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The Virtuous Cycle of Closed-Loop Manufacturing

Brandon Lewis

Closed-loop manufacturing is a strategy for increasing revenue and reducing costs that relies on data from all parts of an organization **(Figure 1)**. The data is used to inform development teams of improvements that can be made in future products, either based on customer feedback or the performance of devices in the field.

But to reap the benefits of closed-loop manufacturing, businesses that are already incorporating industrial Internet of Things (IIoT) best practices must find a way to achieve data transparency among the various data management systems. These systems include Manufacturing Execution Systems (MES), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and other IT and operations technology (OT).

The good news is that research indicates that the global industrial manufacturing sector is on pace to spend roughly $890 billion on IoT technology by 2020 in pursuit of this goal, which will enable businesses to realize the full potential of concepts like closed-loop manufacturing.

Taking the concept of closed-loop manufacturing a step further, quality and test data can be shared across multiple product development teams during the prototyping and production phases to eliminate design flaws and optimize solutions before they reach the market **(Figure 1)**.

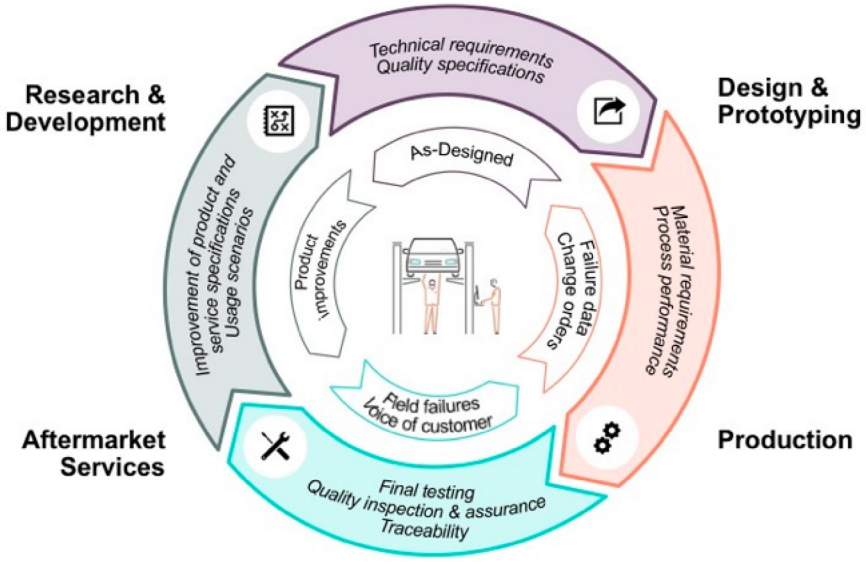

Figure 1. Closed-loop manufacturing capitalizes on data from each stage of the product lifecycle to improve on current and future designs. (Source: Hewlett Packard Enterprise)

But to realize these benefits with any semblance of automation and scale, the data from disparate systems also must be exposed to key stakeholders across the product development lifecycle so they can make the decisions to adjust designs and processes as needed. This requires standardized, converged IT/OT infrastructure platforms, or gateways, that integrate seamlessly with existing manufacturing workflows to improve insight and keep operations running.

A Gateway to Closed Manufacturing Loops

"There are lots of different systems usually in play within an OT environment," said Steve Fearn, Chief Technologist at Hewlett Packard Enterprise. "MES systems are really driving the execution of the manufacturing; you've got ERP that is trying to bring all the components together, but you've also got a lot of quality assurance systems within most sophisticated manufacturing environments that try to marry the finished good to the capability."

Typically, manufacturing sites aren't in the position where they can refresh their entire shop floor in a single exercise, as there may be multiple generations of equipment. "Silos exist purely because of the historic way that the manufacturing sites have been implemented, and those can be difficult to break down," said Fearn. "Operational technologists, very sensibly, are fairly resistant to the idea of making changes to a happily functioning manufacturing cell because a new one's been delivered further down the process."

One of the primary technical hurdles to liberating data is the hierarchical nature of traditional manufacturing networks. As most programmable logic controllers (PLCs) are not designed to support individual IP addresses that would allow direct communications with other IP-enabled systems, data concentrators are used to aggregate bulk data, perform network address translation (NAT), and upstream this information to corporate networks. This limits the velocity and granularity at which data can be transferred among key product stakeholders, especially at the research, development, and engineering levels, where delays in obtaining relevant information can lead to re-engineering, budget overruns, and slower time to market.

Today these topologies are giving way to architectures based on converged infrastructure gateways that incorporate both IT and OT technologies. Deploying these gateways in a distributed manner enables more granular data capture on an individual-device basis and information sharing across sub-segments of the manufacturing network (Figure 2).

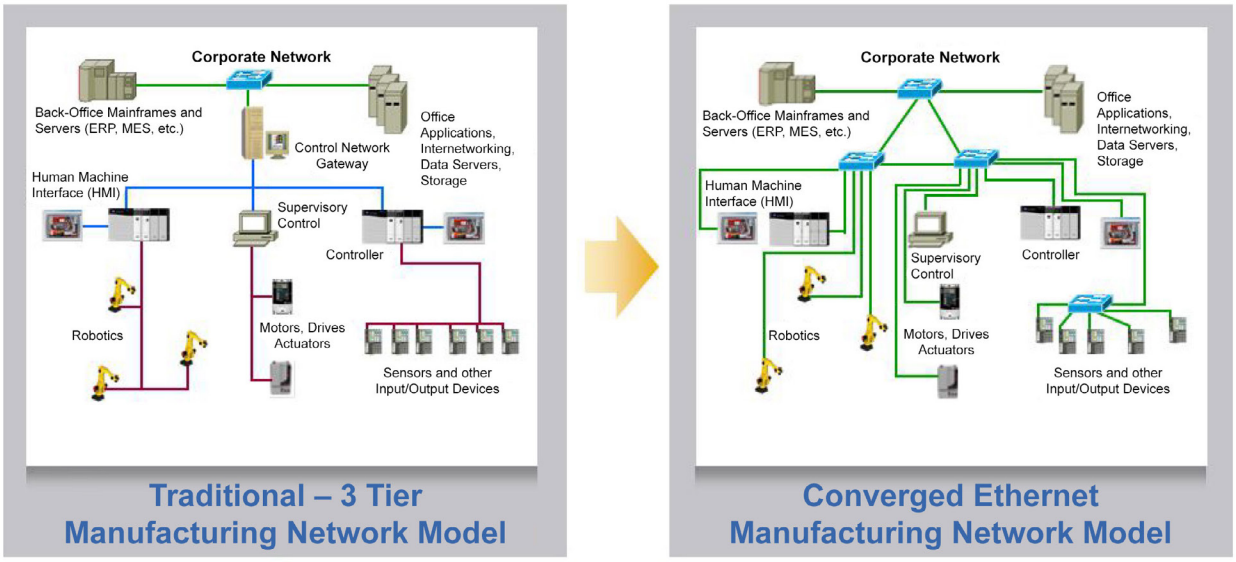

Figure 2. Traditional manufacturing network topologies based on a single data concentrator are giving way to distributed architectures based on converged IT/OT infrastructure gateways that allow more granular data capture and communications among all parts of a manufacturing workflow. (Source: Rockwell Automation)

"Intelligent gateways are a fabulous tool in that situation," said Fearn. Instead of a whole stack of hardware dealing with the data transactions, an intelligent-edge device on the shop floor not only can collect the data, but also do the translation to make that data more friendly to the application stack. "It can offer a kind of store-and-forward service, so instead of having to send messages all the way into your central hub or even into your data center and then push them back out, you can develop logic at the edge within your manufacturing plant to allow very efficient process control right there where the data is being generated and where it needs to be consumed."

Gateways are particularly useful in brownfield deployments within existing manufacturing plants, "where you're not starting with a clean sheet of paper," said Fearn, "and are trying to deliver some sort of asset performance management or predictive maintenance solution."

The Edgeline EL4000 Converged IoT System from Hewlett Packard Enterprise is an example of an IIoT edge gateway solution that helps break down data silos and facilitates the transition to closed-loop manufacturing **(Figure 3)**.

Figure 3. The Edgeline EL4000 Converged IoT System from Hewlett Packard Enterprise combines Ethernet connectivity with PCIe or PXI slots and support for industrial networking protocols to break down manufacturing data silos. (Source: Hewlett Packard Enterprise)

The gateways include two 10 Gbit Ethernet ports for communicating across corporate IP networks, as well as two x8 PCIe or PXIe slots for industrial data capture and control. The platforms support industrial networking protocol stacks such as BACnet and modbus, allowing them to seamlessly integrate into manufacturing environments **(Figure 3)**.

The 1U form factor Edgeline EL4000 Converged IoT Systems are based on four scalable Intel® Xeon® processors with 8 to 16 cores, or a single quad-core 6th generation Intel Xeon processor with integrated Intel® IrisTM Pro Graphics P580. Along with the PCIe/PXI card slots, this flexibility allows manufacturing operators to configure the gateways based on the scenario.

Intel Xeon processors also enable capabilities like virtualization and remote management on the Edgeline systems through Intel® vProTM and Intel® Active Management Technology (Intel® AMT), respectively. Virtualization allows control workloads to be securely partitioned from other enterprise functions and applications, while Intel AMT pairs with Hewlett Packard's Integrated Lights Out (ILO) chips to provide full control over remote assets that may be in dangerous or hard-to-access environments **(Figure 4)**. Now, data from all aspects of the product lifecycle can be factored into ongoing processes to improve manufacturing outcomes.

Figure 4. Integrated Lights Out (ILO) chips from Hewlett Packard Enterprise pair with Intel® Active Management Technology (Intel® AMT) to provide remote monitoring and management functionality for Edgeline platforms deployed in hard-to-access locations. (Source: Hewlett Packard Enterprise)

"Having a nice, flexible compute environment allows you to do a lot of integration there on the shop floor, but also a lot of sampling," Fearn said. "Once you've finished making your widget and you've sent it out into the world, then feedback from that widget can be streamed back into your manufacturing system and inform you of either design improvements that should be made to the actual product or potential process improvements to make it more reliable, reduce its cost, or make it more suitable to the customer's needs."

A Virtuous Cycle of Manufacturing

As mentioned, operational data is not the only information that can be applied to a virtuous cycle of closed-loop manufacturing. Importantly, feedback from sales, marketing, and service departments can be integrated to make sure products are meeting customer demands. While transitioning from concept and strategy to actual implementation can be a challenge for many organizations, Hewlett Packard's institutional knowledge and partner ecosystem of domain experts is available to help align business goals with the appropriate technical IoT infrastructure.

Still, the biggest impact of liberated data and closed-loop manufacturing will be felt on the shop floor, where organizations can realize higher levels of automation, reduced operating costs, and levels of efficiency that previously weren't possible.

"There was a time where in a quality environment you'd basically wait until the thing comes off the end of the production line, and you'd have a bunch of highly trained guys there making sure that it had been built properly," said Fearn. "Those days are going away." They are being replaced by technologies such as video analytics that can check that everything is as it should be on that manufactured item at every step along the way. "That not only gives you a high-quality product, it also gives you the ability to make these process improvements and potentially modify your manufacturing process much more iteratively," said Fearn.

"You can go for a constant improvement methodology, constantly receiving data from all these sensors that you've now combined in these data feeds to make sure that the modification did what it was supposed to do, and also that you're driving towards that more effective manufacturing process and towards that more reliable product," he concluded.