elevator shaft in a highly flexible manner and can move the cabs into a horizontal shaft—not only to make room for a passing cab but also to move them between connected buildings.

HEIDENHAIN's solution for these complicated requirements is the LINA 200: an inductive absolute linear measuring system with special properties. The absolute scale consists of two tracks with different signals periods, from which the absolute position value is then calculated. The EnDat 2.2 interface transmits this highly accurate position value to the subsequent electronics purely digitally. A special feature of this scale is that the two tracks are not located in one plane; instead, they face each other. The U-shaped scale design realized for this not only makes it possible to scan the measuring standard from both sides, but the double-walled design also protects the graduation and the scanning procedure itself from mechanical and electromagnetic influences. In addition, this type of construction provides maximum rigidity at a low weight. The U-shaped design also brings significant benefits regarding the mechanical sturdiness of the scale as well as the stability of the encoder signals.

Newly developed linear measuring technology for the demanding control of the linear drive

The graduation carrier of the LINA 200, with an overall length of 2400 mm, is attached to the elevator cab. The scale consists of four segments, each with a measuring length of approximately 600 mm. These segments are scanned by scanning heads that are placed in the shaft in a cascading alignment. This permits continuous position measurement over the entire distance traveled. Despite the generous guide tolerances of ±5 mm and ±4 mm, the LINA 200 achieves a small measuring step of approximately 2 µm. This means that it reliably supplies highly accurate positioning signals for the drive control of the cable-less elevator, while at the same time offering tolerances that are sufficient for permitting a real-world mounting strategy in the elevator shaft as well as for compensating for movements of the building itself.

The LINA 200, which was designed specifically for cable-less elevators, also attains peak values regarding dynamics and passenger comfort. Initial tests showed that traveling speeds of 6 m/s are achieved easily, and in the laboratory the LINA 200 provided reliable position values at speeds of up to 18 m/s. At slow speeds, as well as during acceleration after a stop and braking before a stop, the high resolution of the position values (18 bits) at a measuring length of approximately 600 mm ensures a very comfortable and gentle motion.

EnDat interface supplies diagnostic data

Furthermore, the signals from the scanning heads are so stable and reproducible that the diagnostic values for signal quality defined in the EnDat protocol permit conclusions about the mechanical tolerances of the guide rails. The LINA 200 therefore is not only a part of the drive control, but it also supplies data for the permanent diagnosing and status monitoring of the mechanism. This makes it possible to detect linear deviations during operation.

In this application the purely digital EnDat 2.2. interface offers yet another important and safety-relevant advantage. Strong electromagnetic interference fields usually arise around linear motors. The EnDat 2.2 interface has a high electromagnetic compatibility, and thus—as opposed to conventional transmission of analog signals—ensures safe data transmission even in this type of environment.

Indeed, the EnDat 2.2 interface for absolute encoders is not only available for the application-specific feedback systems for linear motors described here, but also in encoders for traditional cable-bound elevators. In these applications the encoders with the EnDat 2.2 interface complement the pure position-value acquisition with additional data, such as the diagnosis of the encoder's scanning signals for continuous status monitoring or the possibility of measuring the temperature at the motor winding.

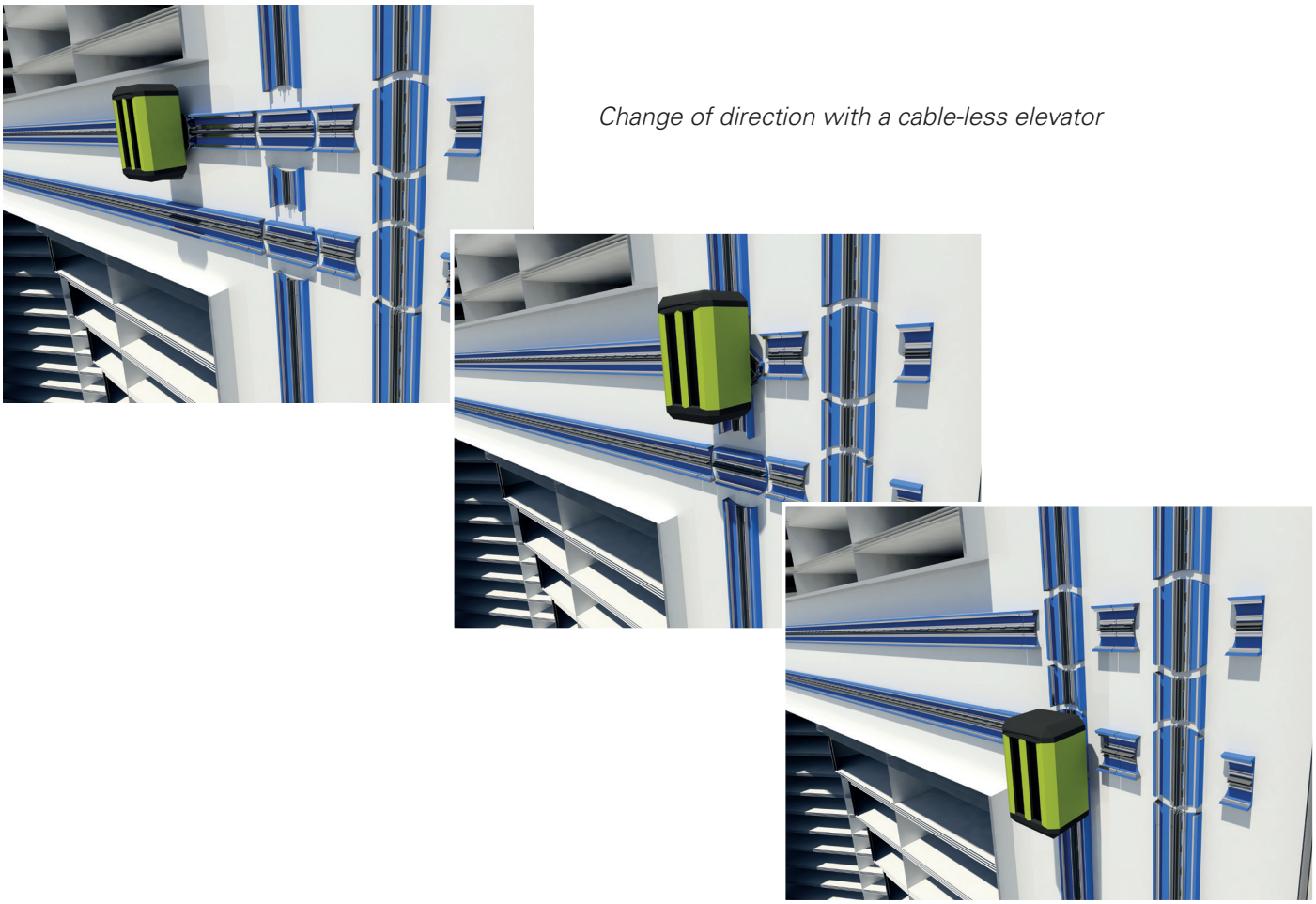
Angular measuring technology for positioning the swivel joint

In order to switch from vertical to horizontal travel or vice versa, the active stators and the associated scanning heads in the shaft as well as the passive magnets and the scale on the elevator cab must rotate by exactly 90° where the shafts intersect. This motion is brought about by a swivel joint in the shaft, driven by a powerful torque motor. The exact positioning of the swivel joint in the intersection is crucial for a smooth change in direction. Only if the linear components of the swivel joint are aligned exactly is a safe change in direction possible that is also free from jerks and oscillations.

The position measurement necessary for controlling the torque motor during the rotational movement is performed by a modular angle encoder from HEIDENHAIN. Like the LINA 200, it also features the powerful EnDat 2.2 interface. The angle encoder consists of a scale segment and the associated scanning electronics, and supplies the motor control with all data necessary for determining the current position of the swivel joint. It also digitally provides comprehensive additional data about the status of the elevator system at a high resolution.

Conclusion

Once again, measuring technology from HEIDENHAIN is proving itself in a challenging application. The skillful implementation of the optimum scanning principle in an encoder configuration tailored to the application, together with the features of the digital EnDat 2.2 interface, turns visions into reality.



Change of direction with a cable-less elevator

The new LINA 200 linear encoder for cable-less elevator technology: above, the U-shaped scale, which is attached to the cab; and below, the scanning head for mounting in the elevator shaft.

HEIDENHAIN

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