Wireless Technology – Changing the Face of Safety Applications

by Javier González Lombardía

Executive summary

Over the past decade wireless technology has increasingly been used in machine safety applications. Today, wireless solutions adhere to stringent safety standards, and new technologies have overcome challenges that have hindered adoption in the past. Together with ensuring operator safety, wireless remote control systems create significant competitive advantage through increased mobility, reduced installation cost and time, and benefits of preventive maintenance.

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Introduction

The primary purpose of machine safety components and solutions is to protect the workforce that closely interacts with machinery. Areas and processes that represent a hazard to machine operators and engineers need to be safeguarded. In the past this was largely done using guarding, which physically stopped anyone from getting close to the hazard. Later, electronic safety components like safety light curtains or laser scanners (opto-electronic devices to detect the operator's presence) started to be used for certain safety applications. This reduced the need for physical guards. In addition to safety, these electronic components also provided other benefits (such as reducing installation time while increasing operator mobility). Such technologies inspired the train of thought that a safe machine or process could be leveraged to increase productivity and operator efficiency.

The latest stage of that evolution is the new generation of wireless remote control systems now available in the marketplace. These new solutions introduce the notion of mobility and they offer higher levels of flexibility and safety for plant floor operators. This paper explores how modern wireless implementations can benefit user safety and boost productivity.

Wireless versus wired

The benefits of wireless technology in safety applications are numerous. Whilst improving safety of operators, there are significant advantages in terms of efficiency, cost, installation time and diagnostics. For these reasons, machine builders and end users are accelerating their use of wireless technologies in order to enhance their competitiveness.

Operator proximity and mobility

Wireless remote control systems allow operators to be remote from the hazard. Rather than needing to control and monitor the application in close proximity, these devices enable operators to distance themselves. An example would be a crane or hoist used to transport heavy equipment in a factory. With a range of up to 50 meters, the operator can safely distance himself from the load and has a better view of potential hazards (see **Figure 1**).

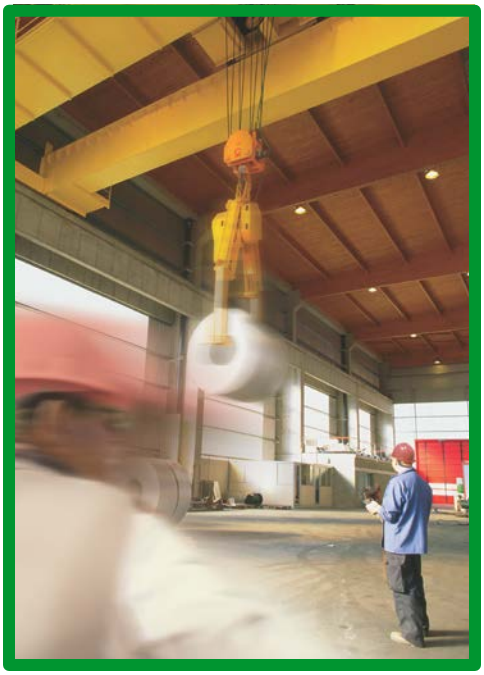

Figure 1
Operators can command an overhead crane from a safe distance by using a wireless control system

In this instance, the flexibility of being mobile is also an advantage in terms of efficiency. The ability to move freely without cabling, allows the operator to work more quickly and with greater perspective.

In addition, crane diagnostics and preventive maintenance data can easily be shown on the remote control device without moving from the floor. This helps to improve overall efficiency and productivity by preventing downtime and better managing asset performance.

Installation and maintenance

In a wired control device situation, the cabling of the control station accounts for 15% of the installation cost. Material costs will continue to increase and installers need to carefully consider the environment of the application; especially where cabling could be damaged. The replacement time and maintenance of such cabling can result in machinery being down for prolonged periods of time.

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With a wireless remote control system the installation and commissioning time is reduced significantly. Maintenance and ongoing lifecycle management are also improved due to the ability to quickly swap remote control devices, which can easily be paired at distance with the base station installed on the crane.

Maintaining and monitoring applications is key to ensuring operator safety. With smart manufacturing also driving initiatives towards greater efficiency, reducing downtime and increasing flexibility, wireless remote control systems play their part through diagnostics (see **Figure 2**). System parameters and alarms can be set by operators to ensure that if the solution tries to exceed specified ranges then the operator is notified. This helps to ensure the safety of factory floor personnel and prevent damage to the installation. Similarly, if a component needs checking/replacing then the operator is notified so that service can be scheduled. Again, this helps to plan resource, avoiding costly downtime and any potential for the solution to fail during operation.

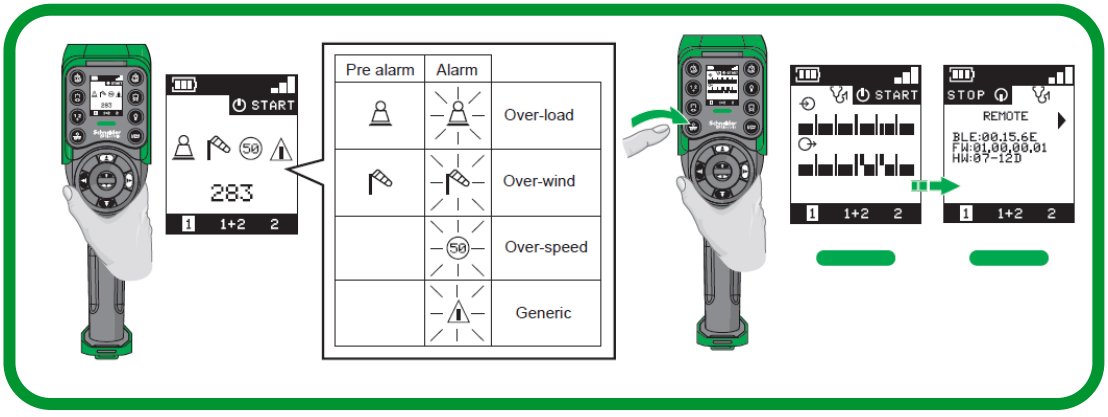

Figure 2
Wireless control systems provide better access to machine diagnostics thanks to the remote device display

When considering wireless versus wired solutions, OEMs (Original Equipment Manufacturers) and end users must consider their specific applications and determine which solution will best fit their requirement. Safety needs to be the primary concern, but this doesn't need to be the only focus. In addition to providing a safe working environment, a wireless remote control system can also improve uptime; reducing the cost and time needed for installation and increasing operator effectiveness.

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Reliable wireless protocols

The leading inhibitor of wireless adoption for safety applications is the perceived reliability issue (see **Figure 3**). The factory floor provides challenges to wireless networking, which, if not properly considered and managed, can lead to reliability problems. However, these concerns are being overcome by rigorous assessment and proven technology.

Challenges and solutions

Radio transmission is susceptible to interference, particularly when line of sight is obstructed by equipment and when an increase in radio signals occurs on the factory floor.

Frequency

The 2.4GHz frequency is being used more and more to solve these problems as its signal reliability is stronger than the traditional lower frequencies. The emergence of new, high reliability wireless technology, such as Bluetooth Low Energy, will help to further improve confidence in the reliability of mobile wireless control systems. This technology uses a floating frequency hopping mechanism, to avoid any possible interference from other devices operating on the same frequency channels.

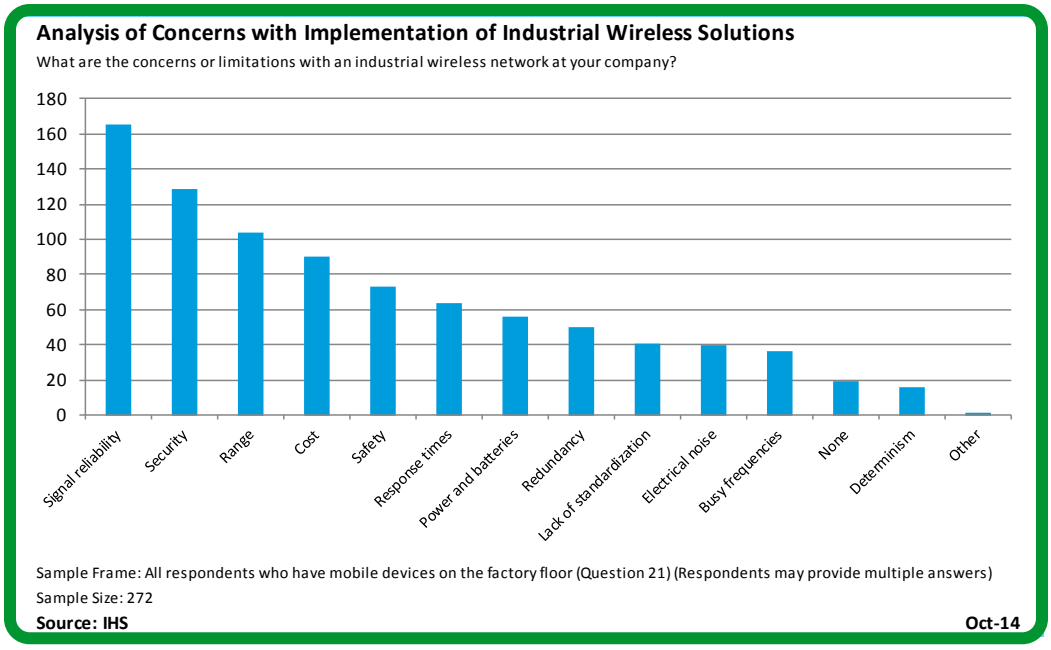

Figure 3
The leading inhibitors of wireless adoption are signal reliability, security and range - these have now been overcome by new technology.

The importance of maintaining network availability at all times often means the use of high frequency network protocols, which can limit the range of communication.

Smart antennas

The latest advances in wireless technology, related to the development of smart antennas, solves this issue by increasing or decreasing the working distance of the system to the adapted values for the specific application. Likewise, using wireless remote control systems in safety applications, the working range must be limited to the precise area where the operator can control the machine.

Security

As more automation devices are networked and wireless remote control systems are adopted in greater numbers, the concern over data and network security continues to grow.

OEMs and end users must adopt a multi-layer security approach, which provides numerous barriers and levels of protection. Particularly with safey applications, the reliability and security of the system must be paramount. The use of specific functions, such as code sequencing and encrypted communication, help to protect against external attacks. Provisions must also be taken to guard against non-malicious intrusions, through educating operators and clear operating procedures.

Battery technology

With any wireless remote control device the power source must also be on-board, to fully maximise the benefit of mobility to the operator. To date this has been a challenge, as battery technology has often reduced system availability and viability of wireless devices.

New battery technologies, such as Lithium Iron Phosphate (LiFePO4), now allow the uptime of the application to be maximised through wireless remote control devices (see **Figure 4**). Due to the very high ratio of time to charge/autonomy; charging the battery for a few minutes provides autonomy for a full working day. This technology, already being used in electric vehicles, also improves overall battery lifetime when compared with traditional technologies.

Figure 4
Battery technology comparison

Chemistry	Voltage	Energy Density	Working Temp.	Cycle Life	Safety	Environmental	Cost based on cycle life x wh of SLA
$LiFePO_4$	3.2V	>120w h/kg	-20 – 60ºC	>2000 (0.2C rate, IEC standard)	Safe	Good	0.15 – 0.25 low er than SLA
Lead Acid	2.0V	>35w h/kg	-20 – 40ºC	>200	Safe	Not good	1
NiCd	1.2V	>40w h/kg	-20 – 50ºC	>1000	Safe	Bad	0.7
NiMH	1.2V	>80w h/kg	-20 – 50ºC	>500	Safe	Good	1.2 – 1.4
$LiMn_xNi_yCo_2O_2$	3.7V	>160w h/kg	-20 – 40ºC	>500	better than LiCo	Ok	1.5 – 2.0
$LiCoO_2$	3.7V	>200w h/kg	-20 – 60ºC	>500	Unsafe w /o PCM	Ok	1.5 – 2.0

Broken or lost devices

Due to their nature, wireless remote control devices are more suseptible to being broken or lost, which can be time consuming and impactful on overall productivity.

However, some wireless remote control system use a pairing procedure enabling fast and easy replacement of the remote control device (the Schneider Electric system is an example of this technology). The replacement process is simplified and the time needed to resolve is reduced significantly as the base station configuration on the bridge of the crane can be downloaded via radio to the remote device. The new remote control device simply pairs with the existing installation and the application is operational again.

Compliance with safety standards

Wireless remote control systems must be compliant with the relevant standards. These can be general standards pertaining to radio emissions and functional safety, or can be for specific types of machinery.

Radio Emissions

The 2.4GHz frequency band has universal acceptance and doesn't require a specific license to be used worldwide. However, product manufacturers are required to obtain an international

radio certification. This demonstrates that there is no risk of interference with other wireless devices (and that they have limited health risks associated with electromagnetic radiation).

Schneider Electric, a global product manufacturer, has certification for most relevant countries. Each region has different rules and procedures of acceptance, so it's important that the product manufacturer understands the different requirements in terms of logos, labeling or technical documentation.

Functional Safety

The evolution from electromechanical to electronic safety, and the increasing levels of functionality that result, require safety solutions which integrate intelligence to monitor and control unintended movements of the machine or unexpected changes to the process.

This includes addressing the issue of operational stops, whereby the stop control does not remove power supply to the actuators. The motion function must be monitored in order to prevent unintended movements of the machine when the operator releases the pushbutton for motion.

The increasing use of mobile wireless controls and variable speed drives requires monitoring of all related functions of the machine (Category 2 according to EN ISO 13849-1), not only for stop functions but also for motion functions. This is already required in the current European Machine Directive 2006/42/CE.

The more advanced wireless remote control systems integrate monitoring of the stop function (up to Performance level e and Category 4 according to EN ISO 13849-1) and motion function (Performance level c and Category 2 according to EN ISO 13849-1) without the need for additional safety devices.

Requirements specific to hoisting equipment and cranes

The EN15011 (Cranes – Bridge and gantry cranes) standard states that electronic and programmable component control circuits must meet at least Performance level c and Category 2 in accordance with EN ISO 13849-1. These components must be monitored at all times, to ensure safe operation.

In addition, the EN13557 (Cranes - Controls and control stations) standard requires circuits to meet Performance level c and Category 3 in accordance with EN ISO 13849-1 as the minimum safety level needed for the stop function of a wireless remote control system (remote control device and base station). Finally, the EN13135 (Cranes- Safety - Design) standard defines that safety devices are required for overload protection of hoisting machines and limiting of motion that must be addressed by machine manufacturers.

Future compliance

The increasing importance of wireless remote control systems in machine safety applications has largely resulted from the revision in progress of IEC60204-1 (Safety of machinery- Electrical equipment of machines- Part 1: General requirements) and the creation of the new international standard IEC 62745 (Safety of machinery - General requirements for cable-free control systems of machinery). This standard IEC62745, aims to define the guidelines of how wireless remote control systems must be designed to comply with the minimum requirements of machine design and safety.

OEMs and end users can better accommodate migration to wireless remote control systems by establishing clear differences between general stop function and emergency stop function. This will allow certain maintenance to occur during a functional stop, which doesn't require the entire machine or production line to be stopped and re-started.

The more information that operators can access, the better positioned they are to avoid and manage unexpected machine stops, which is particularly important when the load is in a critical state. With a remote control device, an alert is issued to the operator if the communication signal between the device and the base station drops to a low level. The system is automatically stopped when valid frames are no longer transmitted or received. Similarly, with the power supply, an alert is issued to the operator once the battery charge reaches a low level. Thresholds can be set by the OEM or end user; and the recommendation is that the warning be issues at least ten minutes before the system loses power.

Conclusion

In the realm of machine safety applications, wireless technology is beginning to emerge as a core technology. Limitations of the past have been overcome and numerous advantages are now available to both end users and OEMs.

The use of wireless remote control systems in critical safety applications, which integrate emergency stop functionality, will increase in applications where operator mobility is beneficial to both safety and productivity.

Safety must remain the primary reason for adopting wireless remote control systems. However, OEMs and end users should also consider factors such as reduced installation time and costs, improved operator mobility, and increased insight as to machine or process performance (preventive maintenance). Combined, these factors offer significant competitive advantage over a wired solution.

The challenges that have historically inhibited adoption of wireless technology have been addressed, and assurance can be given as to reliability of solutions, security of networks and running time of the remote control device itself (in-line with relevant standards). With upcoming legislation aiming to further clarify different levels of safety stop, and Schneider Electric already conforming, the benefits of wireless safety continue to grow, signaling the end of wired control in applications where safety and mobility go hand in hand.

About the author

Javier González Lombardía joined Schneider Electric in 1999 as Technical Product Manager in Sensors department. He's currently working as Project Marketing Manager for new range of wireless remote control stations. Prior to work in this position, he was the Application Marketing Manager for Hoisting & Material Handling Application Centers and later the Product Manager for Safety modules and controllers. Javier holds a Bachelor's degree in Electrical Engineering and Master's degree in Industrial Marketing from Polytechnic University of Catalonia.