FROST & SULLIVAN

Scalable Availability in Plant Architectures

Enhancing Resilience with Modicon M580 Redundant I/O Network

A Frost & Sullivan Whitepaper

In Partnership with Schneider Electric

Schneider Electric

Summary

To minimise the potentially significant monetary and non-monetary costs of unplanned downtime, single points of failure need to be eliminated so that the goal of uninterrupted plant operations is achieved.

Schneider Electric offers scalable high availability options to suit diverse applications, at different levels of criticality and different budgets. From optimised redundancy (with Modicon Hot-Standby CPU and Edge I/O NTS) to standard redundancy (with Modicon Hot-Standby CPU and Modicon X80 Remote I/O), to critical redundancy (with Modicon Hot-Standby M580 CPU, Redundant X80 power supply and the Modicon M580 Redundant Remote I/O network including redundancy both at the communication adaptor (CRA) head level for controlling the I/Os as well as redundancy at the I/O network level, to avoid a single point of failure).

Flexibility and scalability across the spectrum of criticality is now possible for all types of discrete, process or hybrid applications. As a result, end users and operators can realise more fully the benefits of open, flexible, reliable, sustainable, safe, and secure architectures, with appropriate levels of system reliability and uptime.

The Paper was completed in February 2025.
Images from Frost & Sullivan Image Resource and Schneider Electric.

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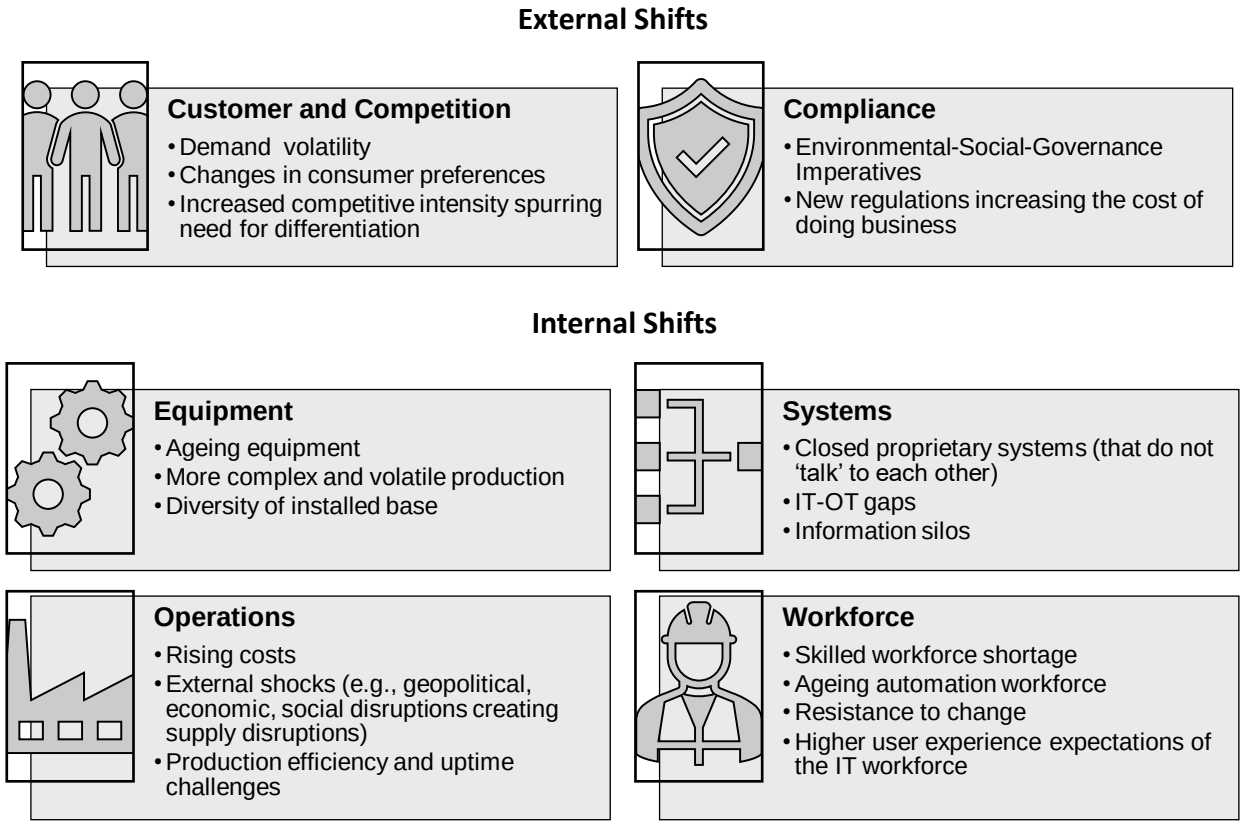
The Resiliency Imperative

Production and process environments are having to address the more demanding needs of a radically different world of today. This is a world in which organisations face intensifying external pressures driven by **changes in the customer, competition, and compliance** domains. At the same time, **internal pressures from machinery, system, and operational challenges**, as well as **workforce shifts**, are triggering a search for better ways of operating.

Production and process environments are impacted by a range of pressures and challenges, as summarised below.

External and Internal Shifts Impacting Production and Process Environments



Source: Frost & Sullivan

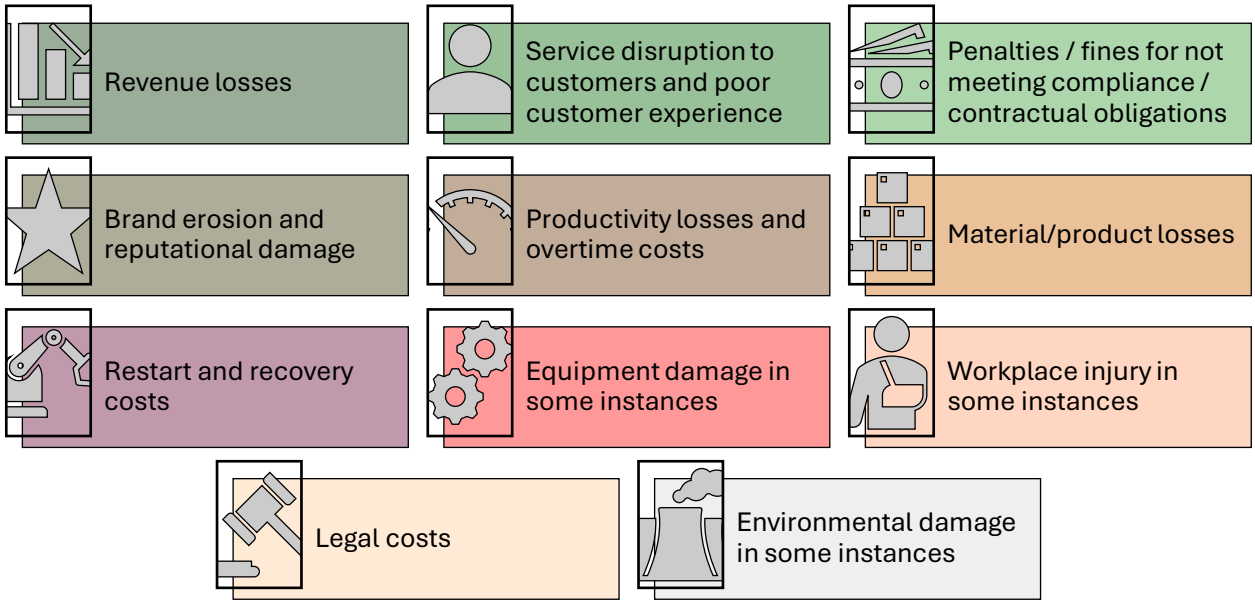
The combination of these challenges is forcing industries to prioritise investments on optimised assets and processes so that they can **enhance resilience** in the face of internal and external disruptions.

Nowhere is this more keenly felt and understood than in the specific area of **operational reliability**.

The High Cost of Unplanned Downtime

Unplanned downtime – from equipment or system failure – results in organisations facing significant costs, including the following:

Impacts of Unplanned Downtime



Source: Frost & Sullivan

The ripple effect of this combination of direct and indirect costs can slow time to market, impede profitability, weaken competitive advantage, and reduce the overall value delivered by organisations to customers and society.

A survey of Global 2000 companies found that the **total cost of downtime** for these companies to be **USD400 billion annually, or 9% of profits**.[1]

Downtime costs the average factory at least **5% to 20% of its annual productive capacity**.[2] And this is often viewed as a conservative estimate since the majority of industrial sites do not have an accurate estimation of their total downtime cost, with significant levels of underestimation of the true cost.

Downtime costs the average factory at least 5% to 20% of its annual productive capacity.

A range of studies across regions and industries[3] has shown that (1) the **majority of organisations have had to contend with unplanned downtime** at some time or the other, and (2) those organisations with **reactive and inefficient management** of their operating environments incur **heavier losses** than those with proactive and efficient management practices.

The good news from these same studies is that, in the recent past, the **instances and duration of unplanned downtime are broadly reducing or stabilising** to some extent – the result of improved

[1] The Hidden Costs of Downtime, Oxford Economics and Splunk, 2024
[2] How Much Is Plant or Facility Downtime Costing You?, ISA Interchange, International Society of Automation (ISA)
[3] Based on Frost & Sullivan's desk research scan of relevant research studies

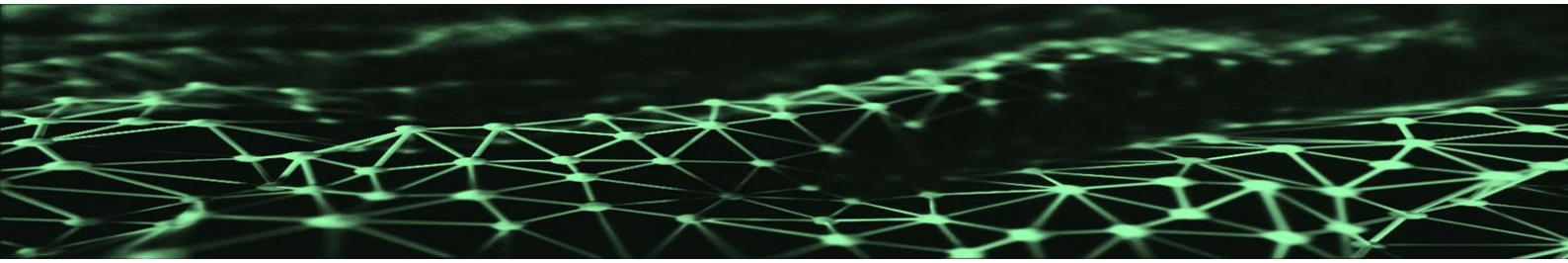
planned and predictive maintenance, replacements/upgrades to equipment/systems, improved training, and use of best practices in achieving operating efficiencies.

The bad news is that, despite these wins, organisations are facing **higher costs of downtime**. Obviously, larger scale operations (for example, a global company with multiple production/process sites) incur higher costs of downtime as the disruption affects larger volumes of throughput across multiple sites and impacts a larger number of customers. Similarly, critical infrastructure sites that suffer unplanned downtime have to contend with disruption of services to the public, potential security breaches, and safety risks. However, **scale and criticality** apart, there are more specific reasons for higher costs of downtime. **Inflationary pressures** (impacting the price of parts, shipping, labour, etc.), skilled and experienced **labour shortages**, **higher penalties**, **damage to key assets**, and **supply chain issues** are some of the main factors driving the increase in unplanned downtime costs.

While the instances and duration of unplanned downtime are broadly reducing or stabilising, the costs of downtime are increasing.

As businesses and their processes become even more integrated, and as the costs of manufacturing goods or delivering services increase, Frost & Sullivan expects the costs of downtime to continue rising.

To minimise this risk, organisations operating across the spectrum – from critical infrastructure to other less critical process or production environments – invest time and money in building resilience. This can take the form of training teams to plan effectively and analyse root causes. It also involves replacing ageing equipment. Nevertheless, the age of parts and components has a much lower impact on unplanned downtime than most factory managers assume. Hence, the need for deploying smart control and automation technology solutions in these operating environments. However, when those **environments run on complex architectures with multiple modules**, the goal of resilience and availability becomes more difficult to achieve.



The Goal of High Availability

Availability – or the duration of time that the system is available to perform its tasks (calculated as the percentage of uptime to total time) – is understandably a key metric for production and process environments. High availability – as depicted in the 'Nines of Availability' – can translate into significant differences in costs incurred (hundreds to thousands to millions of dollars) or time lost (seconds to minutes to days).

High availability is pursued using strategies such as **redundancy** (redundant power supply, SCADA server, control network, controllers, and I/O network) to eliminate single points of failure.

Nines of Availability

Nines	% of Availability	Downtime per year
1	90%	36.5 days
2	99%	3.65 days
3	99.9%	8.76 hours
4	99.99%	52.56 mins
5	99.999%	5.26 mins
6	99.9999%	31.5 seconds
7	99.99999%	3.15 seconds

In addition, more industries operate today with **less plant maintenance staff with relevant experience onsite** than in the past. A global survey undertaken on behalf of Schneider Electric found that **talent acquisition and/or retention of plant personnel** was a **key challenge for over 75% of industrial companies**.[4] This means that even in simple processes without ultra-critical applications, **organisations seek the highest possible levels of availability**.

The Goal of Easier Repairability for Rapid Recovery

One clear strategy to reduce downtime is to be able to **diagnose, repair, and recover quickly**. This is often expressed in the maintenance metric of **Mean Time to Repair (MTTR)** (the average time it takes to repair a failed component or system).

This also relates to the **ability to repair without having to stop the process**. Continuous processes, such as those used in steel manufacturing, cement manufacturing, oil refining, some food and beverage processing, pharmaceutical manufacturing, etc., are more vulnerable to disruptions as a result of stoppages on account of the raw materials used or the processing required.

In such environments, repair without stoppage is possible if controllers can switch from manual to automatic mode or from primary to secondary controller without disrupting ongoing process (referred to as **bumpless transfer**).

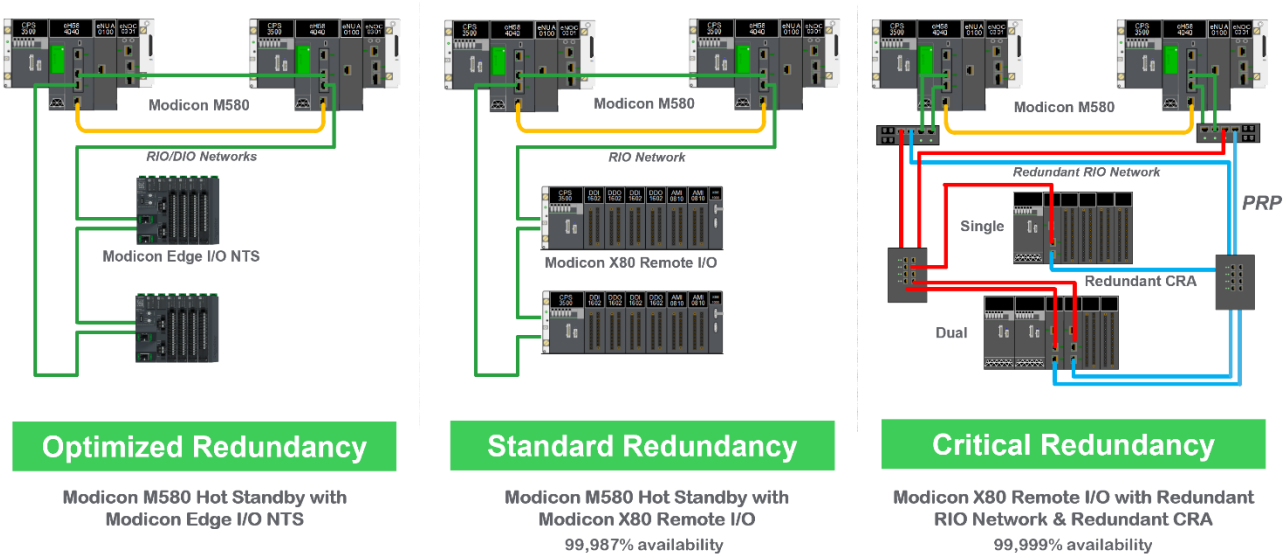
[4] The Future of Work in Industry, Omdia, Schneider Electric, 2024

Modicon M580 Redundant I/O Network

In response to this need for higher availability and easier repairability, Schneider Electric offers different levels of redundancy to suit the applications, the criticality, and budgets. This covers:

- **Optimized redundancy** (with Modicon M580 Hot-Standby and Edge I/O NTS)
- **Standard redundancy** (with Modicon Hot-Standby CPU and Modicon X80 Remote I/O)
- **Critical redundancy** (with Modicon X80 Remote I/O, Redundant power supply, Redundant CRA)

Flexibility and Scalability with the Modicon M580 Platform



Source: Schneider Electric

Optimized Redundancy with Modicon M580 Hot-Standby and Edge I/O NTS: This distributed I/O offer that is compatible with both Schneider Electric controllers and third-party solutions – delivers platform availability through operating with the M580 Hot Standby CPU and supporting EtherNet/IP redundant owner (which translates into no bump/no freeze on CPU switchover on EtherNet/IP). It connects directly to the CPU's Remote I/O (RIO) ring topology network with RSTP, offers hot swappable components[5] and power supply redundancy.

This facilitates an entry level of high availability where uptime is important, but the application may be less critical and/or where cost may be a constraint (for example, in airport baggage handling or liquid cooling in data centres).

Modicon M580 has been chosen because it allows us to make modifications without having to stop the operations.

- **Arcelor Mittal Dunkerque, France**

Standard Redundancy with Modicon Hot-Standby CPU and Modicon X80 Remote I/O: Providing 99.987% availability, this supports high availability in applications that are not ultra-critical (for example, mining, cement, glass, manufacturing, etc.). It comes with the benefits of a more robust

[5] Components that can be removed and replaced without interrupting the system's operation

rack-based concept, fire and gas certification, and safety capacity that is ideal when there is use of isolated signals.

Critical Redundancy with Modicon X80 Remote I/O, Redundant power supply, Redundant CRA: Providing 99.999% availability, this supports ultra-critical applications such as oil & gas, chemicals, water infrastructure, life sciences, and metals processing.

Redundant RIO Network Parallel Redundancy Protocol (PRP)[6] as per the standard **IEC 62439-3**, provides high availability in Ethernet networks (fault tolerant Ethernet with redundant LANs). RIO PRP goes beyond simple ring topology, [7] to **allow flexible topology**, [8] and creates seamless redundancy by sending **duplicate frames to two independent network infrastructures**, known as LAN A and LAN B. The end device detects and eliminates one of the packets. This enables **zero millisecond recovery time, bumpless transfer, and multi-fault tolerance**.

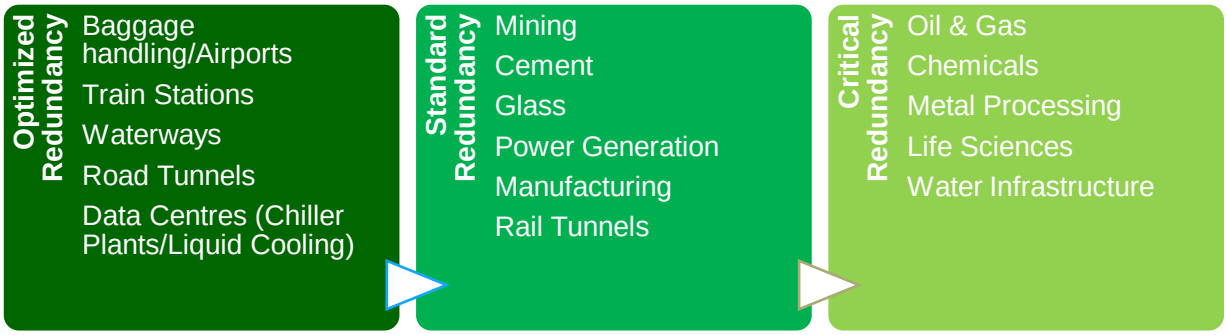
More precise control of operations (using Schneider Electric's full range of solutions) reduced the damage to the steel pliers and enhanced production efficiency, achieving an automation rate of up to 98.5%.

- **Hot Rolling Plant, Baosteel, China**

The shift is from redundancy at control network level and at power supply level, to the I/O network level and to the CRA. This redundancy at every level ensures that redundancy is brought down to below the CPU level and is available even at drop level.

By expanding the offering, Schneider Electric is able to address the needs of both **discrete and process applications, as well as hybrid.**

Flexibility and Scalability across the Spectrum of Criticality



Source: Schneider Electric

This ensures that ultra-critical applications (requiring extra-large configurations and involving intensive analog processing; often in harsh environments), as well as applications that are not ultra-critical (requiring distributed I/O in flexible architectures) are equipped with their **choice of availability**.

[6] A network protocol standard that provides seamless redundancy in Ethernet networks
[7] Network design with devices connected in a circle to form a data channel providing a single path for data to travel (thus being vulnerable to data transmission failure should a single node fail).
[8] For example, star topology (centralised hub) or mesh topology (multiple interconnections for higher redundancy)

Cybersecurity and Operational Resiliency

In addition to architectural redundancy, it is becoming increasingly important to secure operational resiliency through the protection of control systems and their communications. Modicon M580's **embedded cybersecurity features and compliance standards** ensure that communications are safeguarded through:

Modicon M580 gives us large memory capacity and cybersecurity to protect our networks from outside intrusion. It is also more advantageous to work with a single efficient, modern, and reliable platform that makes our maintenance much simpler.

- **Drinking Water Ultrafiltration Plant, Orleans, France**

- Secure firmware updates via Hypertext Transfer Protocol Secure (HTTPS) with user authentication/access control,
- Simple Network Management Protocol version 3 or SNMPv3 as available network monitoring protocol,
- Integrated Modbus-HTTPS,
- An inbuilt firewall,
- Access control lists, configurable user roles, device hardening, and IP filtering to prevent unauthorised access,
- Support for various secure communications protocols[9],
- Integration of a Trusted Platform Module (TPM),
- Use of advanced firmware encryption algorithms and digital signatures,
- The ability to set up Virtual Local Area Networks (VLANs), Virtual Private Network (VPN) capabilities,
- Incorporation of a memory protection mechanism that safeguards the PLC from unauthorised changes during its operational modes, as well as
- Certification under the IEC 62443-4-1 Maturity Level 4 process guidelines, Certificat de Sécurité de Premier Niveau (CSPN), and Achilles Level 2 robustness tests compliance

[9] Including OPC UA Secure, IEC 60870-5-104, Distributed Network Protocol version 3 (DNP3), Internet Protocol Security (IPSEC)

Conclusion

From simple ring topology to high availability, Schneider Electric enables scalable availability that is sized for each application's needs. This not only reduces total cost of ownership (TCO) but also enhances operational efficiencies and safeguards process and production environments with choice of availability level. This enables operators of complex and demanding industrial automation applications to take advantage of open, flexible, reliable, sustainable, safe, and secure architectures, with appropriate levels of system reliability and uptime.

By offering optimised, standard, or critical redundancy, flexibility and scalability across the spectrum of criticality is now possible for all types of discrete, process or hybrid applications. This gives end users and asset operators service continuity and easier repairability for higher returns on assets and enhanced profitability.

The EcoStruxure Platform is very intuitive. It brings all our control systems under one interface, effectively delivering a combination of automation, connectivity, real-time control and visibility. This has allowed us to improve safety and reliability of our factory to provide a benchmark for our group.

- **Wilmar Sugar, Australia**

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About Schneider Electric

Schneider's purpose is to empower all to make the most of our energy and resources, bridging progress and sustainability for all. We call this Life Is On. Our mission is to be your digital partner for Sustainability and Efficiency. We drive digital transformation by integrating world-leading process and energy technologies, endpoint to cloud connecting products, controls, software, and services, across the entire lifecycle, enabling integrated company management, for homes, buildings, data centres, infrastructure, and industries. We are the most local of global companies. We are advocates of open standards and partnership ecosystems that are passionate about our shared Meaningful Purpose, Inclusive and Empowered values. www.se.com

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