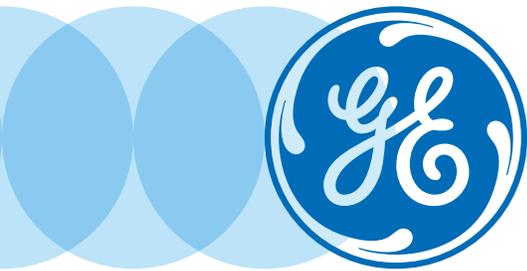


# Ethernet backbone improves design, implementation, and lifecycle management of safety and basic process control systems



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## Introduction

Ethernet communications has become pervasive in today's technological environment. Data from Distributed Control Systems (DCS), Safety Instrumented Systems (SIS), and Programmable Logic Controllers (PLC) are routinely gathered together, transmitted between islands of automation, and served to upper level Manufacturing Execution Systems (MES). Now this flexible, high-speed, low-cost communications layer is being introduced at the lowest level of control system architecture — the rack.

Rack-based systems of various shapes, sizes, and descriptions have been the norm in the DCS and SIS environment. We can now examine the benefits of the Ethernet-based system with regards to system design phase, operations and maintenance, and overall lifecycle impacts. Bringing Ethernet to the control system as a replacement for the control system rack enables the connectivity and integration required in the age of the Industrial Internet.

## Ethernet during design

Ethernet as a control system backplane provides a number of design-phase benefits. The flexibility to add and subtract I/O as required for the combination of Safety Instrumented Functions (SIF) in a SIS reduces costs, improves distributability, and simplifies overall control system architecture.

## Redundancy where the application requires

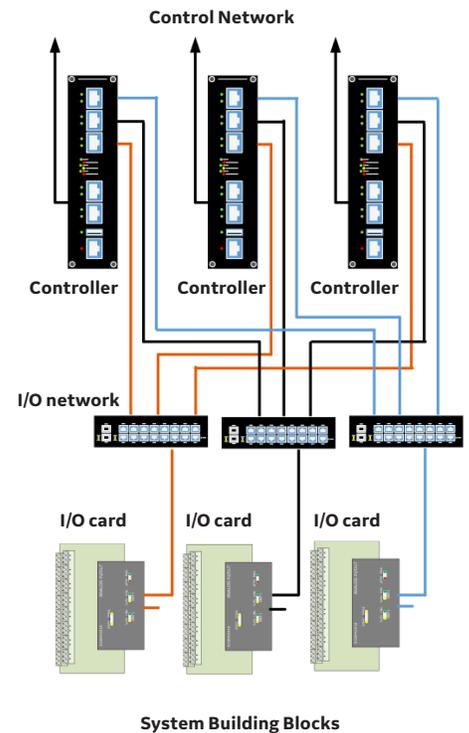
The SIL level and spurious failure tolerance of the process system of each SIF may require a certain fault tolerance. If SIFs of different redundancy requirements are hosted in the same controller, traditional rack-based architecture would force adoption of redundancy at the highest level for all SIFs. Ethernet-based systems can use redundancy (especially for I/O modules) as required, allowing some SIFs to use simplex I/O, and other SIFs to use redundant I/O. I/O modules can even be changed from simplex to redundant, or the reverse, if SIF requirements change, without affecting the I/O structure of any other SIFs.

## Treatment of SIFS on individual requirements

Depending on the SIL level required of a SIF, hardware fault tolerance (HFT) requirements can be different, even if the logic solver system capability is SIL 3. A SIF that is required at SIL 2 may reside in the same SIS as a SIL 3 SIF. Mixing SIL levels in this fashion typically requires that the entire system have the redundancy required by the higher SIL level throughout; but Ethernet-based systems can use two simplex I/O cards for a SIL 3 HFT of 1, and a different channel on the same I/O card for a SIL 2 SIF that does not require fault tolerance. This improves the usage efficiency of the SIS I/O structure.

## Redundant networks and electronics on the same controller

A redundant Ethernet switch fabric between the controller and I/O level allows differing levels of redundancy to mix freely in the same controller. For example, a traditional TMR system may use three set of I/O electronics, while a dual system may use two sets of I/O electronics. Both configurations can use the same communications networks to the controller, even if they use the network in slightly different ways.



## Complete scalability

System size and scalability are critical factors in system design. Rack-based I/O systems restrict the granularity of I/O count to a fixed number of I/O cards. If a rack is specified that is minimally capable for the number of I/O specified, a change in I/O requirement can result in a potentially costly and complicated addition of a new I/O structure, in addition to the wasted cost of the original. Over-specification on I/O capacity results in sunk cost on unneeded equipment. Ethernet backbone architecture allows complete scalability from a single I/O card to hundreds.

## Freedom to distribute

The term Distributed Control System is often a misnomer. DCS and SIS systems are often deployed in a single monolithic location, with home-run cabling for hundreds or even thousands of feet to a central marshalling rack or I/O cabinet. An Ethernet backbone gives control system designers the freedom to truly distribute controllers and I/O to minimize overall cost and maximize system value.

## Single card I/O locations are viable

Many rack-based systems have concentrated design efforts on minimizing hardware cost and footprint. Sometimes this downsizing of the I/O structure comes at the price of reducing the capability of the I/O system. Some I/O cards have overly-dense connection points, or don't have innate power distribution to power

current loops, interrogate contacts, or power solenoid valves. The combination of onboard power distribution and Ethernet connectivity (both copper and fiber-based) make a single I/O card distribution location a viable alternative for system designers.

## Low-cost Ethernet cable replaces bulky, expensive home runs

Redundant Ethernet communications on every I/O card in the Ethernet-based system can replace dozens or hundreds of individual conductors. Fiber-optic cable presents both electrical isolation and excellent noise immunity, and the ubiquitous nature of Ethernet hardware in the industrial infrastructure has made Ethernet hardware and cabling very affordable due to enormous volume and competition.

## Skids and cabinets can be supplied with integrated control components

Islands of automation provided by skid vendor OEMs have been an integration issue for many years. Sometimes proprietary protocols and hardware layers are provided, with connectivity and data integration requiring significant effort. Often personal computer (PC) data conversion is required, leaving vulnerability in the overall plant control infrastructure.

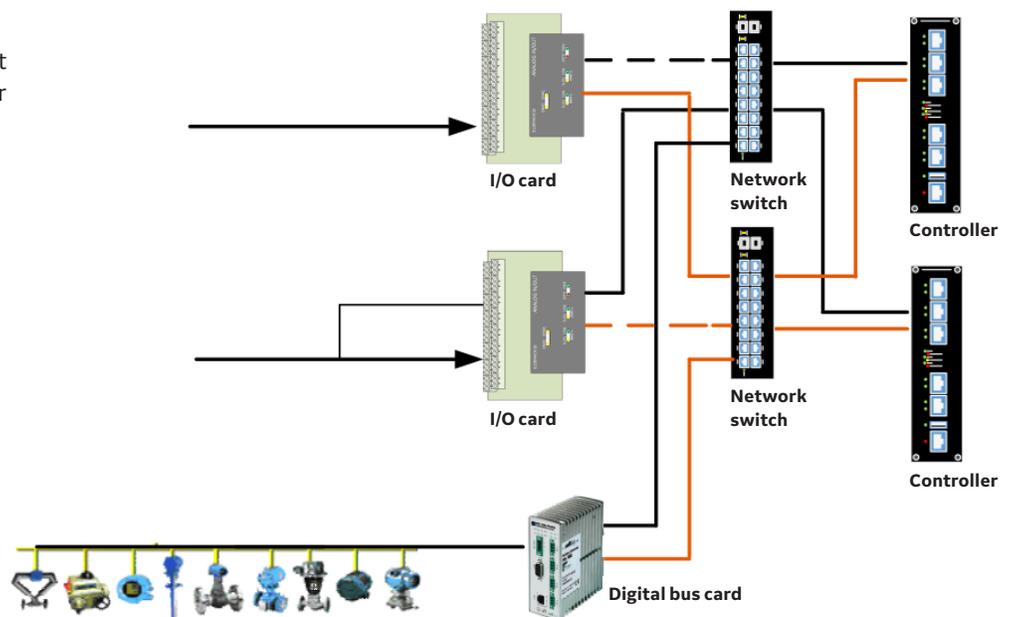
Ethernet-based control system architecture allows supply of skid-based systems with I/O cards instead of complete local PLC systems, allowing seamless integration of skid systems with overall plant control system architecture.

## Ethernet enabling truly seamless integration

With appropriate functionality, more than one Ethernet protocol can be transmitted using the same physical layer. Many emerging protocols share the same physical layer, allowing integration by protocol, instead of by adapter.

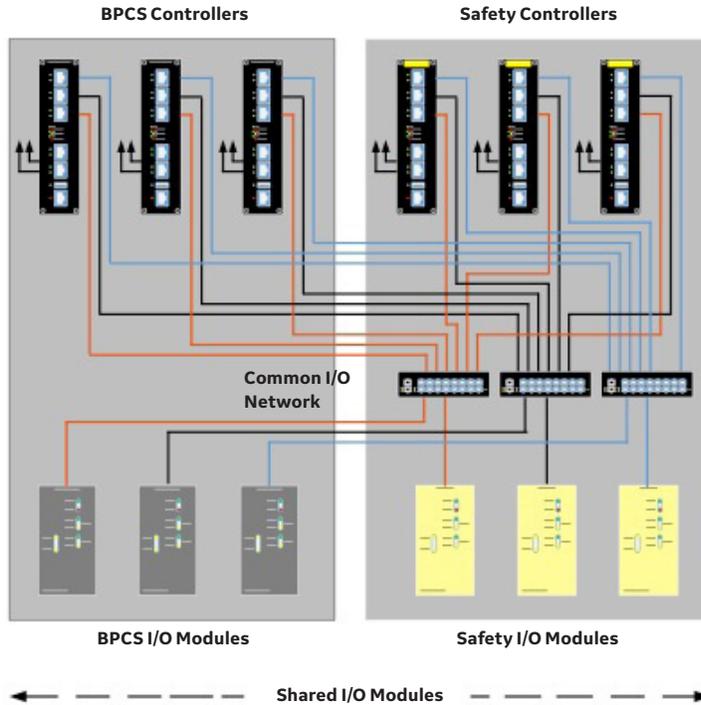
## Digital bus integration

Digital bus networks can be seamlessly integrated with traditional I/O using a common Ethernet connection. For example, Foundation Fieldbus HSE (high-speed Ethernet) can be used along with a high-speed I/O communications protocol for conventional I/O.



## SIS TO DCS COMMUNICATIONS

With appropriate application layer security, SIS and DCS I/O can be shared on the same Ethernet network. This can allow the DCS to access that portion of SIS I/O information that does not interfere with the safety function of the SIS. This improves latency of information transfer and can reduce the number of transmitters required for the overall system operation, since the transmitters dedicated to the SIS may also be used for Basic Process Control System functionality.



## Ethernet for extending the lifecycle

The Ethernet-based control system allows for extending the lifecycle of a control system in ways that a rack-based system cannot. The free-form nature of Ethernet backplane allows integration of newly integrated technology without disrupting the original design intent of the control system.

## Open standards for long life

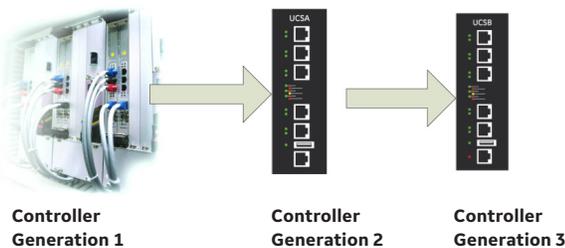
Widespread use of Ethernet technology for virtually every computing function in today's world allows the control system design community to leverage the power of distributed technology development. Proprietary connectivity solutions will become less and less important as more innovations based on Ethernet technology enter the marketplace. Fiber-optic high-speed networks and wireless technologies have already been developed. Use of Open Ethernet standard physical technology allows a lower cost for innovation for the life of the control system. Completely new I/O functionality can be integrated into installed systems without costly ripouts.

## No fit, no form, only function

The old saying for replacing outdated equipment without costly redesign is "fit, form, and function replacement." Utilizing Ethernet as the basic hardware structure means that a newly developed I/O card or controller can be integrated into an existing control system without regard to physical structure of the new component. The only requirement is backwards compatibility built into the new design to support existing installed base.

## Conclusion

Ethernet technology allowed integration of widely varied control platforms at the controller-to-controller level, and has become the standard for developing integration solutions. Now Ethernet technology is moving to the I/O layer, and promises to become the backbone selection for control system design for the foreseeable future.





## Imagination at work

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