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THE KRAKEN OF ZURICH

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When the railway station in Zurich was built in 1847 as the terminus of the first Swiss railway line between Zurich and Baden, no one would have imagined how this station would develop and that one day it would be one of the busiest in Europe. With the renovation of the station in 1871 and the construction of the main hall, its future development was unknowingly but decisively influenced: the buildings constructed at that time are still standing today and are now listed as cultural heritage of national importance. To cope with the ever-increasing requirements and to enlarge its capacity over time, only one direction remained viable: to descend into the ground. Thus, beneath the surface of Zurich, the central station continues to grow to this day. It extends underground in all directions, while above ground the oldest parts remain predominant.

Thousands of people are drawn in and spewed out of the station every day. In a regular rhythm, its cavities are populated with flocks of people and left empty shortly after. Following the beating heart of the Swiss railway's timetable, the station projects its rhythm onto the people and the neighborhood. The departures and arrivals of trains have long ago ceased to be the only attraction at Zurich's central railway station. A multitude of different functions have been put in place to satisfy the needs of its visitors. For example, more than sixty restaurants and cafes offer refreshments, and more than a hundred retail businesses invite customers to go about their daily affairs. This is accompanied by delivery areas and storage rooms, production kitchens and waste disposal stations, ventilation systems, passenger and cargo escalators, recreational rooms, and connecting corridors. Additionally, a large civil protection facility has been incorporated in the maze of corridors, to provide refuge for citizens from all over the city in case of a disastrous emergency. Ultimately, the subterranean structure has extended to the adjacent buildings and forms a connection across neighborhoods. From the Europaallee to Zollstrasse, buildings can be reached through interconnected spaces underground.

The process of accumulating diverging uses can also be observed in other areas, for example in shopping malls, where hundreds of shops

Fig.16 Zurich Main Station, 2018.
Hoizontal section.
By Scanvision

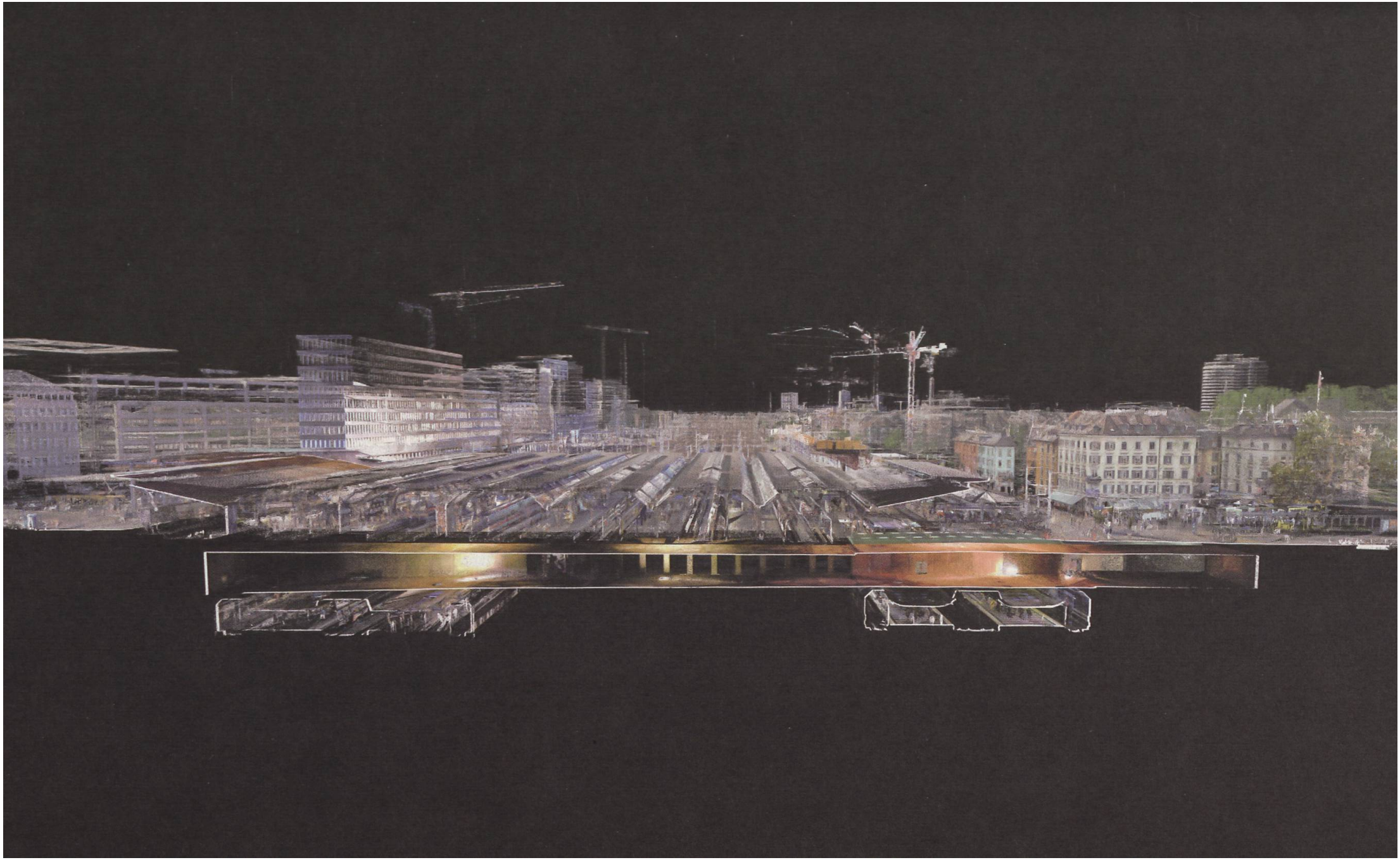
and restaurants line up and are arranged in clearly discernible cubes. In the underground of Zurich's railway station, however, the situation is somewhat different due to its asynchronous expansion and growth over time. Thus, rail traffic, pedestrian circulation, and bicycle passages interweave with shopping, production, and commercial services. Little by little, the station has spread out with long tentacles underneath the city. The spaces are sometimes higher, sometimes lower, always depending on their function and their adjacent surroundings. Serving and served spaces wind past each other, sometimes above, sometimes below and then again alongside each other. The areas situated near the busiest passages are enlarged, while the calmer areas remain unchanged. The spatial form of the underground structure resembles less a human architecture than an organism growing in the ground. Hidden from sight, it expands where the resistance is least and the benefit greatest. Or as Rem Koolhaas puts it in *The Generic City*:

The city of Zurich has found the most radical, expensive solution in reverting to a kind of reverse archaeology: layer after layer of new modernities – shopping centers, parking, banks, vaults, laboratories – are constructed underneath the center. The center no longer expands outward or skyward, but inward towards the center of the earth itself.[1]

Hence, the expansion process in the underground is relentlessly progressing to the present day. When one construction site is closed, the next one is already set up. The number of unused cavities seems endless, as does the possibility of penetrating further and deeper into the earth. Building under the ground follows its own rules and results in unique, unfamiliar settings and spatial configurations. Due to the lack of perception of the outer form, the built spaces remain elusive. When visiting the station, one only perceives the interior spaces of the subterranean buildings. Orientation in these atypical buildings is difficult, as there is no reference to the outside world.

1 Rem Koolhaas, "The Generic City," in Rem Koolhaas, Bruce Mau, *Small, Medium, Large, Extra-large: Office for Metropolitan Architecture*, 2nd ed. (New York: The Monacelli Press, 1998), 1239–1264, here 1249.

Fig.17 Zurich Main Station, 2018. Cross section. By Scanvision



An Attempt to Capture Space

For the exhibition Einfach Zürich[2] at the Swiss National Museum in 2018, we began to capture Zurich central station with laser scanners to create a three-dimensional, digital model. Since then, the exhibition has been portraying the station, its premises, and adjacent surroundings on a three-sided, large-format projection. In virtual flights, visitors travel through the different floors, corridors, and levels of the station. In the process, one encounters everyday realities such as motionless commuters waiting on the platforms, hidden places such as the decommissioned motorway tunnel or the tamed River Sihl, and unknown areas such as the maze of production kitchens beneath street level. Sections are laid through the model, floor plans are extracted, overviews and detailed shots of individual rooms are shown, achieving a spatial understanding through audiovisual continuity. The collected data was not only used for the long-term exhibition, but also served as the basis for research projects at ETH Zurich. The research investigated questions of spatial orientation and perception in the underground, among other things, as a virtual reality application. In the research context of large-scale digital modeling at the Landscape Visualization and Modeling Lab,[3] the case study of Zurich's central station is still one of the most extensive and detailed models acquired and processed with point cloud data. To capture the different areas of the station, different recording techniques were applied and several acquisition methods were combined. Within these, terrestrial laser scanning accounted for the largest share of the recordings.

When scanning on site, one spends a lot of time on location, as confronting oneself with the space and becoming familiar with it is crucial for finding suitable positions for the scanner. The scanner records all visible surfaces from one point of view, without evaluating the reflected spatial information. To communicate one's own imagination of a space, however, one must appropriately position and operate the scanner to capture the aspects that subjectively seem important. One becomes a scanner oneself, searching the space for attributes that are important for the spatial interpretation. The human perception of the

2 https://einfachzuerich.ch/ausstellung (accessed June 6, 2022).

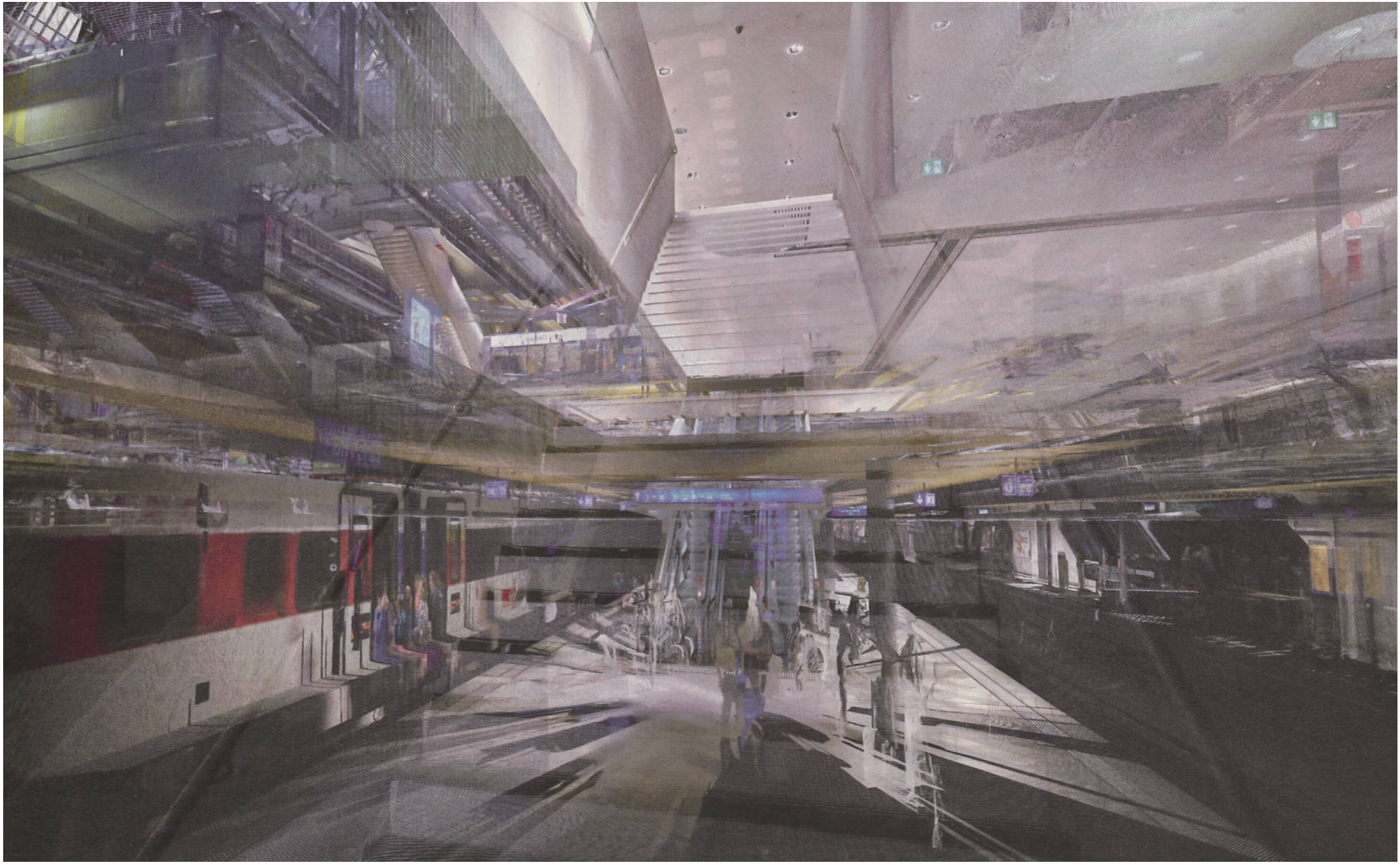
3 https://lvml.ethz.ch (accessed June 5, 2022).

physical space is deepened during this process of intense interaction. One learns about the visible obstacles and features, estimates their spatial dimensions and relative distances, and analyzes their visual power. This methodological approach to spatial perception applies to the work in the central station, as well as to the student work in the topology courses. The engagement with spaces on site shapes the subsequent interaction with space, whether through representational, analytical media or through design interventions.

Ultimately, the terrestrial recordings were combined with the city-wide airborne surveys by the Canton of Zurich,[4] resulting in a geo-referenced digital replica of the railway station consisting of several billion measurement points. The measurement points – a list of spatial coordinates and color values – can be displayed as a three-dimensional colored point cloud. However, the great accuracy and attention to detail contrast with an obvious lack of completeness. Since no additional geometries are generated during the process, gaps in the recordings are not filled. Every point in the model is measured; every gap is visible.

The recording process itself offers potential for distortion and mismeasurements for a variety of reasons. First, the duration of a recording is related to the space or object being recorded. If objects move during the recording, a distortion will occur in the recorded geometry. If one records large areas with countless scan positions, objects like trains may disappear; commuters stream through the halls, and the position of the sun and its shadows change. The rigid image of the environment created by the point cloud is therefore composed of different states in time. In some ways like a long-term exposure in photography, this recorded superposition never existed in reality. Although these "errors" may be addressed, they sometimes represent the character of the recorded location in an exemplary way. For example, the people passing by, normally considered a disturbance for the purpose of measurement, are registered as figures in motion and become a distinctive feature of the highly frequented space. Paying attention to the regular intervals of the timetable made it possible to scan either the rooms and their walls or the life within them, which inevitably covered the walls every half hour and filled the recordings with moving figures.

4 The canton of Zurich provides open access to LiDAR models as part of their public data initiative: https://maps.zh.ch (accessed June 23, 2022).



Viewing and Working in the Point Cloud

Viewing a point cloud model and working in it on a computer changes the perspective on the space once more. When recording on site, memory creates an image of the space that only partially corresponds to what one recognizes in the model. The selective perception and memory on site differ from the impartial scanning of the laser scanner. The model, which is based on individual points, does not distinguish between built architecture, furnishings, surroundings, or terrain. Even complex geometries such as vegetation or the chaos of everyday life are registered equally and become part of the model. This stands in contrast not only to many abstracting documentary media such as two-dimensional plans or maps but also to our selective perception on location. One recognizes the observations made on site, but many other details, objects, and spatial attributes also appear that one has not noticed before. Depending on the position of the scanner, these new features may even be more striking visually than in memory. Although a clear idea of the space might already exist, it is revised during the viewing of the model and supplemented over time, perhaps even modified in parts. In the model, one moves through the same space previously observed in reality, but the attributes important to our perception of the space change in the digital realm. The space is reconstituted, and the human perspective is supplemented with a multitude of possible perspectives in the model.

The punctuated structure of the model is the result of an interplay between information, meaning points, and their intermediate spaces. The relationship between these results in the perception of transparency. If the density of points becomes smaller and thus the spaces in between larger, the model dissolves in perception, walls become invisible, and spaces in the background appear. In this way, spatial relationships can be revealed, "impossible" viewpoints can be assumed, and novel renders can be generated. When looking at a point cloud model, movement becomes an essential aspect to correctly perceive spatial order and

Fig.18 Zurich Main Station, 2018.
Film still from the exhibition "Einfach Zürich" at the Swiss National Musuem.
By Scanvision

transparency. It allows the layers of points tiered in depth to be put in the right order, extending our perception into the depth of the model. Moving around the model using a virtual camera allows an unexpected new experience of a place. In addition to the expanded spatial impression, scales can also be bridged: from the overview or bird's-eye view to the human perspective or close up, a coherent spatial continuity is represented, thus sharpening the understanding of the place.

In addition to the visual modeling of the central railway station, spatial sound was also recorded. These recordings could be positioned as geolocated sounds within the digital model to enrich it with a further sensory perception. The sound can convey additional spatial qualities such as materiality, reflectivity, reverberation, or temporality. For these reasons, the acoustic dimension has become a main research topic at the Chair of Landscape Architecture. It was introduced in the doctoral thesis of Nadine Schütz[5] and continued in various projects by Ludwig Berger and Fabian Gutscher.

Through recording, viewing, and editing, one's own perspective on a place manifests itself. To communicate this impression, a medium must be chosen and thus the desired perception (or an image of one's own perception) must be created. The digital image of a point cloud model transports a reflection back onto the no longer apparent reality. An understanding of the space created in the process of point cloud modeling now becomes a first impression for the recipient of this image or the moving images. A new perception of a real space is created through the representational possibilities of a point cloud that cannot be experienced in reality. The detailed images quickly create a relationship between what the viewer knows and sees. Through the movement in the point cloud, the spatial organization can be clarified, and the viewer's gaze glides into the spatial depth. The boundaries of space open and close, separate and connect depending on the point of view. Without adding or subtracting elements from the space, the point cloud creates an arrangement of a specific perception.

5 Nadine Schütz, "Cultivating Sound: The Acoustic Dimension of Landscape Architecture," PhD thesis, ETH Zurich, 2017.

Learning from Experiments

In both the Zurich central station and in the students' case studies, the working process on site as well as being able to learn while handling in the digital model were of crucial importance. The methodology combines digital working methods with a necessary survey of the physical sites. This not only leads to insightful results at the end of the process, but also allows for building a spatial understanding during the work and a better understanding of places as a preparation for subsequent interactions with the space. Working with the model differs from working with abstracted representations in that intuitive spatial thinking is followed and the model can be interacted with in three dimensions. This becomes obvious when one looks at the projects of the bridges across the Sihl or the students' analyses of the ETH Zurich Main Building. Not only are the works conceived in three-dimensional space, but they also address the existing buildings, landscape elements, topography, and everyday objects in the same way.

Point cloud modeling can be seen as an experiment: an attempt to explore new methods, to push limits, and to think beyond conventional methodologies and media. With the rapid development of recording equipment in recent years, one can look forward to the near future with excitement and imagine how processes that are still very time-consuming and resource-intensive today will work. The already existing applications are likely to find widespread use in communication and mediation, in the design process, or in the creation of planning foundations. When looking at the challenges of climate change, the associated reduction of natural resources, the focus on maintenance and reuse, and the dense planning of urban centers, point cloud modeling will become more and more beneficial. A development toward new methods, work processes, and representation possibilities seems inevitable in view of the ever-growing krakens in contemporary cities.