

# How Embedded Safety Drives and Networked Safety Cut Costs and Boost Productivity

by Alexandre Perrat

## Executive summary

Today's advanced safety technology is not just a means to ensure operator safety but is a way to improve performance. Traditionally, the functions of automated machine safety and control have been kept separate. But technological advances now enable safety functionality to be embedded within automation components such as variable speed drives and servo drives. This paper explains how this simplified, integrated approach — along with networking safety over Ethernet — cuts installation costs, actually enhances operator safety, and reduces the amount of 'full shutdown' downtime, thereby improving overall production line performance.

## Introduction

Ensuring operator safety is a machine process company’s top priority and paramount concern. Consequently, safety always trumps production — a simple safety stop can shut down production for as long as it takes to identify the problem and restart the systems. Given today’s high-throughput production lines, even a relatively short period of downtime can be costly.

Traditionally, the functions of automated machine safety and control have been kept separate. Conventional wisdom held that the two systems should be physically and functionally isolated from each other, so that safety would not be compromised by the same faulty condition that led to the control system’s producing a ‘dangerous’ situation in the first place. Or, conversely, some feared that integrating the safety automation and control automation systems would adversely affect the machinery. Operators were protected from hazardous situations by non–automation control electromechanical hardware such as contactors, safety relays, and interlock circuits. The extra expense of OEMs’ building and customers’ maintaining two discrete systems was seen as an unavoidable cost of doing business.

However, technological advances now enable safety functionality to be embedded within automation components such as variable speed drives and servo drives. A single drive component capable of standard control functions as well as safety monitoring offers several advantages to OEMs and their end-user customers:

- Lower installation costs
- Enhanced operator safety
- Increased machine productivity
- Improved production line performance

*‘Safety has evolved from being a cost burden and “necessary evil” to a strategy for improving productivity and reducing downtime’.<sup>1</sup>*

—ARC Advisory Group

### Advantages of embedded safety drives

<b>Lower installation costs up to 30% savings</b>	<ul style="list-style-type: none"> <li>• 1 device instead of 2</li> <li>• Fewer circuit breakers</li> <li>• Reduced cabling</li> <li>• Simplified installation</li> </ul>
<b>Enhanced operator safety</b>	<ul style="list-style-type: none"> <li>• Fewer potential points of failure</li> <li>• Faster response to safety signals</li> </ul>
<b>Increased machine productivity</b>	<ul style="list-style-type: none"> <li>• Reduced wear and tear</li> <li>• Faster, safer manual intervention</li> </ul>
<b>Improved production line performance</b>	<ul style="list-style-type: none"> <li>• Less ‘full shutdown’ downtime</li> <li>• Faster restart times</li> </ul>

**Table 1**

*Embedded safety drives offer OEMs and their end-user customers several advantages*

Not only do embedded safety drives reduce hardware costs by as much as 30% (since only one device is needed instead of two), but complementary savings are realised from reduced cabling needs, fewer circuit breakers, and simplified installation (e.g., functionality is integrated right into the drive, avoiding the need to figure out how to hook up and wire the logic with relays, resets, and contactors).

Embedded safety drives ensure a safer working environment for machine operators by simplifying the safety system. Drives that integrate both control and safety functionality reduce the complexity of engineering two separate control and safety systems. In general, the less complicated a system is, the safer it is. Fewer devices and less cabling mean fewer potential points of failure.

<sup>1</sup> ARC Advisory Group, ‘PROFI-safe: Networked Safety for Process and Factory Automation’

Instead of compromising the health of machinery, utilising a single drive component can actually improve machine performance and extend its useful lifetime. Advanced safety functions enable safe stop ramps without completely shutting down power to the machines. This reduces the chances of breakdown since there are no wearing parts, and avoids degradation of machinery due to full-stop-and-restart cycles. Safe speed monitoring ramps allow the machine to slow down sufficiently for an operator to safely perform some types of intervention (clearing a blockage, for example) before the machine is damaged.

### Additional information

For an industry analyst's discussion on embedded safety and how modern safety systems improve productivity, download the IHS white paper [Machine-safety in factory automation](#)

The advanced safety functionality of embedded safety drives improves overall production line performance. The 'Safe Stop' and 'Safe Limited Speed' functions reduce full-shutdown downtime and enable faster restart times. Operators can safely intervene to resolve machine stops. Production may continue at a reduced rate while machinery is adjusted (for example, resetting a door and unblocking a chute). Less downtime means more productivity.

Further, networking the safety devices as a cohesive system delivers all the operational and cost-saving advantages of a less-complex system — reduced cabling needs, simplified installation, etc. As noted, a simpler system is generally a safer system.

Integrating safety and control systems allows them to 'talk' with each other and share data such as diagnostics, system status, alarms, events, and other critical information. This data sharing improves productivity by enabling faster restart times through minimising the time it takes to identify and troubleshoot a problem — without compromising operator safety.

There is a growing realisation among OEMs and end-user companies that advanced safety technology is not just a means to ensure operator safety but is a way to improve performance. Variable speed drives and servo drives with embedded safety meet the most stringent regional safety standards while also boosting productivity — and are a less costly alternative to the conventional approach of maintaining separate safety components.

This paper explores how improved safety means improved productivity. Specifically, embedded safety drives and Ethernet-networked drives lower hardware costs, increase operator safety, reduce downtime, and therefore improve overall production line performance.

## Embedded safety improves productivity

Historically, compliance with safety standards and regulations — and the impact this had on machines — has often been viewed as a burden. Safety was an additional cost to bear in an increasingly competitive market. It was something that OEMs and operators had to address, but more often they did so reactively rather than proactively. They would implement the minimum automated safety functionality to meet mandated requirements.

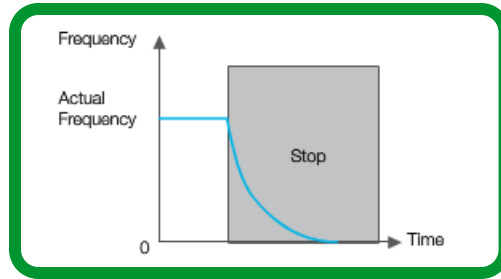
That approach has given way to a new perspective in which safety functionality goes beyond safeguarding people and protecting machinery. Today machine process companies see how safety enhancements lead to better machine performance and improved overall production.

It may seem that the two concepts of 'enhanced safety' and 'improved productivity' are contradictory within the context of industrial machinery. Safety calls for machines to shut down if there is an abnormal condition that presents a danger to operators, whereas productivity requires machines to keep running. In other words, safety demands downtime but productivity demands uptime. But today's advanced safety technology — in particular, variable speed drives and servo drives embedded with safety functionality — are able to better safeguard operators while simultaneously minimising the amount of time the production line is shut down.

Embedded safety drives integrate safety functions that control the drive output to the electrical motor in response to safety-related events. These functions can either stop the drive without shutting off power to the motor entirely, or control the speed of the drive.

Embedded safety functionality means a drive does not have to ‘wait’ for a signal that there is an abnormal condition (e.g., overspeed, blockage). Three of the most common functions are STO (Safe Torque Off), SLS (Safe Limited Speed), and SS1 (Safe Stop 1).

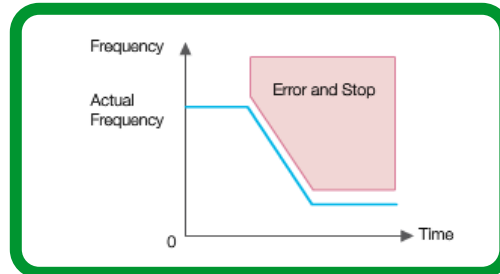
STO (see **Figure 1**) ensures that there will be no torque on the motor, so the machine is not able to move and harm operators or damage components. The electronic switching time is much faster than with electromechanical components in a conventional solution.



**Figure 1**

*The STO function brings a machine to a stop without shutting off power to the motor*

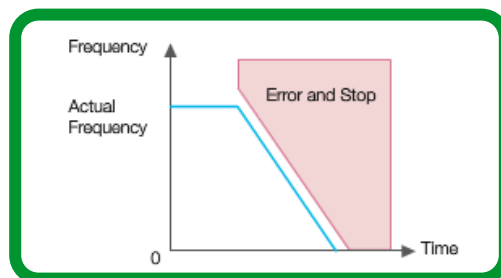
SLS (see **Figure 2**) slows down, then holds the motor at a predefined speed. If this speed is exceeded, STO automatically kicks in. This function protects machinery by ensuring that damage is not caused by machines’ running too fast. It also enables operators to reduce the speed of a machine to a level where they can safely intervene to correct an abnormal condition.



**Figure 2**

*The SLS function slows down a machine to safe speeds*

Safe Stop 1 (SS1) stops a motor by controlled braking, according to a predefined speed ramp. (See **Figure 3**.) It checks that the motor has actually stopped (or reached a predefined minimum speed), then activates STO. This function brakes high-speed motors more quickly and safely than conventional electromechanical solutions. The automatic switchover to STO enhances operator safety.



**Figure 3**

*The Safe Stop 1 (SS1) function stops a drive more safely and quickly before transitioning to STO*

A simple example may illustrate how adopting embedded safety drives can improve operator safety while at the same time boosting productivity. In a woodworking machine that uses a spindle to shape the material, stop ramps (Safe Stop 1, for instance) can be used to precisely

manage operator access — for example, clear away chips from the spindle shaft. As cutting power to a big machine can take several minutes to stop its spindle, there is always the risk that operator will try to interact with the machine too soon (before the cutter heads stop spinning). But the stop ramps also avoid operators waiting longer than required before interacting with the spindle (according to a timer, for instance). The ramps rapidly stop the machine, ensuring that any damage is limited and that operators can quickly assess problems in a safe environment (STO). The drive with embedded safety functionality cuts off the torque on the motor but does not shut off power altogether. This enables faster start-up. Downtime and potentially costly damage are reduced, but operator safety is not compromised.

#### Figure 4

*Embedded safety drives utilise stop ramps to allow operators to intervene safely and quickly*



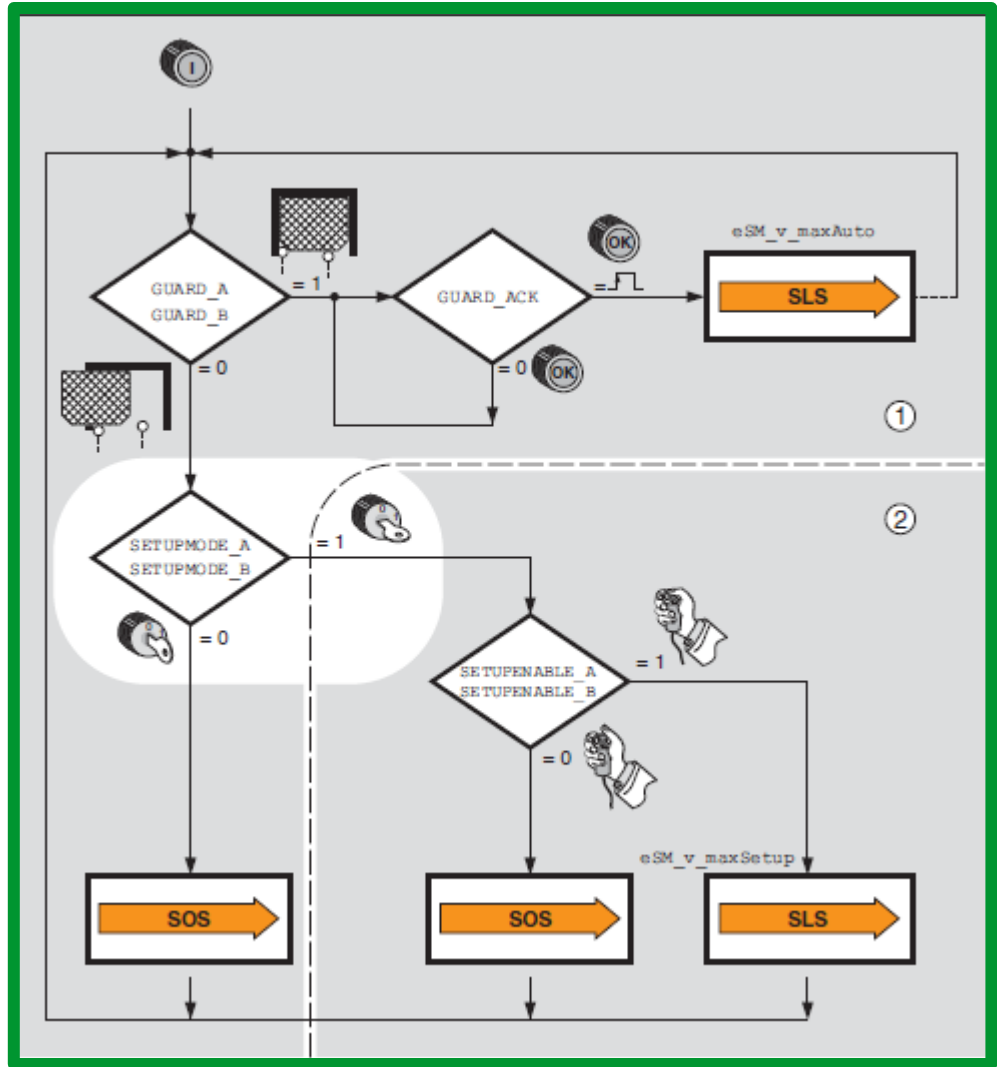
Once operators are in close proximity to the moving parts of the machine, Safe Limited Speed allows operators to inspect, perform basic maintenance, or remove blockages without shutting the machine down completely (see **Figure 5**). This safety function allows machine operators to more quickly assess and resolve problems, improving machine uptime and more efficiently managing the production line. The ability of operators to more effectively manage machinery through embedded safety drive functionality also reduces the requirement to employ specialist electrical engineers, who would normally be needed to take the machine offline and restart.

Embedded safety drives also reduce the amount of waste that normally occurs if a component or machine fails or needs to be inspected. The Safe Limited Speed function allows individual machine or component problems to be more quickly evaluated and fixed so that less material further upstream the production line has to be scrapped.

## Embedded safety drives reduce costs

Put simply, using an embedded safety drive means investing in one component rather than two. Specifically, the initial cost outlay of two devices — one for control and one for safety — is reduced by using a single device that has both safety and control functionality.

Although variable speed drives or servo drives with embedded safety are likely to cost more than drives solely used for control or for safety, the overall hardware cost savings can be as high as 30%.



**Figure 5**  
Example of Safe Limited Speed

*‘Although variable speed drives or servo drives with embedded safety are likely to cost more than drives solely used for control or safety, the overall cost saving in terms of the initial hardware outlay can be as high as 30%’.*

Further cost reductions are realised through reducing the number of circuit breakers needed to achieve a safe stop. Safe Torque Off (STO) functionality on the drive enables the machine to be put into a safe mode automatically, without the need for a breaker downstream. Thus, embedded safety drives offer an improved degree of reliability over other circuit protection components. Conventional approaches require two circuit breakers in series (or a breaker and a monitoring device), so reliability is dependent on several components working in conjunction. Embedded safety drives achieve the same level of safety integrity intrinsically.

The addition of an option card inserted in the drive enables it to manage applications like opening machine guard doors. Managing doors with an embedded safety drive that monitors the speed of the motor is much simpler — and less expensive — than the conventional approach, which requires a number of other devices to manage safe outputs, monitor speed, and manage locks. Significant cost saving may be realised whilst at the same time improving overall safety and performance.

Beyond the reduced hardware costs are the savings achievable from reduced cabling, which can account for 15% of the installation costs.<sup>2</sup> A single embedded safety drive eliminates the

<sup>2</sup> Javier González Lombardía, ‘Wireless Technology – Changing the Face of Safety Applications’ (Schneider Electric).

cabling cost associated with connecting numerous devices. This can be a significant amount, likely only to increase in line with material costs.

Most important, a safety system with fewer devices is likely to be more robust. Fewer devices and less cabling reduce the potential for failure. Generally, a simpler system is a safer system. With every additional device that is needed to construct the safety system, the overall performance and reliability are lessened — no matter how highly rated the individual components are.

Replacing hardware with embedded software, which is certified for specific conditions, increases the overall reliability index of the system. When a system segregates safety and control functions, one must ensure that both control and safety are well coordinated. Whereas with embedded safety, the function and the behaviour of the control are certified to be linked to this safety function — precluding a source of failure.

Modern industrial processes are employing ever larger, faster, and more complex machinery. While more productive, today's machines present more challenging safety conditions and call for more sophisticated safety control. Simply shutting off the power to the machine is no longer sufficient to protect operators and machinery itself. In fact, suddenly powering down a large, high-speed machine can present an even more hazardous situation than the condition that caused the safety stop. Responding to potentially unsafe conditions in a controlled manner has become more complex, which increases the cost of building and maintaining safety control systems.

Technological advancements now enable safety devices to be networked as a cohesive system. Networking simplifies the integration of automation and safety control, offering all the operational and cost-saving advantages of a less-complex system, as well as additional benefits:

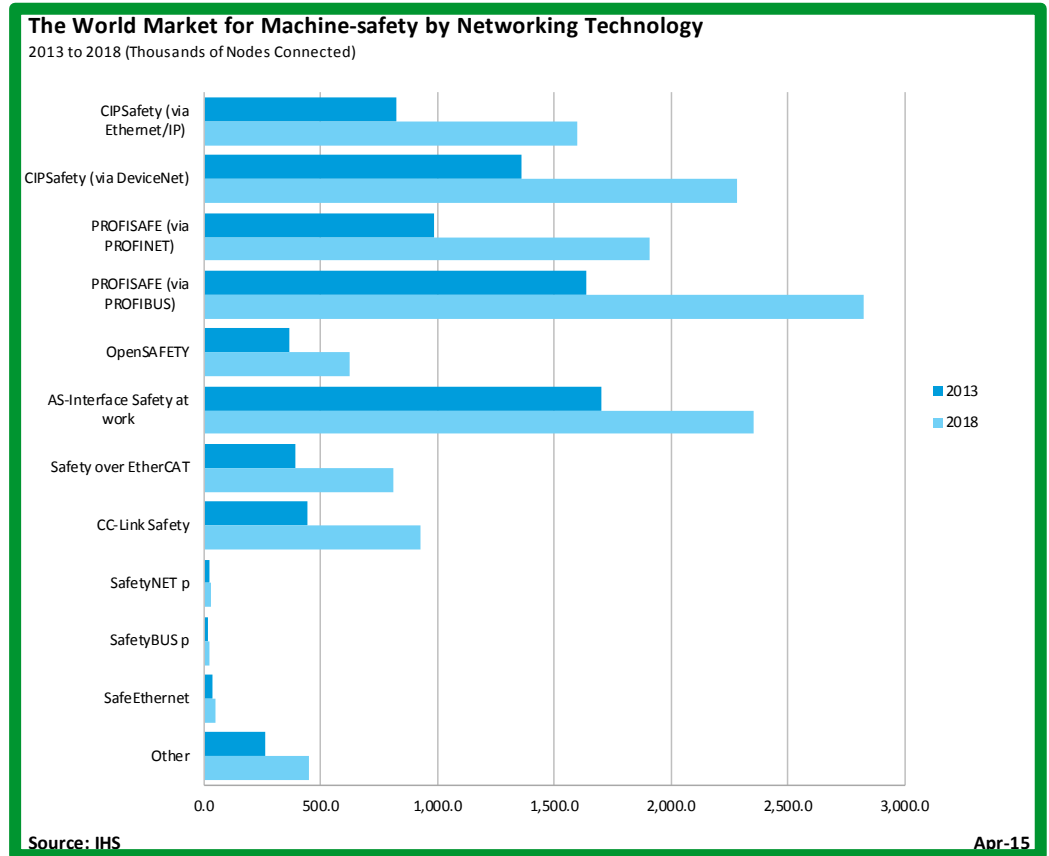
- Lower installation costs due to fewer hardware components and reduced cabling — and therefore fewer potential points of failure
- Faster commissioning time
- Quicker and easier certification
- Simplified (and less expensive) maintenance
- Enhanced operator safety from faster response to potentially unsafe conditions
- Improved machine productivity due to reduced degradation of electromechanical components in separate safety system
- Data sharing among different but integrated systems — enabling better synchronisation to boost productivity

A number of safety protocols are already used widely for networking discrete machine safety components. Analysts forecast an increasingly higher adoption rate in the foreseeable future (see **Figure 6**). They all sit on top of industrial Ethernet variants that are used for networking of a broad range of industrial automation components. Technological advances have overcome the disadvantages of Ethernet communication in previous years, and today its low cost and high speed have established it as the most widely installed network technology. The compatibility of both the safety- and control-based protocols means that integration to a single network is quick and straightforward.

## Embedded safety over Ethernet



**Figure 6**  
Safety networking protocol analysis (2013 vs. 2018)



Integration allows safety and control systems to ‘talk’ with each other and share data such as diagnostics, system status, alarms, events, and other critical information. For example, networked embedded safety drives allow critical events and information to be displayed on one HMI screen. This data sharing improves productivity by enabling faster restart times through minimising the time it takes to identify and troubleshoot a problem — without compromising operator safety.

### Wireless Safety Control

Machine safety applications have increasingly begun to adopt wireless technology. Today’s wireless solutions adhere to stringent safety standards and have overcome challenges that have hindered adoption in the past.

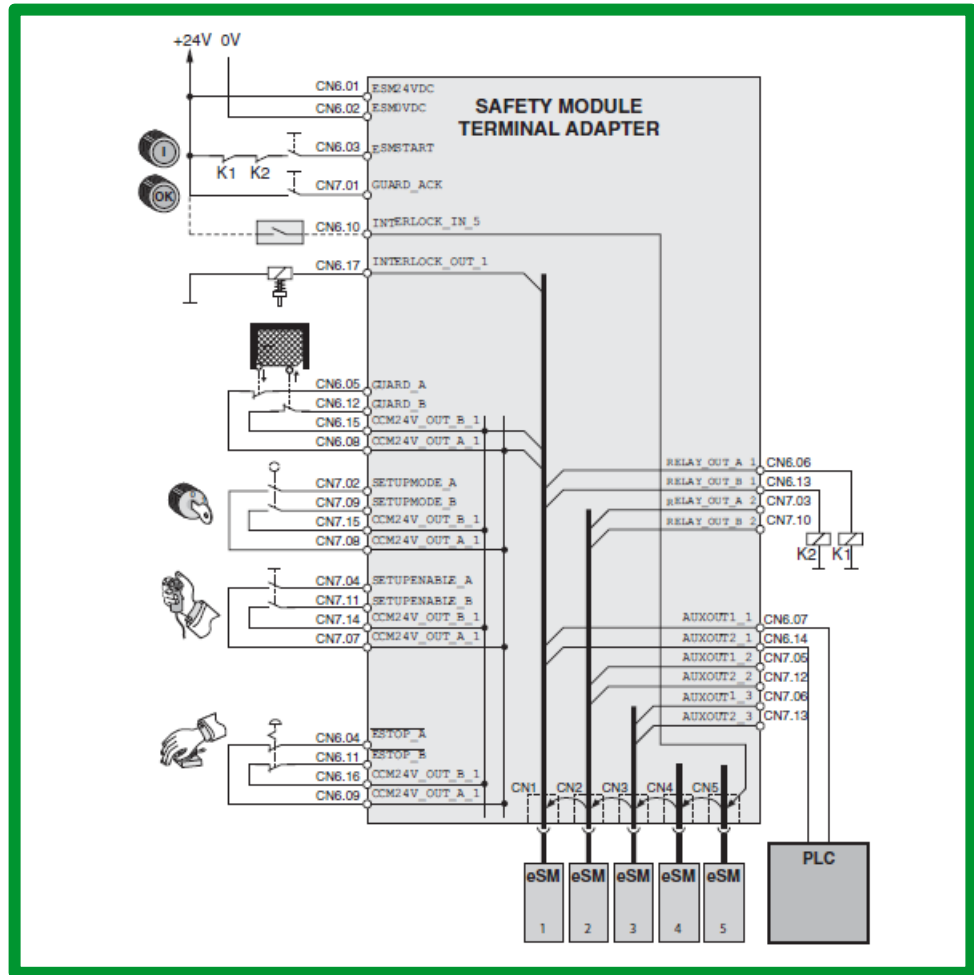
The Schneider Electric white paper [Wireless Technology – Changing the Face of Safety Applications](#) explores how modern wireless implementations can benefit user safety and boost productivity.

Safety over Ethernet simplifies safety system communications, reducing the need for multiple hardware components and their associated expense. For example, hardwiring communications for a 5-axis machine would require terminal adapters at each drive (see **Figure 7**). The more axes the machine has, that many more drives would be required and that many more terminal adapters would be needed. Ethernet-networked embedded safety drives would be fully operational as soon as a single standard RJ45 cable is connected — as opposed to a hardwired system, which would require six different wires to achieve the same level of functionality.

Not only are installation and hardware costs reduced, but so is the potential for connection failures. A standard networking backbone for the safety system means that automatic slowdown can be implemented for the production line, enabling better management and coordination of production.



**Figure 7**  
Safety module terminal adapter of Lexium32



The commissioning process is also simplified with Ethernet-networked embedded safety drives. Safety parameters can be specified using standard function blocks in a programmable logic controller (PLC), which can then be connected via Ethernet to multiple drives. This streamlines an often complex architecture, as a single safety PLC can be used to control multiple parts of the production line. Overall, this makes for a simpler system and potentially improved productivity due to better synchronisation of modules. An example would be a machine where motors are virtually linked, like a packaging machine (in the case of servo drives) or load-sharing applications (in the case of VSDs), in which the wear and tear of the mechanical link among motors could be avoided.

Embedded safety over Ethernet also benefits OEMs and their end-user customers during the certification process. As safety networks are now sanctioned by global industry standards (specifically, ISO 13849), validation of the system is simplified, because less assessment and computation is required. As devices are networked using a standard but robust Ethernet cable using a certified channel, the system performance is guaranteed.

## Conclusion

Machine process companies today must respond to pressure to improve their bottom line through increased productivity without sacrificing operator safety. The nemesis of productivity is downtime: powering down machines and halting production until the problem is identified and resolved. Advanced safety technology — in particular, variable speed drives and servo drives that integrate safety and control functionality — are able to better safeguard operators while simultaneously minimising the amount of time the production line is shut down. No longer are productivity and safety mutually exclusive objectives.

Embedded safety drives represent a new, forward-looking alternative to the conventional approach of using multiple hardware components to create separate, independent systems for machine control and safety. Embedding safety functionality into the control drives reduces the complexity of the safety system. The number of components is reduced — as are the associated cabling needs — making the system more robust and reliable. In general, the less complicated a system is, the safer it is. Fewer devices and less cabling mean fewer potential points of failure.

Not only do embedded safety drives reduce hardware costs by as much as 30%, they also extend the useful lifetime of machinery. Safety functions enable safe stop ramps without completely shutting down power to the machines. This avoids machinery degradation from excessive full-stop-and-restart cycles. Safe speed monitoring ramps allow machines to slow down sufficiently for an operator to safely interact with them, to troubleshoot a condition that would otherwise shut down the production line (clearing a blockage or closing a guard door, for instance). By reducing full-shutdown downtime and enabling faster restart times, overall production line performance is improved.

Networking safety systems over Ethernet cable enables quicker certification and easier integration of safety and control. System complexity and wiring is also significantly reduced, which helps improve overall safety due to fewer components with the potential to fail.

As with embedded safety drives, networking a control and safety system using an integrated, single backbone improves operator safety whilst enabling cost and installation time savings. Adopting embedded safety hardware and communications can realise a significant cost advantage over the traditional hardwired and stand-alone approach.



## About the author

**Alexandre Perrat** is Marketing Director for Drives Business in Schneider Electric's Industry division. He holds a Bachelor's degree in Control Engineering from Ecole Nationale Supérieure d'Electricité et de Mécanique (ENSEM) de Nancy. He has several years of experience in industrial applications, with a focus on variable speed drive automation. He previously held several positions in the servo drives business within Schneider Electric's Industry division.