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How Embedded Sensors will Transform Workplace Performance, Employee Engagement, and Facility Management

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Introduction

Across many industries, the collection of more data on processes and outcomes has driven efficiencies and positive outcomes. There are examples from almost every industry: factories track assembly line defects to improve product quality, parcel companies track their supply chains to enable more package deliveries per employee and to provide detailed delivery times to customers. Grocery stores use loyalty cards to track buying habits and offer customized coupons to shoppers. Homeowners receive detail energy reports from their utilities to drive reduction in consumption. The trend is clear: collect more data, in more places, and to use it to deliver a more efficient service that improves outcomes.

This same trend now enables office space to be more productive. As our urban populations grow, more space is needed to accommodate workers. This will create a demand for data-driven office spaces that can increase efficiency. At a macro level, increased workplace efficiency enabled by real-time sensing will help companies reduce real estate operational costs and create more space for more workers. Offices that take a data-driven approach will realize an increase in rents and occupancy levels and attract more long-term tenants.

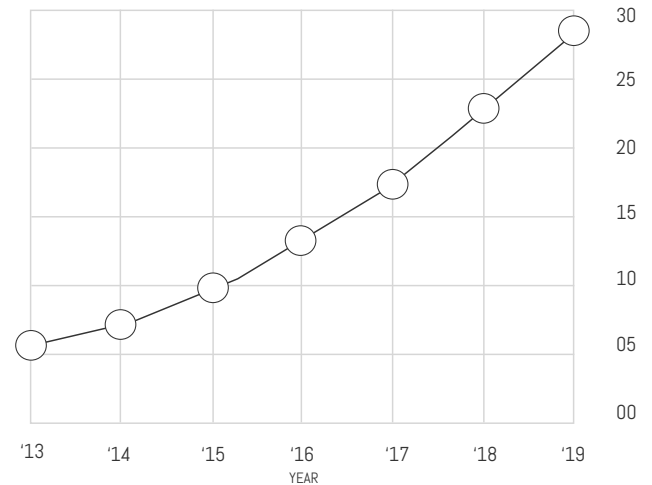**CONNECTED DEVICES (BILLIONS)**
Source: McKinsey & Company

Figure 1. Growth in Connected Devices.

In this paper, provided by CoWorkr & Haworth APAC, we explore the drivers that are enabling ongoing indoor monitoring within offices, specific data streams that can be collected, and the current and future opportunities of collecting these new data feeds.

Data Collection in Offices: Past, Present and Future

Data collection in offices has moved from low-resolution to high-resolution. Additionally, it now is possible to collect high-resolution data streams on an ongoing, real-time basis. In the past, many data streams about office use and activity were tracked at certain times through a time-limited survey. For example, observers might have spent a day in a particular floor to measure use. Then they would extrapolate those data across all similar spaces to estimate total occupancy and use patterns. It has been possible to collect more detailed data on occupancy through security and access control systems, though these systems just provide aggregated counts of occupants and no details about location or movement and no analytics on overall peak times and spaces. The amount of data collected on space usage has been growing, but still is collected on a periodic, non-continuous basis (e.g., during a study). Moving forward, a variety of mega-trends are making it easier for organizations to collect passive office usage data all the time and in high resolution (data are collected every few minutes, rather than every few months or years).
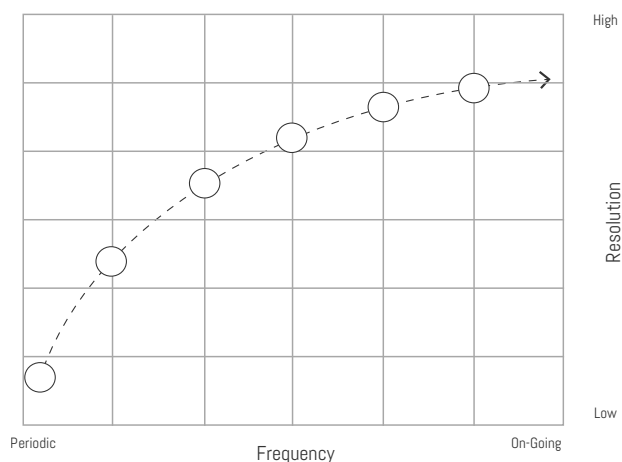
CRE SENSING
CoWorkr White Paper 2017

Figure 2. CRE Sensing Trends

COST OF DEVICES
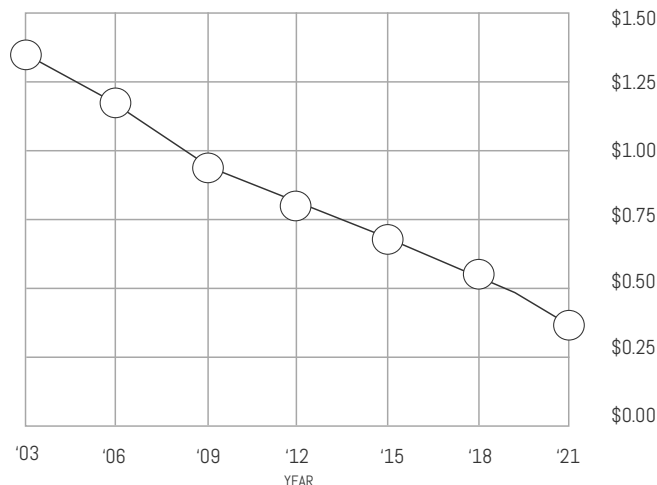Source: Goldman Sachs, BI Intelligence Estimates

Figure 3. Cost of IoT Devices

> **Hardware prices are dropping.** The cost for sensors has dropped from $1.30 in 2004 to $0.60 in 2014. Prices are projected to drop further to $0.38 by 2020 (1) . In some cases, vendors provide sensors with their software licenses and simply amortize the cost over the contract length, removing all upfront capital costs from deployment.

> **Hardware is plug and play.** While many sensors in the past have been deployed with proprietary protocols that don't integrate with other systems, most modern sensors can connect to local Wi-Fi networks and the data is accessible via application programming interfaces (APIs) in common formats. This makes sensors easy to set up and expand across new spaces. Additionally, as technology changes, specific parts of an integrated system can be replaced without requiring a full overhaul.

IOT DEPLOYMENTS IN CRE (MILLIONS)
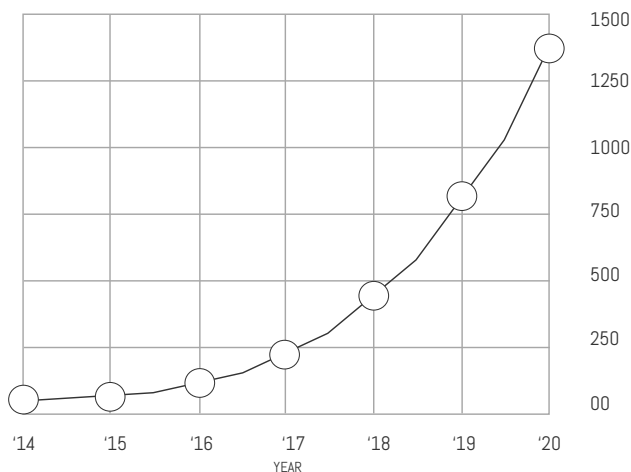Source: Delloit University Press

Figure 4. IoT Deployments in Commercial Real Estate

> **Improving performance and miniaturization of components.** Sensors continue to perform better, with longer ranges and lower energy demands. In addition, they are shrinking in size. McKinsey summarizes the sensor improvements: "The emergence of more integrated system-in- package and system-on- a-chip devices is helping to overcome some of the challenges described earlier, in part by addressing power, cost, and size factors."[2] In addition, smaller hardware means less invasive devices.

> **Increased competition and new vendors.** More vendors are offering sensors and software solutions that are integrated with sensors. The rise of the IoT software space is indicative of the attention and interest of this sector.

All of these trends are driving significant growth in the number of deployed sensors, especially in commercial real estate applications. Deloitte estimates that sensors in real estate will grow at a 78 percent annual growth rate between 2015 and 2020, with a total of 1.3 billion sensors deployed by 2020[3]. The bottom line is that real estate professionals today can collect new streams of data on a real-time and consistent basis, and they will be able to do so in the future for even less expense.

Data types in offices and the importance of ongoing data collection

The metrics that real estate and facility professionals typically track relate to financial performance and operations. In the past, beyond financial performance and inbound requests for service or repair, there was little data being collected to optimize operations or understand office space performance. Data was not in high demand because many offices were permanently assigned to specific employees and assumed to be fixed assets. For example, office space would be cleaned on a scheduled basis based on the assumption that each day the entire staff would be present. Data would enable cleaning to occur based on actual conditions and use. Additionally, HVAC and critical systems repair would occur on a planned basis, not due to actual condition both of which have significant cost implications.

In the past, the key data types collected within buildings included:

> **Financial performance:** Occupancy rate, density, rent per square foot, property value estimates based on comparable properties, which are used by the investors of the building to make decisions on renovating or selling particular offices.

> **Operational metrics:** Cost of facility operations, number of work orders and the time to address them, and other data on repairs and maintenance are used to plan capital projects and understand the ongoing performance of the space. Energy use data, which in some cities must be disclosed each year, is another common operational metric.

> **Occupant satisfaction:** The rent that tenants are willing to pay and the length of leases are two financial-based metrics that can be used to understand occupant satisfaction. In addition, property managers seek data from occupants formally and informally through surveys.

Offices now are able to collect more detailed and continuous data about the performance of the space, and this can be used to better operate the facility. Specific to occupant satisfaction ratings, a survey has many disadvantages. It is time consuming to collect and analyze these data; survey efforts do not take place often, and are rarely done consistently. Survey data can be subjective and less accurate than observed data. There is a gap between perception and reality: how workers respond on surveys may be different than what is observed in a study.

There are other problems with one-time data collection efforts, even when conducted by trained professionals. CBRE refers to them as "areas of risk"[4]:

> **Observer errors:** a data collector must understand the difference between temporarily unoccupied space (out to lunch) and unused space (no employee is assigned to the space).

> **Interpretation errors:** When looking at sharing ratios, it's not possible to use all "temporarily unoccupied" time for sharing, as it would require significant movement of office equipment. For example, if many offices are empty for 2 hours a day, are these two-hour blocks at times that other employees are in need of space? And, can they use all of these open spaces productively based on the office equipment available?

> **Peaks and averages:** While sharing office space may work routinely when looking at average use, the peak times, such as at the end of the month or quarter, will concern workers. There must be buffers so that peak office use times do not lead to office crowding.

Both survey and short-term studies have significant drawbacks that will become more problematic in the future. But, there are two new streams of data that real estate professionals can use to manage their facilities and address these gaps. Due to the trends in sensor data collection, they can avoid the risks that CBRE has identified.

> **Location data.** With modern indoor sensors, it is possible to track number of occupants and if a given seat is being used or not. These data can be collected on an ongoing basis throughout the day to help understand how individual spaces are used throughout the workday. At a macro level, the frequency of use data can be analyzed to drive conclusions about how various spaces are shared by multiple workers.

> **Office meta data.** In addition to real-time data on particular space and seat use, it is important to understand the characteristics and assets of each space. This includes a description of the location and details such as if it has a desk, a phone, an external monitor, and others.

> **Environmental data**. As worker health and indoor environmental quality become more prominent issues, sensors across an office can be used to track air temperature, indoor air pollutants and lighting. The WELL Building Standard[5] launched to help buildings certify their performance as it relates to indoor health and wellness. Additionally, the same sensor data can be used to track comfort issues, such as hot/cold offices that might negatively impact productivity.

When these two sources of data are combined, a deeper understanding of current space utilization can be discerned. For example, aggregated data can be used to identify workplace trends: are cubicles popular in the morning, or do occupants prefer sitting in communal tables or couches. On a personal level, a particular occupant can more quickly find available space that meets his or her preferences.

Ongoing, or "On-Demand" data collection provides much more detail on the peak use and specific vacancies within an office during the peak. For each individual, it is possible to discern the duration of stay and aggregate these individual records to calculate the average number of simultaneous users throughout an average day and a peak hour All the passive data can be rolled up to provide analytics on the most popular and least popular areas throughout the day. This all can be collected in a non-obtrusive and anonymous way. When combined with metadata, the kinds of work being conducted can become clearer. This also can drive space allocation efforts, as specific room or space types, such as collaboration areas, can be identified as in short supply.

There are specific use cases and value streams for these data types, which will only grow in the future. Section 3 details the ways these data can be used today and in the future. Moreover, FM Link notes that there is a big difference between planned usage - how the space is designed - and actual usage - how it is used each day. An article in FM Link notes: "The ability to capture actual space utilization has been the holy grail of real estate management because—while answering planned utilization questions is generally simple—answering actual utilization questions is more challenging. Unless one knows exactly how space is being used, one can't know how to hone it for more efficient and effective exploitation"[6]. It's common for tenants and building owners to have good information on the planned usage of their space, but the actual usage typically is quite different. Of course, actual usage is much more important information and can only be tracked with real, ongoing measurement once a space is occupied.

As an example, architectural firms typically perform a study of office space use prior to recommending any design changes or construction activities. In the past, these studies would occur over the course of a few weeks, with observers walking floor space each hour. With sensors now available to collect the same data on a continuous basis, these architectural firms can get much better data about how a space is used, which informs their recommendations to the building occupants. In addition to providing rich data, architectural firms do not need to dedicate as much time to collect it.

Beyond operational considerations, such as condition-based maintenance of infrastructure, flexibility in office space will be increasingly important in the future. Jones Lang Lasalle, in their 2017 Global Commercial Real Estate Trends report[7], notes that 34 percent of time spent in offices is away from a workstation: in the workspace of a colleague, in a conference room, or in an informal collaboration space. This opens up opportunities to increase density of workstations, and free up more space for collaborative settings.

AVG. TIME SPENT AWAY FROM SEAT
Source: JLL, Human Experience Survey 2017

34%

Figure 5. Trends in Office Space

Location, time, duration, and peak data is all required to make decisions about what modifications to make. Similarly, JLL forecasts that 30 percent of corporate portfolios will be flexible workspace, which will increase utilization but also will require high-resolution, ongoing data on how these offices actually are being used.

An increase in co-working space will also drive down the per employee cost for office space, and similarly, the amount of square footage each employee will have. CoreNet Global, a real estate association that provides industry data, reports that from 2010 to 2013, the amount of space per office worker declined from 225 square feet to 150 square feet[8]. According to a 2015 CBRE report[9], in the United States, 40 percent of office space is not occupied. Ongoing location and use data within offices will be crucial to understanding how office space should be modified to best accommodate its occupants and how the office space is performing after it is converted to a more flexible layout. Making these changes without data is risky: CBRE also notes that continued reductions in office space will have negative impacts on worker productivity, performance and retention. At the same time, better ongoing data on the use of office space will enable what CBRE calls "dynamic density", which "allows staff to work flexibly through choosing different
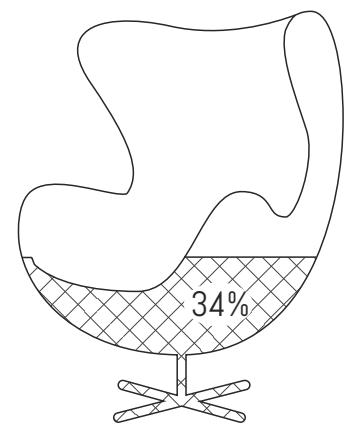
places to work within the office rather than being assigned a fixed desk as the one primary place of work." To reduce the cost of real estate, some vendors now help corporations rent out parts of their space for events and meetings on a short-term basis. Ongoing data on how an office is required to effectively do this.

Additionally, office space is no longer seen as just a place to work, but an enabler of innovation. JLL found that 42 percent of survey companies expect collaboration with entrepreneurs to increase disruptive innovation and 63 percent use shared office space to increase collaboration. They recommend that property managers and real estate professionals "embed 'user experience' at the forefront of workplace strategy through people-centric approach." Real estate also is increasingly thought of as a talent retention tool for employees. Similarly, some corporations with multiple offices in a region allow their employees to pick a particular office based on the kind of work that needs to be accomplished and the desire to collaborate with colleagues. In some cases, firms are eliminating work-from- home policies to encourage collaboration with co-workers and increased productivity. Providing real-time visibility into office occupancy - how dense the office will be, who will be in the office, and where people will be - is a core requirement to give employees this flexibility.

SQFT PER WORKER
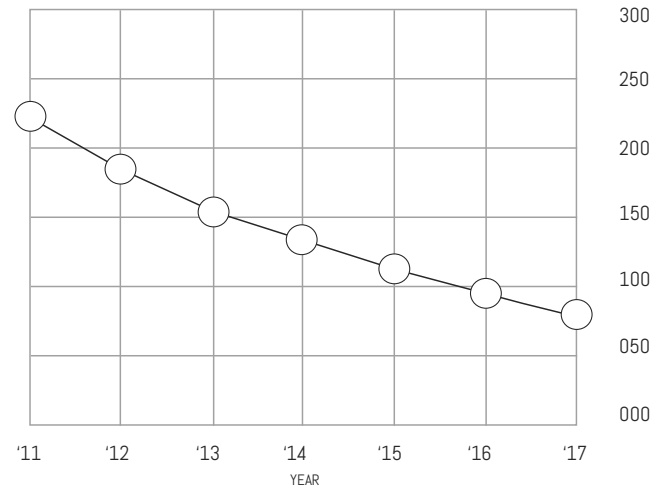Source: CoreNet Global 2012 Projection

Figure 6. Change in office square foot per worker

Current and Future Opportunities for Workplace Analytics

It is clear that increased data collection in office space will create significant value. McKinsey estimates that by 2025, the Internet of things (data collection and the actions it enables) will create between $70-150 billion of value in offices. McKinsey highlights a few categories of value, including organizational redesign and worker monitoring, augmented reality for training purposes, energy management and building security. Specifically, McKinsey estimates that increased indoor sensing and activity monitoring will increase worker productivity on average by 5 percent, or $19-43 billion of total economic impact[10] . Additionally, sensing will support indoor way-finding and encourage collaboration with other employees.

Moreover, these estimates may be conservative. Or, like many emerging technologies, the value of indoor office sensing may not be fully understood yet. McKinsey found that in pilot programs, indoor sensing and activity monitoring increased productivity of workers by 10 - 12 percent, far more than their own estimate of 5 percent. The paper notes "the greatest benefits would come from improved productivity of knowledge workers such as engineers, marketers, and lawyers whose performance depends upon collaboration with others."

There are a variety of current opportunities to use data to improve office space. Moving forward, there will be even more opportunities. That said, any employer that is implementing such data collection efforts must be transparent with workers and clearly illustrate the benefits. McKinsey notes "employees might be willing to trade off some of their privacy if they can acquire new skills and find ways to perform their jobs better."

Current opportunities for ongoing indoor data collection include:

> **"Right sizing" office spaces and increased utilization.** The cost of rent and management of office space is significant for many enterprises. Reducing the square footage is a good cost saving strategy. This includes using ongoing performance data to pick the right amount of space in new offices. Or, such data can be used to identify failing spaces or high-productivity and high-use spaces, to determine where to make modifications. Additionally, data can identify peak or low hours of the day to enable smart scheduling of shift-workers. For example, conference rooms are a huge opportunity for efficiency. According to the same CBRE space utilization report[11], over 35 percent of all meetings include just two participants, while only about 5 percent of meetings rooms are designed for two people. Similarly, 15 percent of meeting rooms are designed for both 6 and 8 person meetings (making up nearly a third of all meeting rooms), while fewer than 10 percent of all meetings include 6 or 8 people. By converting larger meeting rooms into more small rooms, there is an opportunity to increase utilization. But, data is required to understand how many people use which rooms frequently and at what times.

> **Condition-based maintenance of critical systems and equipment.** Most operational systems, such as HVAC, lighting, and elevators, operation on a defined schedule that rarely considered the actual number of occupants. In addition to cost savings due to increased efficiency, HVAC and elevator systems are costly to maintain - reducing the use based on better data on the number of occupants will extend equipment life and reduce maintenance costs.

> **Enabling internal co-working and collaboration.** JLL cites data that finds 63 percent of companies want shared office space so that employees can collaborate[12]. But to more effectively use shared office space, data collection is important. For example, the density of workers can be used to understand how much collaboration is occurring.

Future opportunities for ongoing data collection:

> **Corporate office-worker flexibility.** Moving forward, corporations will give their workers more choice in how and where they work. This is especially true for enterprises with multiple office locations within a given metro area. Employees will be able to pick from a variety of locations, even getting recommendations on the office with the most vacancy, or the office that is occupied by other team members on a particular project. Once at a given office, data will enable workers to receive recommendations on specific desks and locations to use.

> **Office personalization.** Offices will become more dynamic in the future. While hanging family photos in a cubicle was the old definition of personalization, now workers will be able to select many other facility- and environment-based preferences. For example, workers will be able, on a day-by- day basis, to select type of desk, location, level of noise, proximity to various amenities, and other selections, and will be directed to the particular open workspaces that meet these preferences. Additionally, some level of control will be given to the workers to control lighting, temperature, and other factors. In short, preferences will move with the workers. Untethered employees will be more productive at work and have more tools that make them aware of what conditions make them productive.

> **Healthy buildings, workers and productivity gains.** The WELL Building Standard is an emerging protocol that provides guidance on how to design buildings that are healthier for their occupants. Tracking movement within a space is one factor that can contribute to employee well being and will become a more recognized strategy in the future. Indoor environmental sensing also can be used to more efficiently operate HVAC and lighting systems, reducing energy and maintenance costs. In addition, the more detailed temperature, lighting and indoor air quality data could be linked with HVAC and lighting systems to optimize temperature,

utilize natural light and ventilate spaces.

> **Security and fire safety.** Many security systems track entry and exit from office space, but do not track the location of occupants once inside of a space. Such data could be especially useful for visitors and guests. Additionally, during a fire emergency, data on the location of occupants will be used by firefighters to direct their rescue efforts or confirm that there is no one in the space (and thus no firefighters need to enter).

> **Dynamic interiors and furniture.** As workers demand more flexibility, there will be more flexible physical space within offices. From agile furniture, easy-to- modify cubicles, and walls that can be moved more quickly, more data on the use of a space will be required to drive the decisions about how to make modifications.

> **New office supplier business models.** As more data on actual office and furniture use is collected, new business models can be offered that enable capital expenses to shift to ongoing, operational costs. Some furniture companies are leasing their equipment and using data to confirm that the desks and chairs are being used. This improves customer satisfaction because suppliers can swap out specific pieces of equipment that aren't used. The flexibility is valued by the tenants and occupants, while the furniture suppliers have ongoing, predictable revenue streams from the leases. Similarly, co-working space providers use data to track how their occupants are using their space and can optimize based on spaces of high and low demand.

Ongoing data collection within office space is now cost-effective and technically feasible for corporations. It also drives greater productivity. Higher worker satisfaction and can reduce per square foot and per employee real estate costs. Leading organizations now should consider how they can empower their staff with these new sources of data. Many organizations have started to invest in limited trials of indoor sensing technology or more complete rollouts. Additionally, many property management firms see this as huge differentiator moving forward. The office of tomorrow will collect data continuously, empowering occupants, helping real estate professionals be more responsive, and optimizing the workspaces.

Sources:

1. Atlas, from Quartz. Data sponsored by GE. https://www.theatlas.com/charts/BJsmCFAI

2 McKinsey, http://www.mckinsey.com/industries/semiconductors/our-insights/the-internet-of-things-sizing-up-the-opportunity

3 Deloitte, https://dupress.deloitte.com/dup-us-en/focus/internet-of-things/iot-commercial-real-estate-intelligent-building-systems.html

4 CBRE, http://www.cbre.com/research-and-reports/apac-space-utilisation-the-next-frontier

5 Well Building Standard, https://www.wellcertified.com/en/our-standard

8 CoreNet Global, reported in Building Design and Construction Magazine, https://www.bdcnetwork.com/corenet-office-space-worker-shrinks-150-sf

9 CBRE, http://www.cbre.com/research-and- reports/apac-space-utilisation-the-next-frontier

10 McKinsey, http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world

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12 JLL, http://viewer.zmags.com/publication/c078946b#/c078946b/7

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