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Machine Builder's Guide to Improving Turns on the Floor

Enhance your manufacturing efficiency through distributed modular controls architecture

White Paper

Machine Builder's Guide to Improving Turns on the Floor
Enhance your manufacturing efficiency through distributed modular controls architecture

Production management or operations management at turnkey automation systems providers are always seeking for ways to improve production efficiencies on the manufacturing floor. The challenge is to keep up with sales growth and deliver systems on time, while maintaining the same amount of resources.

This paper proposes a business case for how adopting a distributed modular controls strategy for your machine can improve turns on your manufacturing floor while offering potential cost savings.

"Machine Turns" or "Turns" is a very powerful measure of productivity for turnkey automation systems providers. Simply put, turns measure how many machines can be built in a year in the same space with the same amount of resources. For example a 100,000 sq. ft. facility can produce 5 machines simultaneously, in other words, production of one machine takes up 20,000 sq. ft. If each machine takes 4 weeks (28 days) of production time, then the same 20,000 sq. ft. could produce about 13 machines in a year (assuming 365 days of operations- for simplicity of calculation). Therefore, the machine turns of this space is 13. The total production capacity of the manufacturing floor would be 65 machines a year.
Now, if the machine builder decides to increase production to keep up with growing sales – there are two options – add facilities in multiples of 20,000 square feet, maintaining the same turns on the floor, or increase turns with existing resources. If this machine builder can save 4 days per machine it would improve turns from 13 to 15, making the facility 15% more productive, compared to investing more capital and resources for an additional 20,000 sq. ft. to achieve 20% more productivity. This relationship between turns and efficiency can be seen in the graphic below.

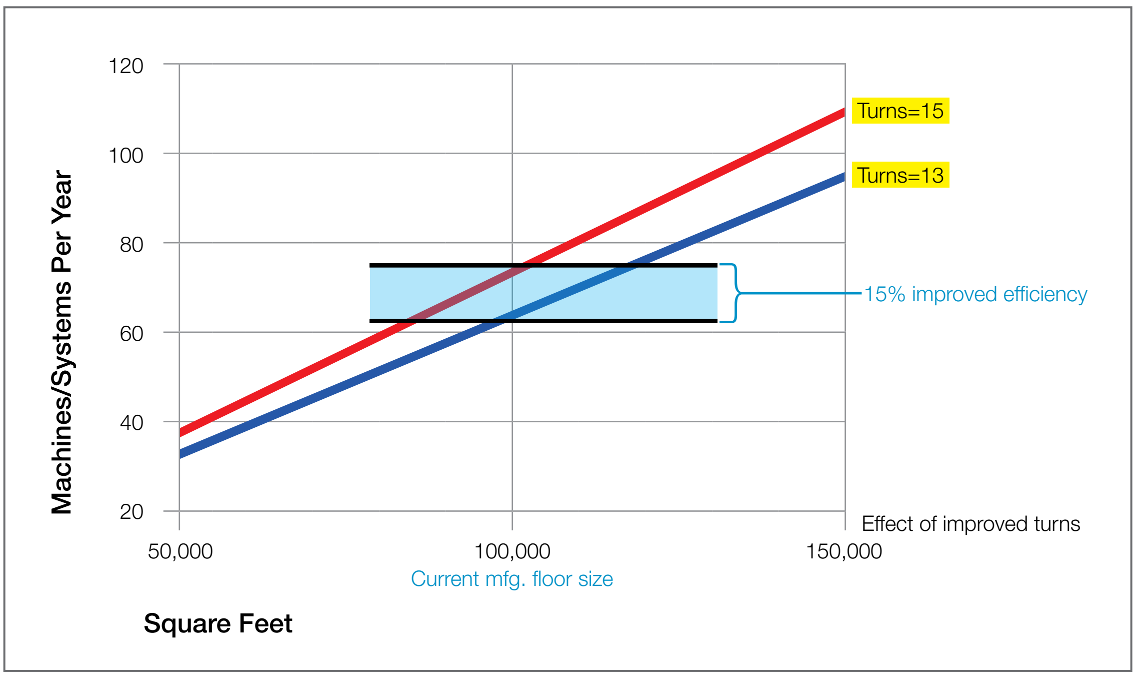


Figure 1: Relation between machine turns and efficiency

The concept of turns is not new and neither is the concept of process improvement. There is a plethora of knowledge on improving manufacturing efficiencies – from adopting newer technologies, improving internal processes through lean manufacturing initiatives like six-sigma, to building sustainable supplier relations for just-in-time production. This paper brings up a topic that is often overlooked or ignored as an area of efficiency improvement – the controls architectures.

Controls architectures, being the integral part of the system/machine, are usually not thought to be an area for process improvement. Of course, as with any process improvement initiative, cross functional teams are necessary. In this case, engineering and production play an important role.

Cabinet Mount philosophy vs. Machine Mount philosophy

Traditional and the most prevalent approach to managing low voltage sensors and actuators on the machine is based on a centralized control strategy – also known as cabinet mount philosophy. In this approach, while sensors, valves, and other electro-mechanical devices are out on the machine, the wires (conductors) controlling their actions are routed back to the controls cabinet, a long distance away, where the PLC or controller for the system resides. Once the wires are routed through the maze of wire-ways or cable trays, the wire ends are stripped, crimped, labeled and then screwed into the terminal blocks located on the panel of the control cabinet.

Figure 2: Cabinet mounted I/O example

Based on the complexity of the machine, one machine could have 50-200+ wires of all different colors and characteristics. This requires significant amount of detailed engineering and planning, not only for the I/O, but also for the routing and wiring diagrams for inside the cabinet. Furthermore, exhaustive debugging follows the electrician's work of wiring the cabinet. With this approach, I/O mapping and programming become sequential activities.

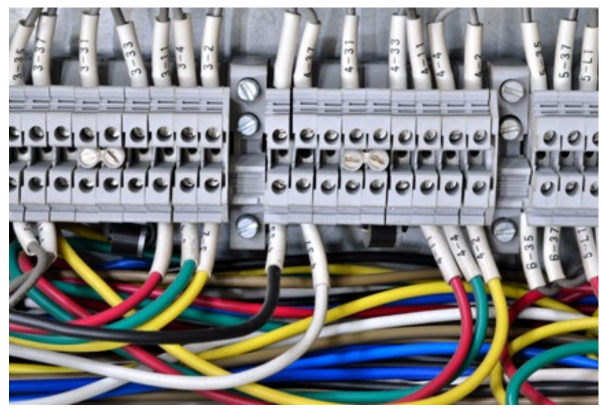


Figure 3: Crimped wires attached to the terminal strip inside cabinet

The centralized strategy for I/O is labor intensive and therefore time consuming activity costing valuable machine build time. Alternatively, a distributed or machine mount control strategy eliminates several of these steps to simplify overall machine design and build process. At the foundation of the distributed architecture is the network or the fieldbus system that allows for exchange of I/O as messages amongst networked nodes. Today, almost every machine has adopted some level of distributed controls architecture. A good example of this partial adoption is in robotics automation. Robot controllers and end-effectors usually have fieldbus or network nodes. The information about hundreds of I/O is communicated amongst the robot, the end-effector, and the machine controller over a single fieldbus cable. This tremendously reduces the complexity of the system.

Today's distributed modular architecture eliminates wiring and extremely simplifies the control cabinet. All I/O points are transformed to a quick connect mechanism. A recent article in Control Design Magazine[1] pointed out that customers are saving about 80% on the control cabinet space and about 50% on the labor costs by adopting the distributed machine mount philosophy.

Additionally, enhanced versions of network I/O blocks today, offered by some vendors, have onboard diagnostics for connectivity, short circuit protection, and over-current protection. This diagnostic functionality saves valuable time during commissioning of the system. Machine mount IP67 (Ingress Protection Rating for waterproof and dust proof) versions offered by some vendors have an added advantage for deployment in harsh industrial environments.

Figure 4: Cabinet space saving

Benefits of IO-Link

The distributed architecture becomes even more attractive when it is combined with IO-Link technology. (www.IO-Link.com). IO-Link is a vendor neutral and fieldbus neutral communications protocol for point to point communication. This protocol is specified by the IO-Link consortium and published in the IEC 61131-9 standard (IEC: International Electromechanical Commission). There are three major benefits offered by IO-Link technology with a distributed controls strategy:

1. **Modular machine design with increased I/O count and reduced cost per network node:** In the most primitive form of the full distributed architecture, each network node can host up to 16-32 I/O points. The IO-Link enabled network blocks could go anywhere from 136 up to 480 I/O per network node. For some machines this can be a lot more I/O than required. This offers the benefit of built-in flexibility for the future and the ability to handle any last minute change requirements with much less effort compared to the traditional cabinet mount case. In more complex machines, machine builders can place the slave I/O blocks in different locations on the machine and when the machine is disassembled for shipping, the only disconnections for I/O would be the network and power cable from the cabinet, providing significant reduction in commissioning time.

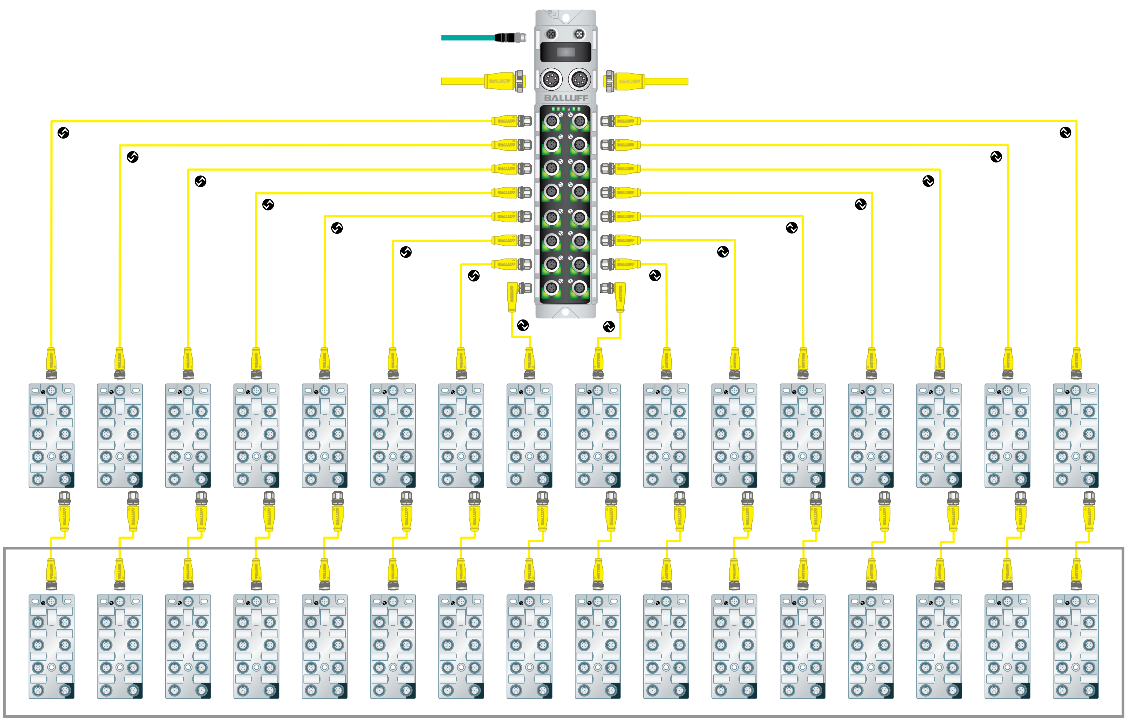


Figure 5: Balluff expanded I/O with 480 points

Fori Automation, a major assembly automation supplier in Shelby Twp, MI, employed this concept by dividing their assembly line in 30-40ft (transportable size) sections equipped with the machine mount I/O. This not only saved time during the machine build phase, but also made it easy for tear-down, transport, and reassembly at the customer location in plug-n-play fashion with absolutely no need to disconnect wires or sensors.[3]

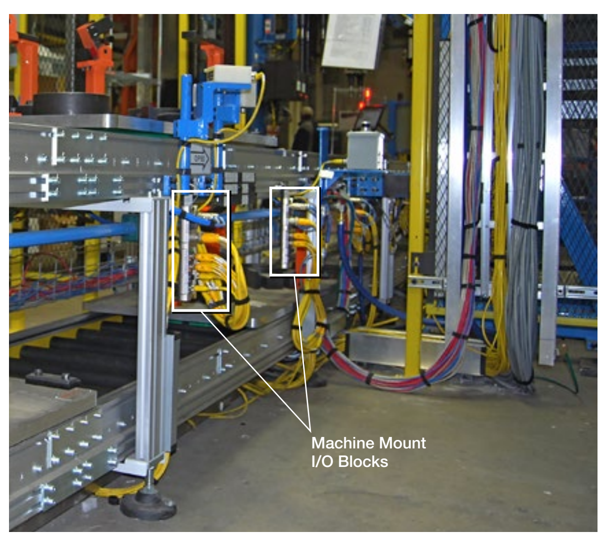


Figure 6: Modular assembly line – courtesy Fori Automation

2. **Significant labor savings by simplifying complex connections:** Valve connections, similar to SMC or Festo valve banks (shown in Figure 8), typically require 16 to 25 conductors (wires) to handle expandable 16-24 electro-mechanical pneumatic valves. With the traditional cabinet mount strategy, installing a single pneumatic valve bank could take between 3 and 4 hours of labor. Conversely, with IO-Link valve connectors, the install time takes only minutes.

Parallel wiring solution
- Up to 25 individual terminations
- Installation time: 3-4 hours

Distributed Modular I/O solution
- single connector
- Installation time: 5-10 minutes

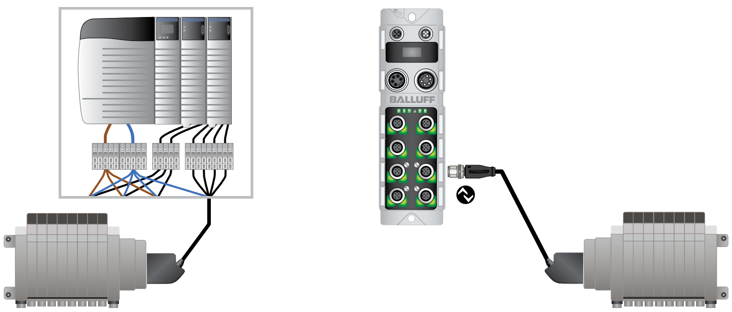


Figure 7: Traditional vs IO-Link

Figure 8: Example valve bank

As stated in the Assembly Magazine[2] article, Kimastle Corp./Dager Systems in Chesterfield, Michigan, saved about 3 hours of labor per valve using IO-Link valve connectors over the hardwired connectors. Kimastle also realized savings of over $350 per connection by using IO-Link.

Figure 9: Kimastle Corp./Dager Systems new generation of edge folding machines – courtesy Kimastle Corp

3. **Reduce engineering and design time with effortless smart sensor integration:** Smart measurement sensors such as; pressure, temperature, distance or inclination measurement, vision or color sensors, and even RFID read/write heads are increasingly being used in today's automation. No matter what vendor supplies these devices, as long as they are IO-Link capable, they can be easily integrated in the distributed controls architecture schema. Integrating these devices over IO-Link eliminates the need for expensive shielded cables or complex hardwiring to the cabinet, resulting in considerable time savings. Furthermore, manual calibration on the device is no longer needed as the configuration can be done directly in the machine controller or the PLC.

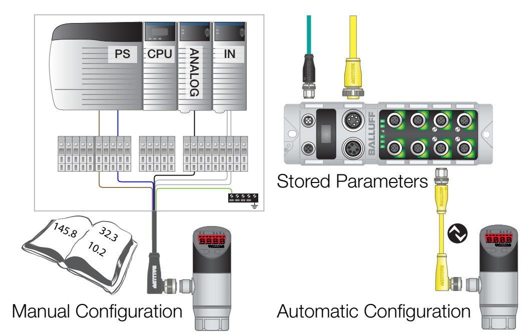


Figure 10: Ease of Smart Sensor integration

Implementing a Machine Mount Control Strategy

Machine mount strategy for controls architecture is not only a huge time saver during the machine build phase, but also reduces time in tear-down, transport, rebuild, and commissioning. Several machine builders who adopted the distributed machine mount strategy, often found opportunities for further improvements in the machine.

Up to 50% reduced engineering time

For example: Fori Automation, as mentioned previously, standardized their machine designs with a distributed architecture, so their programming and configuration tools, along with their engineering designs, are easy to replicate on the next machine, thereby reducing design engineering time on the recurring machines to about 50%.

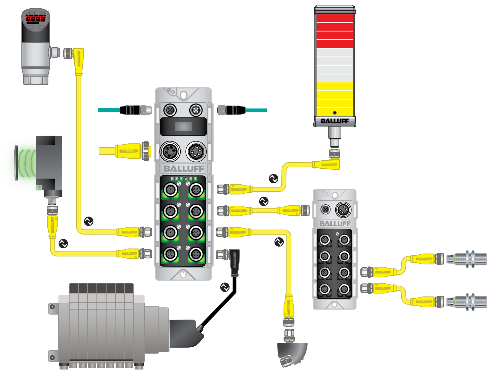


Figure 11: IO-Link distributed modular architecture

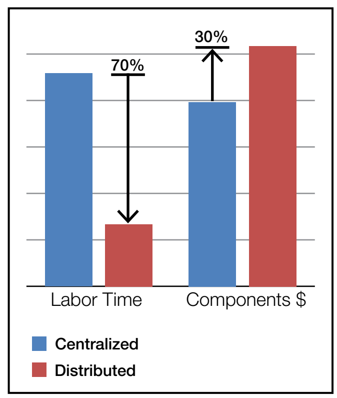
Recommendations for implementing your next system using a distributed modular strategy:

#1: Identify the need for distributed modular controls architecture

As pointed out earlier, there may already be some level of distributed architecture in your system. To determine whether your system needs a full distributed strategy, look for these signs:

- **Inspect the machine build and rebuild schedule:** If your machine build schedule includes more than 25% of the time for building control panel and wiring, there is a good chance you can significantly reduce that time to about 1/3 by switching to a distributed controls strategy. It's also ideal to look at the total labor hours for electrical technicians.
- **Review the control cabinet:** In some cases, especially in building standard machines, the control cabinet build is outsourced, but the final wiring might be completed in-house. This might appear like a good idea because the activities can be done parallel. However, if you can save approximately 80% on cabinet space and 50-70% on labor time, does that activity still make sense?
- **Discuss with controls engineers:** Controls engineers are the most affected by changing over to a distributed strategy. Two important questions to ask your controls engineers:
  - How often during the machine programming do you refer to the electrical wiring diagrams and perform testing and debugging for the wiring?
  - If you had Add-On-Instructions (in case of Rockwell controllers) or function blocks (for most other brands of PLCs) for all the network blocks and connected devices, would this reduce any installation time?

Answers to these questions will provide a good understanding where the time is spent with the current controls strategy. If controls engineers are spending more than ½ their day debugging, especially on standard machines, and they think having added tools could significantly reduce time in development and programming – then a distributed modular strategy for the controls architecture makes added sense.



Internal Balluff study conducted on automation projects, compared cost of components to the labor time between centralized architecture and distributed modular architecture. The study indicated that in case of distributed modular architecture for machine design, the component cost goes up 25-30% but labor time goes down by as much as 70%.

Figure 12: Comparing labor and component cost

#2: Get your team on board with distributed modular architecture

As with any improvement initiative, a team's buy-in on the decision goes a long way in the implementation stage. Design engineering, Controls engineering, and Production teams are primary stakeholders in this decision making process. The highest amount of resistance may come from design engineering as changing over the control strategy involves significant upfront work. Usually, design engineering teams are pressed for time on design changes to the sold orders, so even when they agree to the value proposition and benefits of the distributed modular architecture, taking on a new initiative is challenging. When implementing a distributed modular architecture strategy for the first time, it may take a little longer for the engineering side of things, as it is a paradigm shift, but the savings on recurring machines could offset the cost at a rapid pace. Allocating more time for the first system can work in everyone's favor in the long run. The significant benefit for the design engineering team is that future customer driven changes can now be handled with minimal efforts.

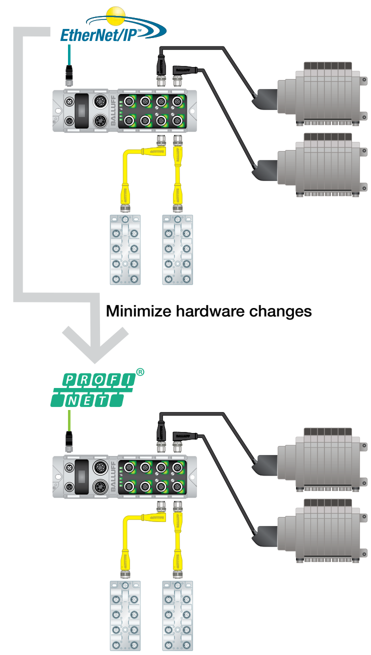


Figure 13: Minimizing bill of material changes

#3: Find the right supplier partner

Finding the right supplier is an essential step to your implementation success. It is a struggle whether the step of finding the right supplier should be done before or after getting your team onboard. The right supplier may help demonstrate the value of the distributed modular architecture to your team, or if the team is already onboard, they may ask the right questions to help identify the right supplier. Three important things to look for in a supplier when adopting the distributed modular strategy:

- **Open Architecture Portfolio:** Simply put, support for open architecture offers the flexibility to use the same components on any major network with fewer changes to the bill of materials or the configuration. This flexibility is very useful, as it minimizes design changes when the customer demands a different choice of network or fieldbus from the standard on your machine. The open architecture also offers the ability to connect to other devices and sensors from different vendors with equal ease.

- **Strength of technical support or expertise:** The best way to understand technical support expertise and knowledge is to request the supplier's local technical experts to demonstrate the configuring components/sensors on your choice of network, possibly on your existing machine. Or even asking the experts to demonstrate the technology by walking through the configurations with your controls engineers could validate the strength of technical expertise. This is essential, as the local technical experts will be a valuable asset in your endeavor to implement a distributed modular controls strategy. They can work with your team to define the initial bills of materials and walk you throughout the process for selecting the right components for your solution and keep you abreast of the latest technology.

- **Breadth and depth of product line for distributed modular architecture:** Understanding the breadth of product support for different networks, industries, or applications might provide better insight into the supplier's agility to respond to market needs. In the future, if your portfolio expands to other industries or your products need to adhere to various standards, you can count on your supplier for the right solutions.

Tracking Time Savings

Distributed modular architecture offers several benefits to end users and machine builders in terms of modularity, flexibility, and scalability of the system. However, this paper strictly focuses attention on the significant time savings potential that eventually results in a more efficient manufacturing floor, without adding more resources.

There are three major areas for time saving potential:

- Labor time in wiring and building the cabinet
- Controls engineering time in programming and commissioning
- Design engineering time on recurring machines with minimal changeovers

The time savings on design changes may be realized over a period of time. The controls engineering time changes are challenging to track and validate – primarily because the requirements are sometimes fluid and their extra time can be utilized to improve or enhance machine functionality. The labor time savings, however, are easy to track and quickly evident from the project timelines.

Example Calculations

Let's review the hypothetical example presented at the beginning of the paper. In this scenario with the traditional cabinet mount strategy for the controls architecture, each machine took 28 days (4 weeks) to build, let's assume that 30% of the build time or 8.4 days are allocated to the electrical wiring of the cabinet. Based on the real case studies provided in the paper, changing over to a distributed modular architecture could save between 50-70% of the electrical wiring time. So, 50% of 8.4 days would be 4.2 days of savings, or 70% would be 6 days of savings per machine. This implies improved turns between 15.3 and 16.5. In other words, the same floor with the same resources can now build 76 to 82 machines instead of the original estimate of 65 machines a year.

Figure 14 presents various scenarios for an original cabinet build time and expected time savings per machine leading to improved turns on the floor.

Total machine build time in days (cabinet mount) **28**

Electrical wiring time as % of machine build time		Labor time saved with a distributed strategy		Reduced machine build time	Turns	Floor efficiency improvement
% of total time	**# of days**	**% of savings**	**# of days**	**# of days**		
20%	5.6	30%	1.68	26.32	13.9	6%
20%	5.6	40%	2.24	25.76	14.2	9%
20%	5.6	50%	2.8	25.2	14.5	11%
20%	5.6	60%	3.36	24.64	14.8	14%
20%	5.6	70%	3.92	24.08	15.2	16%
30%	8.4	30%	2.52	25.48	14.3	10%
30%	8.4	40%	3.36	24.64	14.8	14%
30%	8.4	50%	4.2	23.8	15.3	18%
30%	8.4	60%	5.04	22.96	15.9	22%
30%	8.4	70%	5.88	22.12	16.5	27%
40%	11.2	30%	3.36	24.64	14.8	14%
40%	11.2	40%	4.48	23.52	15.5	19%
40%	11.2	50%	5.6	22.4	16.3	25%
40%	11.2	60%	6.72	21.28	17.2	32%
40%	11.2	70%	7.84	20.16	18.1	39%

Figure 14: Expected time savings

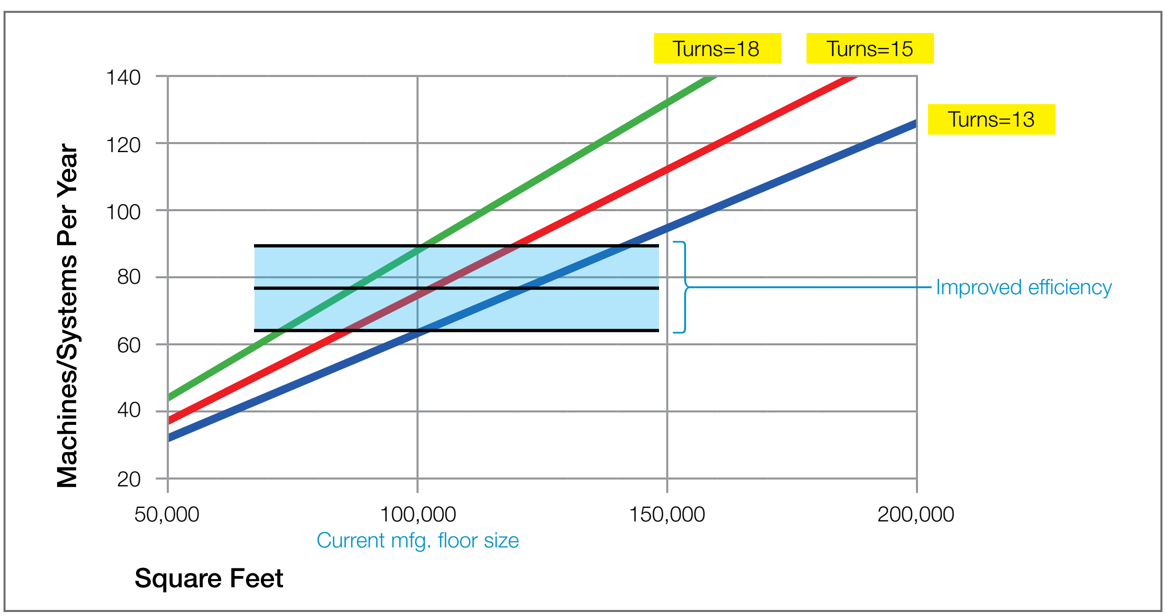


Figure 15: Impact of improved turns

Your Next Step

Schedule a meeting with your local technical expert to discuss your particular machine design and review how turns on your manufacturing floor can be improved.

Contact us by phone and ask for inside sales.
Contact us by email and ask for "Improving Turns".

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About Balluff

Rugged Control Components from Network to Sensor

Balluff specializes in delivering dependable, rugged and precision products for industrial sensing, networking, and identification to help prevent downtime and eliminate errors. We are a complete system and component supplier, offering industrial network and I/O products for use outside of the control cabinet. We add value to automated systems by providing a wide range of enabling technologies that unlock hidden productivity potential.

Our products include a complete line of sensors, transducers, ID systems, and connectivity products. Our sensor lines include photoelectric, inductive, capacitive and magnetic, as well as other more specialized sensor products to fit virtually any sensing application.

References and additional reading:

[1]Control Design Magazine article on machine mount I/O:
http://www.controldesign.com/articles/2015/when-machine-mount-does-and-doesnt-make-sense/?show=all

[2]Assembly Magazine article on Kimastle Corp./Dager Systems:
http://www.assemblymag.com/articles/90798-latest-pneumatic-controls-increase-assembly-capabilities

[3]Assembly Magazine article on Fori Automation's modular design concept and associated time savings
http://www.assemblymag.com/articles/92890-machine-builder-masters-assembly-line-uptime-flexibility

Control Engineering article on Cost savings generated by choice of Distributed modular I/O:
http://www.controleng.com/index.php?id=483&cHash=081010&tx_ttnews[tt_news]=7048

What is IO-Link? Read more in our Basics PDF:
http://usa.balluff.com/OTPDF/007_BB_What-is-IO-Link_2015-03.pdf

Simplify Valve Connection with IO-Link:
http://asset.balluff.com/std.lang.all/pdf/binary/SPT_DriveSMCValveManifolds_en-US.pdf

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