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RODENT MONITORING SYSTEM: AN IoT PLATFORM THAT AUTOMATES RODENT MONITORING TO DRIVE DIGITAL TRANSFORMATION AND ENHANCE FOOD SAFETY

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Abstract A rodent infestation in a food manufacturing, distribution or retail facility threatens both the integrity and safety of the food supply. The consequences of a rodent infestation in food manufacturing facilities can include failing audits, regulatory fines, product recalls and - in extreme cases - plant closures, all of which have outsized impacts on brand reputation for a food manufacturer. Rodent Monitoring System (RMS) is an Internet of Things (IoT) platform that automates rodent monitoring services, providing continuous monitoring and real-time alerts that is transforming an industry and enhancing food safety and biosecurity. Embracing Open Innovation with technology partners, Bayer is building a network of connected sensors that can be retrofitted to most common rodent monitoring devices (e.g., multicatch traps, bait stations, snap traps, glue boards). Communicated over an encrypted wireless network in the facility, once transmitted through the cloud, data on rodent activity is visualized in a web-based platform and a smart phone App making insights accessible to all stakeholders, including impactful digital tools (e.g., heat maps, visualizations) and advanced analytics. Here we review the origin, design and operation of this novel system, and discuss how it addresses multiple customer pain points in bringing 'the rat catcher' into the 21st Century.

Key Words Rodents, Remote Monitoring, Automation, Digital Pest Management

INTRODUCTION

Rodents, specifically rats and mice, are arguably the most significant pest threatening food manufacturing, distribution and retail industries. It is estimated these pests, either through direct consumption or indirect contamination, may be responsible for destroying as much as 20% of the world's food supply annually (Buckle and Smith, 2015). Their presence in agricultural fields and food facilities can spread disease; rodent infestations have been implicated in the spread of a wide range of diseases (Kilonzo et al., 2013), many that frequently contaminate the food supply and lead to attention grabbing headlines (Newman, 2018), product recalls and closure of facilities (FDA, 2018). Such infestations may also cause significant damage to the facility itself, from gnawing at walls or wiring, damaging expensive equipment or causing fires (Fisher, 2019).

In response to these risks, industry has developed rather rigorous service protocols to monitor for rodent presence in food facilities. An industry standard practice for interior rodent monitoring consists of deploying dozen or 100s of multi-catch traps in key areas within a facility to detect rodent presence. This may be supplemented with scores of bait stations along the exterior perimeter of each structure to intercept rodents before they can enter a facility. A pest management professional (PMP) will routinely inspect each trap or bait station at the facility, remove captured rodents, replenish bait and note rodent activity. This is a lengthy, laborious process and, in many situations, is repeated at weekly intervals! To ensure service quality and prove that every trap is checked every time, barcodes were added to the interior surface of the trap. An unintended consequence is that this has transformed the art pest inspection services into the tedious act of trap-checking, where barcode scanning is prioritized. This practice leaves limited time for the technician to make thorough and proper inspections of conditions throughout the facility, take corrective actions and preventive measures.

Given the importance of food safety to human welfare, it is not surprising that government regulations, such as the Food Safety Modernization Act (FSMA), and food industry best-practices, such as the Global Food Safety Initiative (GFSI), have been enacted and embraced as industry standards. Pest management services to the food industry must be aligned with these regulations and standards. These changes have galvanized the need for change in the industry, and in no small part are driving the present boom in electronic rodent monitoring.

The Internet of Things (IoT) provides significant opportunity for many industries, including pest management in food facilities. The impact of digital transformation is enormous and is evident all around us in our daily lives already. Beyond the technology of connected devices, these innovations in technology spark a transformation in business models, changing the very nature of the service. Bayer is launching a business service platform to leverage IoT and connected technologies to automate workflows, translate data into actionable insights, and use artificial intelligence to drive profitable growth in the industry, helping it stay ahead of rapidly evolving regulations, and build a more sustainable business for the future. The Rodent Monitoring System (RMS) is a first offering in the platform, with more technology solutions emerging from in-depth collaborative innovation with pest management professionals interested in reinventing the industry.

Design and Operation

At its core, RMS is a distributed sensor network (Figure 1), built around a series of sensors that monitor rodent activity in and around a facility. In most cases, the sensors are based on simple mechanical switches; this simplicity is key to both ease of operations and limiting risks of technological errors that arise from more complicated sensor systems. All sensors are designed to be fitted to existing, time-tested rodent trap or bait station designs; the industry has come to trust and accept these forms, so the goal is simply to automate the information flow that must otherwise be gathered by the human inspection. To date, sensors are available for multicatch traps (Figure 2), bait stations and snap traps; new sensors are in development for use with glue boards.

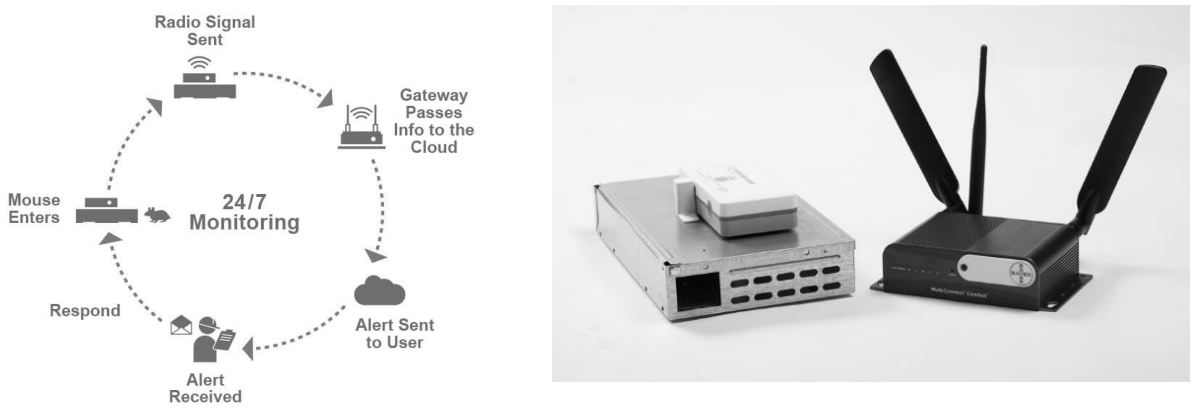

Figure 1, 2. Schematic illustrating the components in and operations of the Bayer Rodent Monitoring System **.** Images for a sensor and transceiver fitted to an industry standard multicatch mouse trap (L), and the LoRa gateway receives messages from the transceiver and routes them to the cloud database

Each sensor is connected to a transceiver unit (Figure 2) powered by a 9-volt alkaline battery; in “normal” operating conditions the lifetime for a battery will be 4 years. This transceiver converts an electronic signal from the sensor into a message which is transmitted over an encrypted, stand-alone network operating on a low-power, wide area network (LoRa Alliance, 2020) that uses unlicensed radio frequency bands (< 1,000 MHz). This enables very long-range transmissions, as signals can travel several kilometers in rural, line-of-sight locations and signals have great capacity to penetrate normal building construction materials. In the absence of a rodent-related event, the transceiver will send a daily “heartbeat message” to confirm sensor status, battery levels, etc. to document that the system is functioning properly.

The sensor and transceiver hardware are dust and water resistant (IP54 rating) to help ensure proper system function in wet, dirty environments for any indoor installations or in outdoor installations with perimeter bait stations. The data packets from a sensor/transceiver are received by gateway (Figure 2), connected to the on-site power supply, which sends the encrypted data packets by cellular communication to a cloud based system. A single gateway can support several 100 sensors distributed inside and outside of a facility that may exceed 100,000 square feet.

A cloud-based user web-portal allows all authorized users to access information on the monitoring system at a facility. To support of real-time monitoring, the web system will generate instant notifications via email or text messages of rodent captures (or other events in the system). This enables rapid response to rodent issues, which improves root cause analyses to identify corrective and preventive procedures. Today a captured rodent will remain undiscovered (for a week if not longer) until the trap is next inspected manually, which makes knowing the when or why of any rodent activity difficult at best and limits the ability of root cause to head off further infestation.

A critical aspect in rodent control programs is proper placement of devices; e.g., against walls. If a trap or bait station is not in the proper location, it won't operate effectively. The transceiver has an accelerometer that reacts when a trap is abruptly or rapidly moved to transmit a "move message" that alerts a user of its being out of position so they can relocate the device and ensure the system is functioning properly. A new software feature in 2020 allows sensors that are fitted to a bait station to count rat activity; in this mode every time a rat triggers the sensor this is collected (and reported at a desired intervals), allowing the user to identify the where and when of rodent pressure at specific monitored locations. An algorithm based on rodent activity levels will also estimate bait consumption to predict when bait replenishment is necessary at a monitored location. These measures of rodent activity are used to generate "heat maps" that help the users better visualize trouble spots, and better direct preventive procedures at vulnerable locations.

The web-system will enable the user to generate rodent program verification and system status reports, maintenance logs, it automates the generation of trend analyses, and utilizes a dynamic, graphic floorplans to show the status of all monitor locations in a facility. Together, these features increase transparency and accountability for users, allowing them to reallocate time away from checking (typically empty) rodent traps so they can focus on more thorough, integrated pest management inspection. Up-to-the-minute reporting and trending on the system helps users review program operations, optimize placement schemes, and improve effectiveness of the rodent control program. Just as important, it helps auditors to verify the rodent control is effective and compliant with standards.

CONCLUSIONS

Electronic rodent monitoring empowered by the Bayer Rodent Monitoring System is changing rodent control in many ways: Continuous monitoring with real-time capture alerts; rapid response allows faster root cause analyses and more immediate corrective actions; allow users more time to proactively inspect a facility for possible pest entry points or conditions conducive to an infestation; daily monitoring, system status reporting and documentation of system maintenance that will verify a rodent program conforms to Good Manufacturing Practices (GMP) requirements and GFSI benchmarks; automated, real-time information (up-to-minute trend analyses, benchmarking and reporting) that helps improve audit readiness; dynamic floorplans and digital "heat maps" to improve spatial understanding of rodent activity; time stamps of capture events to improve temporal understanding of rodent activity; help users to focus on improving skills in facility inspection and understanding of rodent biology, rather than checking traps

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