

# Electronic Marshalling Availability and Redundancy

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This document describes the details of how Electronic Marshalling with DeltaV™ delivers unparalleled system availability and robustness compared with traditionally wired systems.



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## Executive Summary

In a direct comparison of similar configured systems, the Electronic Marshalling system delivered a Mean Time Between Failure (MTBF) that is **3 times greater** than a fully redundant conventional I/O system.

While creating a system architecture which will greatly reduce costs associated with installing, changing or adding I/O, Emerson Process Management also made improvements to overall system robustness and performance. DeltaV Process Automation Systems provide “Availability by Design” with Electronic Marshalling. This architecture provides redundancy down to the individual signal channel. Additionally, single channel integrity protects loop errors from affecting any other loop.

- Availability by Design is achieved through
  - Simplicity of architecture
  - Layers
  - Maintenance Practices
  - Redundancy architected down to the individual channel
  - CHARM (CHARacterization Module) I/O Cards
  - CHARM (CHARacterization Module)
  - Single Channel Integrity

## Introduction

In 2009, Emerson Process Management introduced an innovative way to eliminate unnecessary work and reduce costs associated with wiring field devices to process automation systems. Starting with the version 11 release, the DeltaV™ Process Automation System has Electronic Marshalling capabilities which significantly reduce new installation wiring costs as well as expensive changes to I/O late in a project. Electronic Marshalling is enabled by using CHARacterization Modules (CHARMs) instead of traditional wired cross-marshalling. For additional details on, and benefits of using Electronic Marshalling and CHARMs, please refer to the [Electronic Marshalling Overview Whitepaper](#).

## Architecture

Electronic Marshalling delivers many benefits, and at the heart of the technology are two I/O components developed by Emerson in the version 11 release - CHARMs and the corresponding CHARM I/O Cards (CIOCs). The architecture of CIOCs in a DeltaV System is a traditional ‘star’ configuration, where all of the CIOCs and their related controllers are connected to one or more segregated switches. The CIOCs are segregated from traffic on the rest of the DeltaV Control Network by this topology.

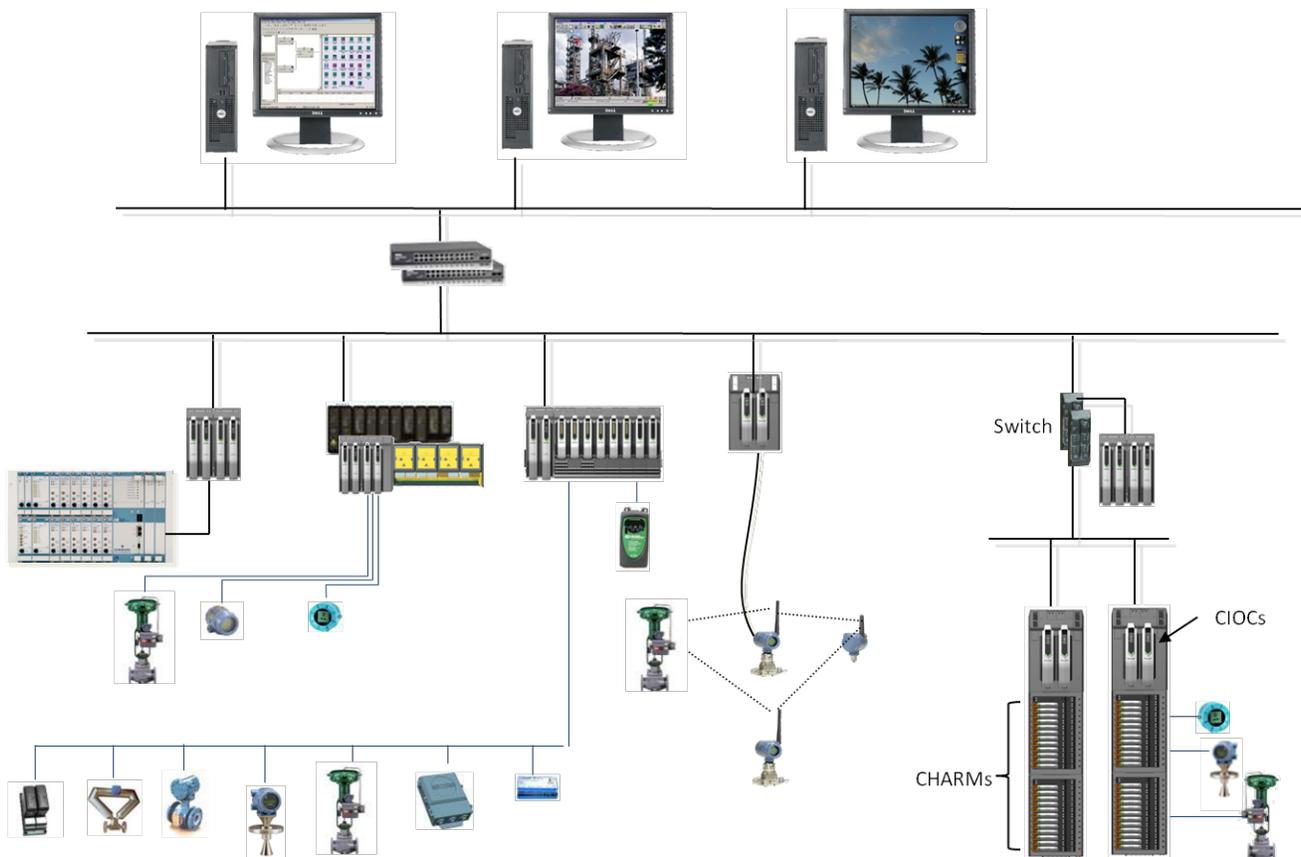


Figure 1 – DeltaV Architecture with Electronic Marshalling

This network design provides maximum availability because of the redundant communication network. The primary and secondary networks are completely isolated from each other and do not share any common hardware.

CIOCs can be installed with copper or fiber optic communication modules. Fiber optic modules are end point devices and must be connected to a switch directly. Copper modules have a cascade port that can be enabled to allow a series of CIOCs to be connected together in a cascade manner, utilizing a single switch port. The I/O network can have a combination of the two topologies – star topology, with multiple CIOCs connected in cascade to each switch port. The cascade port on the copper communication modules is a way to connect additional CHARM I/O.

Full duplex communication to each device allows the network to be very efficient. Each device has a dedicated switch port that only allows through data traffic intended for that device. The full duplex connection eliminates collisions of outgoing messages with incoming data. Data packets themselves are optimally sized and packaged, allowing the switch to quickly route data from all CIOCs to the controller with extremely low latencies.

## Availability by Design

Process Automation Engineers typically require redundancy as a means of attaining high system availability. Primarily, redundancy is used to protect against component failures that could affect production. These are unplanned events that can impact multiple control signals. A secondary use of redundancy is to support online upgrades of control system software. By performing an upgrade online, system availability is maintained. Finally, redundancy offers the ability to repair the system without disruption of functioning control loops.

The goal Emerson achieves is one of Operation Excellence by providing “Availability by Design” across the DeltaV platform. Availability is a product of the entire system and is composed of

- Simplicity of Architecture and Design
  - Avoid single points of failure (e.g. client-server architecture)
  - Reduce scope of impact of failures
  - Design Strategy – active versus passive components
- Layers
  - Diagnostics
  - Hot Backups
  - Redundancy
- Maintenance Practices
  - Simplicity – minimize unnecessary work processes
  - Minimize the number of field related components

## Redundancy

To achieve high availability, DeltaV supports redundancy throughout its architecture. The control network and associated switches are redundant. The family of DeltaV controllers, both M-series and S-series, also support redundancy. Monitoring and automatic switchover technology is built in; further decreasing the amount of time the system is impacted by a failure.

Electronic Marshalling is architected with full redundancy down to the individual channel, providing maximum availability.



Figure 2 – Redundancy with Electronic Marshalling

### CHARM I/O Cards

- CIOCs are redundant and, therefore, can be upgraded online.
- Each CIOC has redundant Ethernet communication modules that connect to the control networks.
- Redundant 24VDC power is supplied to the CIOCs.
- Power distribution is provided on redundant busses that connect each channel to the CIOCs.

### CHARMs

- Each CHARM has two separate communication transceivers that connect the signal to the redundant communications bus.
- A CHARM connects the field signal to the redundant bus and provides loop power from redundant 24VDC power supplies.

CHARMs perform continuous diagnostics to confirm their availability on both the power and communication busses. Internal diagnostics provide proactive hardware alerts to developing conditions. There is no loss of control if one of these redundant transceivers stops working, and the easy replacement mechanism create an extremely low Mean Time to Repair, resulting in an extremely high availability of the field circuit.

The redundancy throughout the architecture provides the highest availability of the system I/O infrastructure while providing individual channel fault isolation of the field signal.

### **Single Channel Integrity**

With Electronic Marshalling installations, any problem with a field loop is limited to just that loop. The CHARM has current limiting circuitry to prevent wiring faults such as short circuits or ground faults from damaging any components. Correcting the wiring restores operation of the channel. In addition, each CHARM is designed to fail open and isolate the field circuit on an excessive voltage fault, such as wiring a DC channel to an AC power source. No fault with one loop can affect any other loop or affect the availability of any other signal.

This provides increased availability for all loops compared with using classic I/O cards. With classic I/O cards, a problem with one loop may affect all other signals/loops that are connected to that card. So, at a minimum, seven other signals/loops can be lost. With higher density cards, more signals are potentially affected. However, with CHARMs, if one signal has a problem, none of the other 95 channels of the CIOC will be affected. Everything from transients and surges to field wiring faults will be contained within the single loop.

In the event of a CHARM failure, replacement of the CHARM is fast, with no engineering or configuration activity required. Replacement of the CHARM or terminal block itself impacts only that single channel. This is different than a traditional terminal block, in that all signals on a traditional terminal block must be disconnected to replace it. The single channel granularity of CHARMs reduces the repair time to a matter of minutes without impact to any other signal.

With the single channel integrity design of CHARMs, Electronic Marshalling provides higher availability of all control loops compared to traditional I/O cards and wiring.

## System Availability

The normal life period and amount of failures for any component can be depicted by a 'bathtub curve'.

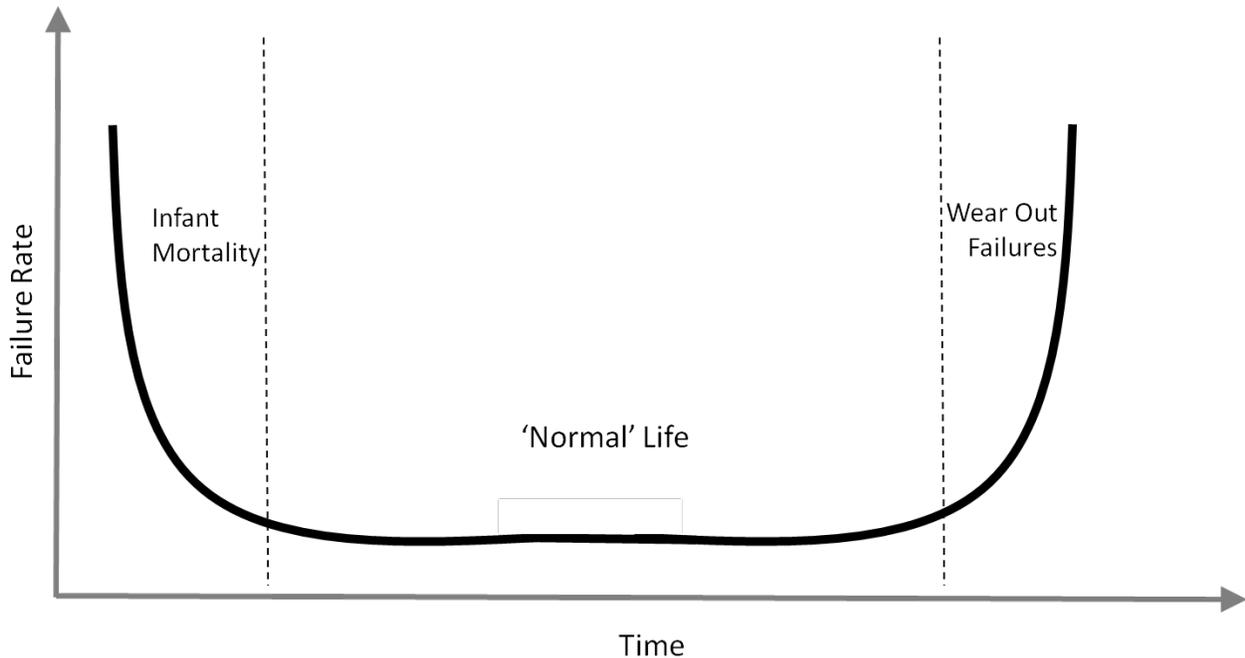


Figure 3 – Bathtub Curve Example

There are typically higher rates of failure early in a component's life span, referred to as infant mortality. These often occur upon power up of the components due to quality issues in manufacturing. During the normal life of the component, the rate of failures is basically constant. And then, as a component nears the end of its life span, failure increase due to wear out.

Emerson has processes in place to prevent high infant mortality failure rates when they are first put into service. For example, CHARMs are power cycled at both -40°C and 70°C to significantly reduce the infant mortality in the field.

### Mean Time Between Failure

Mean Time Between Failure (MTBF) is the average amount of time a system will run between failures. The MTBF model assumes the failed system will be repaired and restarted. This is in contrast to Mean Time To Failure (MTTF), where the assumption is that the failure is not repairable. MTBF is used to determine system availability for a DeltaV System, because the component that caused the system failure can be repaired or replaced, and the system can be started again.

In order to demonstrate the unparalleled availability and robustness of DeltaV Electronic Marshalling, a comparison was made between a system using conventional DeltaV Redundant I/O cards and a system using DeltaV Electronic Marshalling. The following mix of 1656 I/O was used for both systems:

Table 1 – I/O Mix

I/O Count	Type
192	HART Analog Inputs
64	HART Analog Outputs
1040	Discrete Inputs
360	Discrete Outputs

The following two tables detail the Bill of Materials for the Conventional Redundant I/O system and the Electronic Marshalling system.

Table 2 – Bill of Material, Conventional Redundant IO

Quantity	Component	Details
	<b>Common Network</b>	
2	Network Switch	24-port Smart Switch
	<b>Main Cabinets</b>	
14	2-wide Carrier	S-series Carrier
14	System Power	
14	Controller	SD Plus
52	8-wide Carrier	
24	AI Cards	Redundant AI 8 Channel
8	AO Cards	Redundant AO 8 Channel
131	DI Cards	Redundant 8 Channel
45	DO Cards	Redundant 8 Channel
2	2-wide Carrier for VIM	S-series Carrier
2	System Power for VIM	
2	VIM	S-series
14	Bulk Power	AC to DC bulks
14	Network Switch	6-port DeltaV Smart Switch

Table 3 – Bill of Material, Electronic Marshalling

Quantity	Component	Details
	<b>Main Cabinet</b>	
2	2-wide Carrier	S-series Carrier
2	System Power	
2	Controller	SD Plus
2	2-wide Carrier for VIM	S-series Carrier
2	System Power for VIM	
2	VIM	S-series
2	Bulk Power	AC to DC bulks
2	Network Switch	6-port Smart Switch
	<b>Remote Area</b>	
4	2-wide Carrier	S-series Carrier
4	System Power	
4	Controller	SX
	<b>Electronic Marshalling</b>	
18	CIOC	
139	Baseplates	
18	Address Plugs	Sets (1 to 8)
64	AO CHARM	4-20mA HART
192	AI CHARM	4-20mA HART
360	DO CHARM	24 Vdc; High Side
1044	DI CHARM	24 Vdc Dry Contact, Low-side sense
10	Bulk Power	AC to 24 Vdc

Other system components (servers and workstations) were the same for each system, and were not included in the overall availability calculations. For both systems, a Mean Time to Repair of four hours and a duty cycle of 100% were assumed.

**Electronic Marshalling Delivers Higher Availability**

For this example and set of assumptions, the system using Electronic Marshalling has a Mean Time Before Failure that is **over 3 times** greater than that of the fully redundant conventional I/O system (the MTBF is calculated using the MIL-HDBK parts count method).

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