GUIDANCE NOTE

# Internet of Things for Facilities Management

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# What is the Internet of Things (IoT)?

## The Internet of Things (IoT) is the network of devices that can collect and share data, as well as talk to each other.

IoT can be defined as the network of physical devices and objects embedded with electronics, software, sensors and network connectivity which enable these objects to collect and exchange data. Therefore, IoT is essentially a system of machines or objects that can collect data and communicate with one another. The machine-to-machine (M2M) data that is generated has a wide range of uses but is commonly seen as a way to determine the health and status of things[1].

**The Internet of Things can be viewed as being made up of four distinct layers:**

- **The physical layer** comprises hardware such as sensors and gateways that collect and send data; and the remote devices such as smartphones, tablets, laptops and smart watches which enable people to connect with and control IoT devices using a dashboard such as an app, web portal or dedicated IoT software platform. The physical layer also includes servers and databases for storage and processing of data collected, which are either company owned or held by a provider.

- **The network layer** is made up of the networks that transmit the data collected by the physical layer. This layer includes the internet communication that enables the entity to communicate with their device and for devices to communicate with each other.

- **The application layer** is the layer that contains the protocols and interfaces that devices use to communicate with each other. The dashboards of these interfaces are used to display and report information about the IoT ecosystem and enables control of IoT.

- **The cloud layer** can be in the form of either private, public or hybrid cloud. The cloud is internet based computing and acts as a passageway for services to be delivered to and from an entity's device. IoT software for data management, integration and analytics can be hosted in the cloud along with some data storage.

For Facilities Management, IoT offers the possibility to understand in real-time what is happening throughout every aspect and component of a building and its operation, and can provide valuable contextualised data for analytics. The 'golden egg' for facilities management is the attainment of predictive instead of reactive maintenance to reduce downtime of assets and aid efficient labour management, amongst other benefits. Not only can IoT provide the possibility to ensure predictive maintenance of assets but IoT can also be used to improve space management and gain an improved understanding of how a facility is being used and interacted with by its occupiers. This allows a facilities management professional to identify and make informed decisions on how to ensure their facilities are operated and maintained to optimal efficiency. Acting on the knowledge gathered and analysed through IoT can help encourage a reduction in operational and maintenance costs, lower energy use leading to lower greenhouse emissions, promote building user well-being and stimulate demand for further IoT technological advancements.

**Footnote**

[1] Source: Wikipedia https://en.wikipedia.org/wiki/Internet_of_things


The Internet of things is changing businesses and will lead to a digital disruption and data explosion. The opportunity that technology presents to change the way FM works is huge, but it will have to be leveraged by skilled and knowledgeable professionals who understand how best to facilitate the convergence of people, place and process for business. The potential technology can transform the FM function and advancements such as the Internet of Things (IoT), Building Information Modelling and robotics are already contributing to improving business performance.

# Implementations in FM

**There are a huge number of applications of IoT technology within the field of facilities management. Once the data has been generated by the array of sensors, beacons and other integrated technologies inside the "things", then there is a wide range of applications that can utilise this data whether it be to produce real-time information, historical analysis or future predictions.**

In the tables below we have attempted to outline some applications of IoT being used in FM today as well as providing a flavour of the possible future applications. This list is not meant to be exhaustive as the technology is evolving exponentially and each industry, organisation, estate and company will come up with their own requirements and use for IoT. For FM professionals, the key is to understand the potential applications and what benefits these could provide.

| FM area of interest | IoT application (current) | Practical example / use / scenario |
|---|---|---|
| Smart buildings | Sensor Controlled HVAC | Air conditioning/heating switched on at the optimum time based on the first booking in a meeting room to ensure the desired temperature is reached with minimal energy wastage. |
| | Smart navigation (including emergency evacuation). | A smartphone app can guide an occupant to their meeting room or a colleague. In an emergency, room signage devices use information from smoke sensors to lead staff to safety. |
| Resource Management | Sensors on resources – rooms, desks, parking spaces, providing real-time data on space usage and availability. | Staff can view hot desk and meeting room availability throughout the building from a reception kiosk or mobile app. Users can also search for the nearest available meeting room relative to their location or the location of their colleagues. |
| | On-demand estates. | A company with a flexible working policy can analyse their past and future hot desk bookings and realise demand for space is 50% lower on Mondays and Fridays. They close zones, floors and buildings to save on energy and personnel costs on these days. |
| | Embedded beacon in portable equipment. | Mobile equipment such as projectors and laptops can be tagged so their location can be tracked within an estate and alerts generated if they move outside of the estate boundaries. The objects can also be easily found within a given space. |
| Transport | Driverless cars, auto traffic management and navigation. | Users enter the vehicle and ask it to take them to work. The vehicle uses traffic sensors and mapping data to plot and execute the optimum route. |
| | Sensors collect data on infrastructure alerting to real-time issues and scheduling preventative maintenance based on predictive analytics. | Sensors indicate a dangerous motion on a bridge during high winds and automatically close the bridge and reconfigure lane usage on alternative routes. This also leads to automatically scheduling emergency maintenance checks.<br><br>Sensors can also detect if an accident has occurred and notify the emergency services within milliseconds of the accident occurring. |

# Implementations in FM (continued)

| FM area of interest | IoT application (current) | Practical example / use / scenario |
|---|---|---|
| Workplace well-being | Personalised workspace based on sensor data. | Staff member chooses a work area based on preferences of natural light, climate, noise pollution and population density, based on other bookings and real-time occupancy data. |
| Health and Safety | Sensors to identify risks in environmental elements such as a drop in air quality or noise pollution. | Within chemical or mechanical engineering, plants sensors are placed on all staff so that all areas of the plant where staff are operating have full environmental sensor coverage as well as enabling early warning alerts in that area. |
| | Sensors identifying physical risks such as over populated areas. | Flow sensors installed in a nightclub to monitor population within a space as people enter and leave. |
| | Occupancy sensors provide data on user presence. | Emergency crews utilise live occupancy sensor feeds to identify if, where, and how many people are in danger areas during an incident. |
| | Sensors detecting noise and vibrations provide data in an area or during an activity. | Exposure to vibrations for machine operatives can be monitored in real-time as well as analysed over time to provide data to avoid any over-exposure. |
| Security | Occupancy sensors or personalised tags indicate the locations of individuals in an estate. | Alerts triggered for unauthorised personnel in restricted areas as well as providing automated access for authorised personnel throughout an estate. |
| Cleaning and maintenance | Sensors on bins/containers. | Real-time data on bin/container capacity to help schedule collection and cleaning rotas. |
| | Sensors indicating which resources have been used and associated volumes. | On a Friday occupancy data indicates that only a 1/3 of the meeting rooms are used and therefore may need cleaning. The room signage and FM mobile app indicates whether the room needs to be cleaned or not. |

The table below outlines some examples of where IoT is predicted to be applied in the future. These applications are either in their early stages of development or are not yet in common use. Some of the applications below may already be in use but are not yet commercially viable, or socially acceptable for widespread adoption. The idea of this table is to show the art of the possible rather than to suggest which ideas should be adopted.

| FM area of interest | IoT application (current) | Practical example / use / scenario |
|---|---|---|
| Security | Implanted sensors to authenticate identity. | Removal of ID cards with the ability to have sensors implanted into hands. Doors and equipment will then use the IoT device to authenticate users. |
| Workspace Personalisation | Environmental and occupancy sensors. Workplace environments automatically adjusted to a user's personal preferences. | An employee books a meeting room and the booking and building system adjust the environmental elements such as light and temperature to the known personal preferences. |
| Health and Safety | Embedded identity tags on personnel or safety clothing or equipment utilised to check personnel files for appropriate training/authorisation for tasks. | Machinery will not switch-on unless they sense a personnel beacon associated with a suitably trained operative or an exit door to a secure area will not release unless a high vis vest is detected. |
| Security | Staff/pupil tracking inside and outside the building using sensors or beacons. | Built-in beacon in school uniform, staff card or implanted in the body to track the location of tenants. Facial recognition via camera could also provide data. |
| Well-being | Sensors to identify personal physiological levels, e.g. Alcohol levels, hydration levels, illness. | Personnel passively scanned upon entering the building for illness. Periodic 'at desk' scan or via wearable device to provide real-time well-being advice. |
| Transport | Driverless cars and auto traffic management and navigation. | Driverless cars and auto traffic management and navigation. Driverless cars will choose all elements of a journey from the route, speed based on traffic and weather information as well as minimising mechanical and environmental effects of the journey. |
| Wayfinding | Augmented reality wayfinding within a building. | Augmented reality allows people to navigate in an unfamiliar indoor environment. |
| Automated task allocation | An AI building management system will automatically allocate tasks. | Said system would analyse data and allocate task based on proximity, skill set, priority, etc. |

# Benefits of IoT

**IoT gives us the opportunity to enhance the daily lives of the operators and transform the end user experience of our facilities. We've identified some areas that stand to benefit greatly from the implementation of IoT, but the list below is not all-encompassing and will always be expanding.**

**Cost reductions**
One of the greatest areas to benefit from the use of IoT is cost management. IoT enables data to be gathered regarding how and when every space in a building is used thereby facilitating evidence- based decisions regarding space usage. By providing better space management the FM professional can identify opportunities to release space or avoid allocating additional space where it is not needed. Energy consumption can be regulated based on occupancy and provide real- time usage and efficiencies. The monitoring of occupancy also extends to better asset and facilities management. By knowing which areas have seen increased usage we can better schedule cleaning and maintenance activities.

The holy grail of maintenance, predictive maintenance, can only be achieved by using IoT. By monitoring the condition of the assets and allowing them to self-monitor, we will know when an asset is due to fail and act before a failure. Furthermore, by communicating with each other, assets in a system can warn other assets that they are going to fail and stop the process before it extends to the entire system. These measures will lead to increased asset performance and life through optimised asset operation.

**Improved well-being**
Organisations have started paying more attention to the well-being of their most valuable assets, their employees. The use of sensors and smart building systems allows us to improve the well- being of the occupants by monitoring and adjusting the indoor environment in real-time to better meet their needs. The environment can be easily adapted to the preferences of the occupants by continuously monitoring the temperature and humidity of the space. Instead of having constant disputes about the temperature being too high or too low, clustered areas can be created that fit the requirements of the occupants. Air quality can be monitored and altered to ensure the health and well-being of the employees and circadian lighting can help avoid strain and stress. All this can be further enhanced by providing the occupants with suggestions on how to improve their health and well-being by monitoring their habits, such as how many hours they are active and how long they've been sitting at their desk.

**Enhanced organisational profile**
The workplace has become a major differentiator in the attraction, development and retention of talent[2]. IoT can assist in alleviating daily frustrations from the work environment and even improve the experience of customers and visitors by streamlining visitor registration and wayfinding to colleagues and meetings. In addition, the use of a mobile application can provide accurate information and allow occupants to create a social network and community for the specific building.

**Reduction of risk**
From security cameras and sensors to implanted tags, physical security of a building is improved and augmented by the use of IoT. The building can now see if there is a threat to its occupants or its fabric. The systems in place can stop intrusions, notify the authorities and assist the occupants in evacuating the building using the safest and fastest route. Paired with technologies like drones and robotics, security can be further improved and risks lowered.

**Enhancement of compliance**
Compliance can be further enhanced using IoT. Using unique identifiers, an employee or contractor can prove that they have the right permits and training to perform work on a facility. These checks can be conducted instantly using beacons and smart tags. Another area where IoT can enhance compliance is in assisting with the evacuation of buildings. Sensors can identify if there are any occupants still in the building, guide authorities to them and help them find their way to the nearest emergency exit.

**Footnote**
[2] The Workplace Advantage - The Stoddart Review

# Demystifying the technology

**Networks and Connectivity**
Connecting all the devices is essential for the existence of the IoT. This is why whenever there is a mention of IoT it will be followed by another mention of one of the popular communication methods. The connectivity issue is addressed by the following technologies:

- Short-range wireless - Popular technologies in this area are Bluetooth, Li-Fi, NFC, RFID, Wi-Fi, Ultra Wide Band and ZigBee
- Medium-range wireless - Consisting of HaLow and LTE-Advanced
- Long-range wireless - Consisting of LoRaWan, Sigfox, NB-IoT and Weightless
- Wired - Using Ethernet, MoCA and PLC to connect the devices

**Beacons**
A beacon is a small wireless device that continuously transmits a simple signal with a message about its ID. This is usually achieved using Bluetooth. When a nearby device receives this message, it uses the ID and distance from the beacon to trigger an action or enable a workflow within a compatible app.

**Sensors**
Sensors give "senses" to the IoT. With them, a device can see, hear, measure temperature and a myriad of other variables. The following is a non- exhaustive list of available sensors:

- Machine Vision/Optical Ambient Light
- Positions/Presence/Proximity/Location
- Motion/Velocity/Displacement
- Temperature
- Humidity/Moisture
- Acoustic/Vibration
- Chemical/Gas
- Flow
- Force/Load/Torque/Strain/Pressure
- Leaks/Levels
- Electric/Magnetic
- Acceleration/Tilt
- VOC
- $CO_2$

It's important to note that although these sensors can gather a lot of information about an individual, it is not always possible to identify individuals using the captured data. For example, a PIR sensor can identify movement and a body, but it cannot identify who the person is. However, technologies that can identify an individual are available and should be used with care to protect their privacy.

**Gateways**
An IoT gateway bridges the communication gap between IoT devices, sensors, systems and the cloud. The gateway can provide local processing and storage, as well as control of devices based on input from the sensors. The flow of data via the gateway can also be adjusted to the particular security requirements of the building or the organisation utilising the system. For instance, the hub does not always have to connect to a cloud instead it could connect to a local server.

**Machine to Machine (M2M)**
Machine to machine is a broad label that can be used to describe any technology that enables a networked device to exchange information and perform actions without the assistance of staff.

**Big data**
Big data refers to datasets that are so complex that traditional data processing software cannot deal with them. The challenges when handling big data include the capturing, storage, analysis, visualisation, querying and security. When referring to Big Data, most people actually refer to the use of predictive analytics, user behaviour analytics and other data analytics methods that extract value from data and not the actual size of the dataset. Analysis of these datasets can provide us with intelligence and help us spot trends.

# Security and data management

**The availability, capture and storage of all this data, brings up great challenges for cyber and physical security, as well as data management. Specific legislation is being put into force, to protect data that, if not adhered to, could have a significant impact on an organisation's bottom line.**

Furthermore, security will be required that protects the devices and platforms from information attacks and physical tampering. All communication and stored data need to be encrypted and new challenges, like impersonated "things", need to be addressed.

**GDPR**
GDPR (General Data Protection Regulation) has a broad definition of data privacy, meaning organisations need to be vigilant when using and collecting data. This is especially true of IoT, where devices are capturing a growing amount of personal data. At the heart of IoT is the concept of the always-connected customer, but appropriate measures need to be put in place to ensure data protection is not an afterthought. Data collected may not be linked to personally identifiable information such as name or contact information, and data controllers need to demonstrate consent has been given by way of a clear affirmative act establishing a freely given, specific, informed and unambiguous indication of the data subject's agreement to the processing of his or her personal data – and how can this be obtained through an IoT device?

For example, employees who wear fitness devices for corporate wellness programmes need to be aware who is accessing their data – the device manufacturer? The organisation? Other third parties? And is the ability to opt out of all data sharing clear enough?

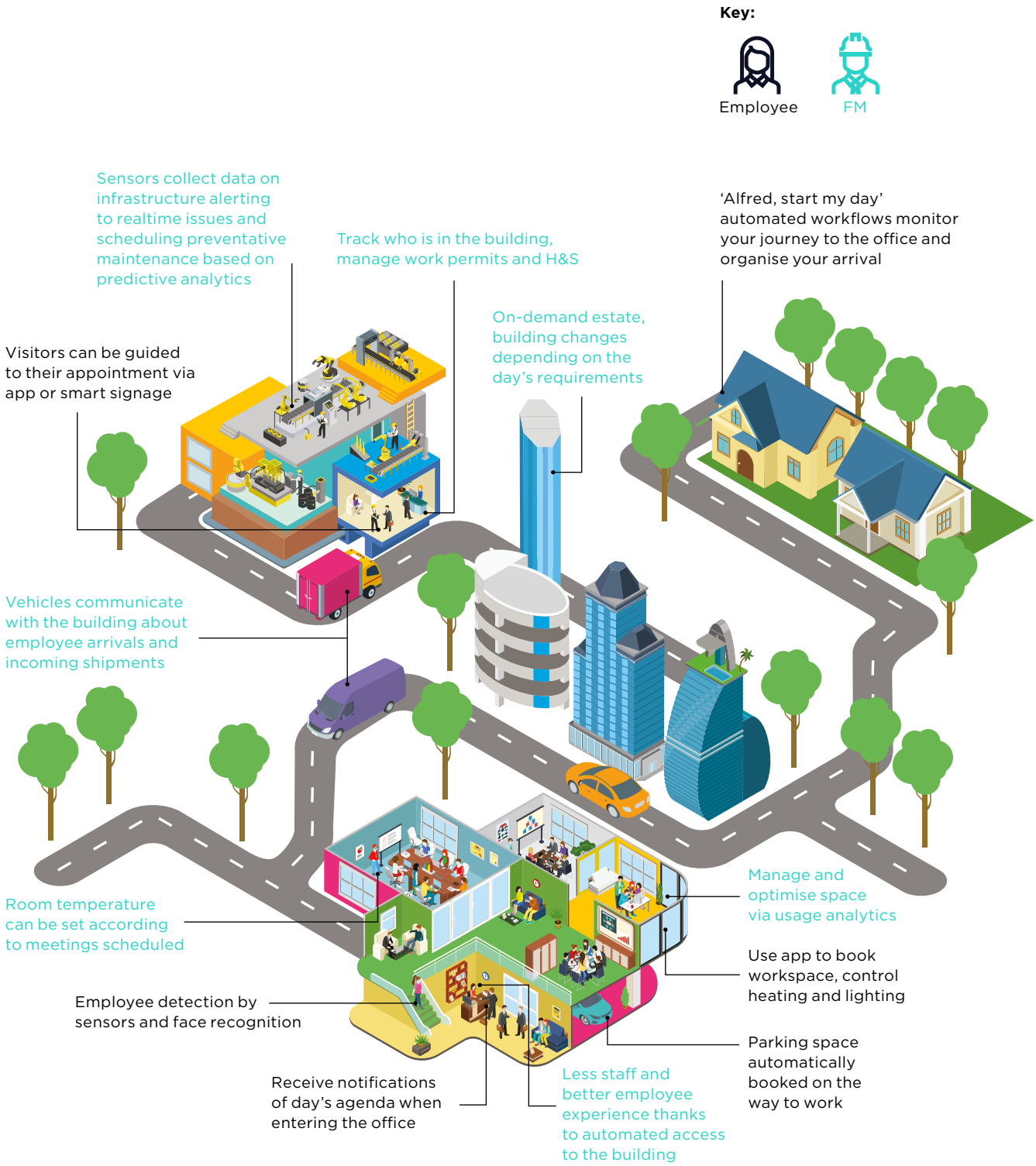
**FM and data management scenario**
A common area of particular concern is CCTV – capturing personal data by way of imagery. FM professionals must now think carefully about justifying where they can place cameras that may detect intruders but not invade the privacy of employees. Signs must highlight the use of a camera, and data should only be retained for as long as is strictly necessary rather than stored indefinitely.

GDPR states 'Any person whose image is recorded on a CCTV system has a right to seek and be supplied with a copy of their own personal data from the footage' so systems must be in place to supply this easily and in an appropriate time frame.

**Data storage and analytics**
Cleansing, processing and interpreting the vast amount of data which is gathered by the sensors is a great challenge when implementing IoT. Storage is another challenge that needs to be addressed. During project planning and implementation, these challenges need to be evaluated and addressed. If not planned appropriately, there is the risk of gathering unusable data that fills up the allocated storage space, doesn't lead to meaningful insights and might even lead to making the wrong decisions.

**Restricting access**
Although cloud systems can provide better analytics and deeper learning, deploying IoT software on the premises can provide better security by limiting the access points to the systems. Another alternative is working on the edge, by performing data processing near the source of the data and having stricter controls on the access to the cloud.

# Life in the Internet of Things



# The last word

**We hope that this guidance note has been informative and easy to follow. The IoT technology working group has played a crucial role in collecting and collating the material that was presented in this guidance note. As stated before, this is not and cannot be a definitive guide. IoT is still in its infancy and the next few years will see continued innovation and hopefully standardisation. We will keep updating the relevant sections when deemed necessary.**

IoT has the potential to disrupt most aspects of service delivery and improve the end user's well-being and experience. While the gains are significant, it's important to implement the technologies while keeping the data safe. Because of the latest regulations in the EU, breach of the data collected can have a tremendous financial impact on our companies, not to mention the ethical issues involved, so care must always be taken. Whenever you need some inspiration and want to explore what's possible, read through the Implementations and Benefits sections in this guide. Finally, use the demystifying section in this guidance to deliver information that is informative and easy to understand.

We are in the process of collecting use cases and best practices from real applications. If you have recently implemented IoT projects and would like to talk to us, please contact **research@ifwm.org.uk**

**The IoT Technology Working Group include:**
Dan Andrews (CBRE), Peter Brogan (IWFM), Paul Djuric (Urgent Technologies), Annie Gales (SWG), Colin Hall (PACS), Tom Harrington (ABRSM), Annie Horsley (IWFM), Richard Kennedy (Spaceti), Kieron Murphy (Keytree), Harry Mylonadis (ENGIE), Jon Newson (Daimon), Roger Parslow (LMG), Patricia Sibley (Bam FM), Neil Smith (Mitie), Steve Tomkins (BESA) and Giles Wheeler (Facilicom).

IWFM would like to thank all the members of this group for their valued input into this guidance note.

This guidance note is the first output of our Technology Working Group. We aim to produce more content including case studies, webinars, workshops and presentations. Alongside our group, the BIM and AI technology working groups have also been producing some great content and events. If you are interested in getting involved please contact **research@ifwm.org.uk** in the first instance.

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**Author**
IoT Technology Working Group

**Editor**
Harry Mylonadis, ENGIE International FM

**Peer reviewer**
James Pinder, 3 Edges Workplace Ltd

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**IWFM**
Charringtons House
1st Floor South
The Causeway
Bishop's Stortford
Hertfordshire CM23 2ER

T +44 (0)1279 712 675
E membership@iwfm.org.uk
www.iwfm.org.uk

iwfm
Institute of Workplace and Facilities Management