Active Personnel Monitoring and Access Control in Steel Manufacturing Environments

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

This report is part of the final report for the AIST Don B. Daily Safety Grant. This portion of the final report is an abridged version of the full paper presented at AISTech 2019.

Effective safety systems in any industrial setting are paramount to an efficient workplace. Depending on the industry, safety can mean anything from online safety training to personal protective equipment (PPE), to active monitoring systems that track personnel activity and hazards. The steel manufacturing industry presents a unique environment including significant heat, electromagnetic interference, collisions and particulate buildup. While most steel manufacturers have embraced broad safety cultures, part of that adoption insists on continuous improvement. The purpose of this research project was to perform an extensive review of existing safety technologies and provide recommendations to the sponsor facility.

A team of four undergraduate researchers at the University of St. Thomas in St. Paul, Minn., USA, started with a desktop study and identified success criteria through discussions and visits to the sponsor facility. Based on these success criteria, the student team identified a system most suited for the sponsor facility's needs and attended a demonstration at the vendor facility for an in-depth review of its capabilities and applicability. This article is an overview of the project; a more detailed discussion can be found in the AISTech 2019 Conference Proceedings.[1]

Review of Existing Technologies

The first phase of this project was a comprehensive review of existing technologies designed to improve worker safety. A cursory review yielded a broad range of technologies, so the team organized them into tiers of similar solutions, including physical barriers, proximity detection, passive asset tracking and real-time location systems. Anderson et al.[1] provides an exhaustive review of all these systems; however, only those considered for quantitative assessment are discussed.

Proximity Detection

Proximity detection systems focus on collision detection in order to alert nearby employees of potentially dangerous situations. They often use a series of transmitters and receivers to detect vehicles and/or personnel in the area. The receivers are generally worn by workers and the transmitters are usually installed on vehicles or other moving equipment. Representative systems in this tier include Protran,[2] Hit-Not systems[3] and TotalTrax.[4] Each of these technologies provide a relatively low-cost option to improve safety in an environment where workers often interact or cross paths with large equipment; however, they rely simply on proximity and cannot specifically locate or track personnel.

Specifically, Hit-Not systems use a transmitter and receiver, in conjunction with an electromagnetic field; the vendor claims this yields effective accuracy through different obstacles. This technology was originally developed specifically for forklift collisions and has since expanded to other large vehicles.

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Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

Real-Time Location Systems (RTLS)

RTLS use some manner of base network to triangulate and actively track workers and assets. Some RTLS are accurate to within 12 inches through walls and other obstacles, while others allow third-party GPS tracking to follow assets and thereby monitor and improve productivity. Representative technologies in this category include AeroScout,[5] Q-Track[6] and Precysetech.[7]

AeroScout, a subsidiary of Extronics, uses a Wi-Fi network to triangulate and track a wide array of personnel tags. It is important to understand the existing Wi-Fi infrastructure in a target facility, as installing a Wi-Fi network in a large industrial environment can be a substantial investment. With the Wi-Fi network extracting and recording necessary data, AeroScout boasts the ability to maximize the effectiveness of the Internet of Things, integrating third-party applications into their MobileView interface system. Q-Track, a subsidiary of Geeks and Nerds, utilizes near-field electromagnetic ranging (NFER) to triangulate and track their tags. This is an important distinction from a Wi-Fi-based system, as it does not require any existing infrastructure. Due to the low frequency of these waves, they can easily pass through walls and bypass interference, which allows for an accuracy of up to 12 inches. Each electromagnetic field requires a data link to Q-Track's real-time location software, which can be accomplished using either a wired Ethernet network or a wireless network.

Selection Methods

The selection of an appropriate technology was based on multiple discussions with the sponsor and visits to the site. Success criteria were then developed to assess each system's applicability. These success criteria include durability, risk reduction, return on investment (ROI), productivity and worker friendliness.

- Durability is a measure of the system's ability to resist harsh environmental effects associated with steel mills such as heat, impact and electromagnetic interference.
- Risk reduction is a measure of the system's ability to reduce the amount of accidents specifically associated with the sponsor facility.
- ROI combines the cost of the system and the estimated reduction in incidents to evaluate the time it would take to recover the system investment.
- Worker friendliness is a measure of how unnoticeable any tag or receiver might be to a worker, or how little it might impact their daily tasks.

Selection was broken down into three phases: a preliminary selection including all the systems reviewed; a secondary quantitative assessment based on return on investment, risk reduction and other success criteria; and a final recommendation.

Secondary Selection Phase

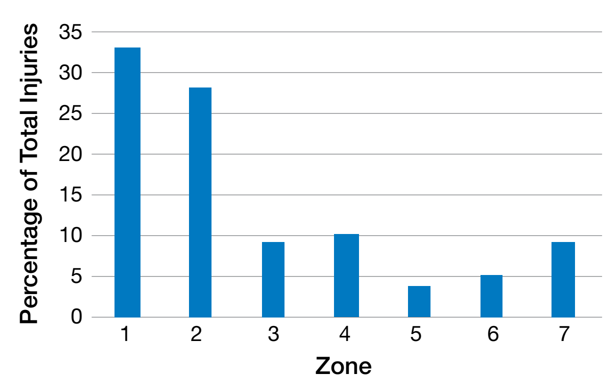
The purpose of the secondary selection phase was to quantitatively evaluate the defined success criteria, specifically the ROI. In order to determine the ROI for each system, a risk analysis was performed using information from seven years of Occupational Safety and Health Administration (OSHA) incident logs, provided by the sponsor facility. The risk analysis was performed both on a site-wide basis and broken down into specific zones in the mill. Breaking the facility into multiple zones helped identify specific problem areas with the highest risk.

Fig. 1 shows a breakdown of the percentage of total injuries that occurred in the mill during the seven-year period in each zone. Zones 1 and 2 contain a large majority of the incidents, and therefore were the focus for improvement.

Fig. 2 shows the ROI for the Hit-Not system, the AeroScout system and the Q-Track system. Installation of Wi-Fi infrastructure would encompass a significant majority of the installation costs for any of these systems, and it would be uneconomical to install such an infrastructure in just one section of the facility. However, the Q-Track system is easily scaled, and therefore it was assessed for ROI based both implementation in the entire plant and implementation only in the high problem area (Zone 1).

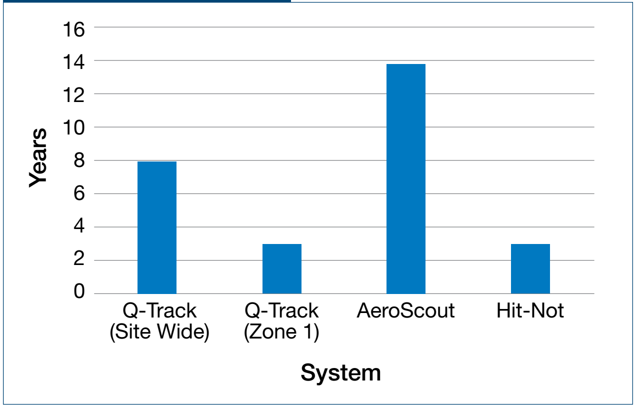
Table 1 is a Pugh chart comparison of the reviewed systems based on the previously defined success criteria; each system was ranked on a scale of 0 to 10 for each success criteria. Each of the technologies offered similar performance with respect to durability. The

Figure 1



Percentage of total injuries by zone.

Figure 2



Return on investment by system.

products available were made from similar materials, making them also similarly resistant to heat and impacts. It was unclear which systems would be more susceptible to interference; however, the system vendors did not present any concerns in this area. As shown, the quantitative assessment indicates that the Q-Track system, integrated into Zone 1, is the more effective system for improving safety at the sponsor facility. As such, the team selected this system for further review by means of a demonstration at the vendor's location. Anderson et al.[1] provides a detailed summary as to how each of these success criteria were evaluated for each system.

Vendor Demonstration

In order to collect information and data to make a sound conclusion, team members visited Q-Track's headquarters in Huntsville, Ala., USA. The demonstration focused specifically on the necessary system hardware and software functionality. The system is comprised of tracking tags, receivers and a central computer. The tags each have a unique corresponding magnetic signal that is tracked by the receivers. Each tag must be calibrated to the system using user-defined calibration points for improved accuracy. The receivers calculate each tag's location by using triangulation and then send this information to the central computer through an internet network (either wired or wireless) to analyze the data. The system boasts a minimum of 3-foot radius accuracy; however, this can be improved to within 12 inches with more receivers. Fig. 3 is a comparison of actual worker locations with a 3-foot radius drawn around them to the locations calculated by the system.

Both the tags and receivers are rated for –20 to 50°C (–4 to 122°F) and an ingress protection (IP) 68 rating for water and dust resistance. Clearly, the tags would need additional protection when used near extreme sources of heat (e.g., furnaces); however, this could easily take the form of the worker's personal protective equipment. The battery life of the tags ranges from a few days to a few weeks based on duty cycle. Considering the implications of a tag losing power, it is likely that workers would need to recharge after each shift. The magnetic field that triangulates tag positions has no known interference with medical devices — such as pacemakers — but a 6-inch separation is still recommended.

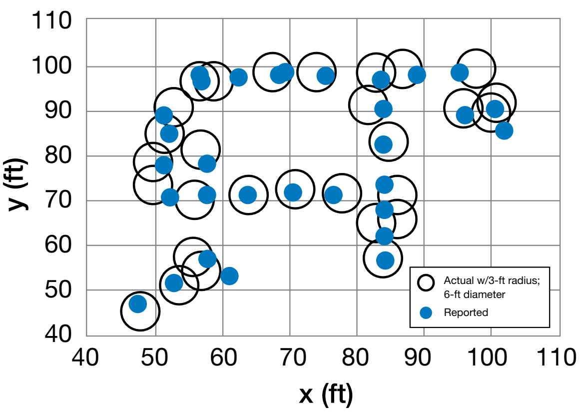
One of the more important features of the Q-Track system is the ability to perform equipment shutdown where a collision or other pre-defined trigger is imminent. For example, Q-Track offers a set of equipment for use specifically with overhead cranes. When a worker comes within a pre-defined distance of an overhead crane hook, the system will temporarily shut down the crane, preventing further movement. Furthermore, working with the Q-Track engineering staff, it may be possible to perform a controlled stop instead of a sudden stop to avoid unnecessary additional hook travel. Then, when the worker is safely out of the pre-defined range, the crane becomes operational again without the need for a system restart. Q-Track offers similar systems for other various pieces of equipment that may benefit from an automatic shutdown due to a worker proximity alert.

Table 1

Selection Criteria Pugh Chart

Technology	Durability	Risk reduction	ROI	Productivity	Worker friendly	Total (__/50)
Hit-Not System	7	3	9	0	6	25
AeroScout	7	5	2	9	8	31
Q-Track	7	8	4	8	7	34
Q-Track (Zone 1)	7	8	9	8	7	39

Figure 3



Location error based on actual radius versus reported location[6].

Discussion and Recommendations

The purpose of this investigation was to perform a broad review of existing technologies with the potential to improve worker safety in the steel environment. The project was a collaboration between the University of St. Thomas and their sponsor, and was made possible by the Don B. Daily Safety Grant awarded by AIST. The student team identified a range of systems that fell into the following categories:

- Physical barriers and mechanical guards.
- Proximity detection.
- Passive asset tracking.
- Real-time location systems.

The team's recommendation to the sponsor facility is the Q-Track system (an RTLS), as it provides a reasonable return on investment of 2 years and offers automatic equipment shutdown and worker location tracking. This offers both preventive safety measures and post-incident investigation data. AeroScout was also found to be an effective and useful system; however, its accuracy was slightly less than that of Q-Track. This could lead to false alarms and equipment shutdowns. In addition, the AeroScout system requires a Wi-Fi infrastructure, which can be a significant investment, which resulted a long return on investment of 14 years. However, if an adequate Wi-Fi system exists already at a facility, the ROI would be similar to that of Q-Track.

References

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Did You Know?

New Modular System Could Transform Construction

The Snap Interlock Module System (SIMS) is a steel-built innovation that could shake up modern construction methods. This award-winning innovation is promising a new era of modernization in architecture and engineering.

Jin Young Song, an assistant professor at the University of Buffalo, began experimenting with interlocking steel components. He used digital models and 3D-printed prototypes to arrive at a module with four hooked legs that snapped together. Each module has four interconnecting legs and a central slot. Two of the modules slide together to create a dual-axis shape with eight points of connection. Each of these points connects with the leg of another module allowing simple, sturdy structures to be easily assembled.

Song considered a number of different materials from which to construct the modules, but ultimately the dependability of steel made it ideal for his system.

"Advancements in the fabrication of steel using multi-axis cutting with parametric tools, robotics and additive manufacturing are accelerating new uses of steel," he said.

The simplicity of SIMS combined with the strength of steel could drastically reduce the complexity of construction projects. Unlike conventional steel beam and post construction methods, building with SIMS requires no welding or bolting.

"We are exploring a couple of interesting ideas such as using SIMS to build envelopes for solar panels or rain screens. But really, because the system is based on easy assembly and the idea of modular stocking, what's most exciting is how other people will use it."

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