THE COMPLETE GUIDE TO AUTOMATION

CREATED BY TRI-MATION

Ingenuity. Quality. Results.

The Complete Guide to Automation

TRI-MATION
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Who are We, and What do We do?

We are Tri-Motion. We started in 1995 as a small machine shop in a garage. Today, we are a leader in specialty machine design and build. We strive to be inventive and clever and efficiently produce quality machines that exceed our customers' expectations.

We have assembled this guide to automation to provide an accurate understanding of how we can work with our customers to produce a machine that fulfills all their needs at the lowest possible cost.

I. What is a Machine?

A machine is a mixture of motions and poka-yokes coming together to perform a task.

The cost of a machine is set not only by the number of motions and poka-yokes but also by the complexity and tolerances required to perform a desired task. The other significant factor in the cost of a machine is the expected cycle time.

Motions can be as simple as a gripper closing to pick up a part (see Figure 1) or as complex as two robotic motions working in tandem to tip, twist, and assemble two components (see Figure 2). To envision the types of motions of your machine, you should study your product's design. Can it be assembled with a single straight-line motion or a combination of straight-line motions, or does it require curves? Are these motions limited to a single plane, or are they three-dimensional? Do they require any axial rotation?

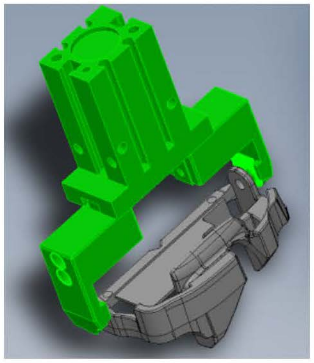

Figure 1: *Simple single vector motion*

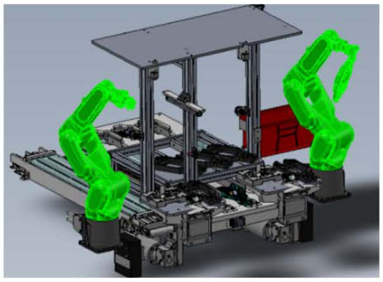

Figure 2: *Complex Motion - two robots working in tandem*

Pro Tip: Assembly motions are a result of the product design. When possible, look at the assembly motions required during product design. Simplify them when feasible.

Every sensor and every poka-yoke must have a tolerance. All measurement has error. There is no such thing as fully seated. The presence of a component can be detected cheaper than the position of a component. Be aware of the tolerances stack-ups of the entire assembly when determining the feasibility of your poka-yoke request. In Figure 3, you'll notice some pins positioned in a part. Detecting their presence can quickly be accomplished with small proximity sensors. However, the customer was concerned that short pins and long pins could get into the wrong positions. A proximity sensor would not be able to detect a long pin being put in a short pin location. We developed a tumbler system that allowed us to detect which pin was in which location. The difference in the heights of the two different pins was 0.300". The tolerance stack-ups allowed us to verify at +/- 0.075", and we could easily catch any pin in the incorrect location.

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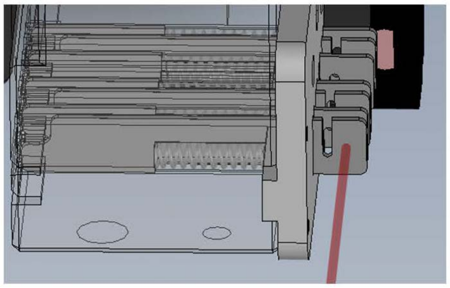

Figure 3: *Pins would compress the springs, aligning the slots up when lengths were correct.*

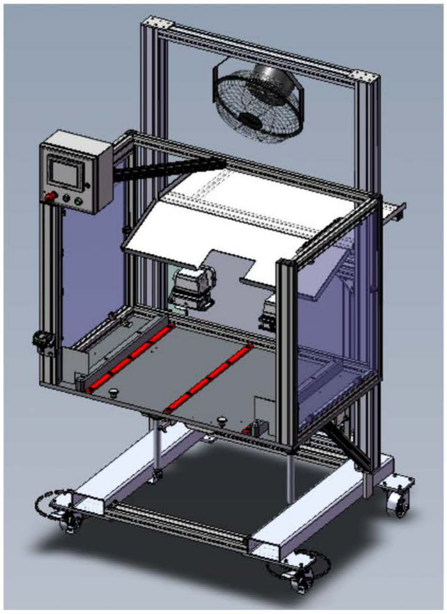

Figure 4: *The stand-alone assembly type machine allows fixtures to be changed.*

Cycle time is essential to the cost of a machine. Many machines need to perform a functional test on a product, such as a leak test or effort test. Typically, these types of tests take time. If the test time is greater than the desired cycle time, we must incorporate the ability to simultaneously test multiple products into the machine's design.

Transferring the product in and out of multiple stations continually tests our creativity. Depending on the desired cycle time, only a limited amount of work can be performed at a station. Decreasing the cycle time mandates the number of stations the machine must have.

Future use of the machine should also be considered. Will the product fully utilize the machine, or will this machine still have a substantial amount of production time left? How long will this product be in production? If there will be a good amount of production time left, or this product won't be in production for long, it may make sense to ensure the machine is planned for fixture changes.

Changing over fixtures can allow an assembly machine to produce many different products. An assembly machine is like a molding machine with different molds installed to produce different parts. Just like the molding machine has size and core pull limitations, the assembly machine is limited to products of a similar size, type, and number of motions. Planning for future use costs more up-front, but it reduces later retooling costs. Many companies decide to phase in the changeover portion of the machine when the next product comes along. Using the second program's capital budget to make machine changes is understandable. What typically happens, however, is while the first product is still in production, the complexity of breaking into current production to run the second product's trials leads to the purchase of additional machines. The largest advantage of designing tool changeover from the start is that later modification to the machine will not be required. This allows current production to continue as future product fixtures are being made and tested. See Figure 4 for a simple machine base example.

II. What Makes the Perfect Machine?

The perfect machine generates no scrap, requires no maintenance, doesn't break down, uses no energy, takes up no floor space, produces any part you want instantaneously, and is free. That's right! It doesn't exist. Nevertheless, we continually strive to create the best machine possible.

The best machine for you is possible. First, we need to understand your priorities. Many of a machine's different aspects directly conflict with one another. A machine that is easy to maintain likely consumes more floor space to allow for maintenance. A robust, durable machine moves more mass and is likely slower than a machine designed to move quickly, where mass is removed to increase speed.

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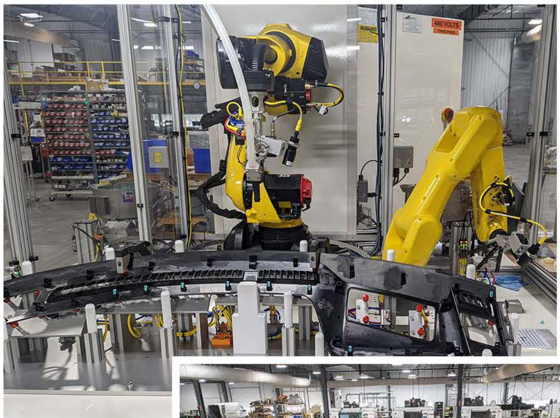
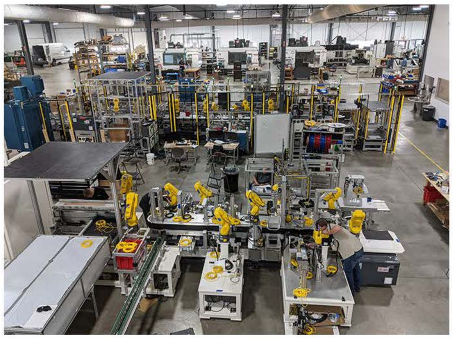
All the different aspects of a machine also affect the cost. For Tri-Mation to design and build the best machine for you, we must understand what you hold most important. Unfortunately, this isn't a one- or two-word answer; it is always in flux. For example, if the cycle time looks like it is already 10% better than the target, additional cycle time reduction might not be as crucial as reducing downtime. The difficulty is in communicating those changes with priority in an environment of infinite combinations.

Minimum finite requirements are a must (e.g., cycle time of 15 seconds; floor space must fit in a 25' by 20' area of the plant; 120 VAC, 60 Hz, and 20 CFM at 75 psi available). If these requirements are not met, the machine fails. These are the types of requirements that always take top billing. Please note that padding these finite requirements can hurt you by causing you to miss out on a more beneficial aspect. For example, if a faster cycle time is listed than is required, you might end up with actions that break more often because of a design meant for speed versus reliability. This increase in unplanned downtime and repair might be more significant than the cost gained by the cycle time.

After these requirements are met, what are your most important factors? The end-use location of the machine is usually essential. How skilled is the labor force? Is the turnover high? Does the machine need to be as simple as possible to run? How talented is the maintenance group? If your maintenance department is always busy, unplanned downtime is the next most important. If the machine is part of an assembly line and paced by a different machine, cycle time reduction is probably not as important. Any information about your priorities will help us make better decisions in the design and build of your machine. Unfortunately, most of the time, the best machine is one that everyone is OK, not perfectly happy, with. It's easy to maintain, but it could be easier. It's fast enough, but it could be faster. Satisfaction is usually the goal.

III. Spend Your Money Where it Matters





We must understand potential failure modes and the effects they have on production. Knowing where the most likely and worst failures can occur allows you to focus your money in those areas. One example could be mixing components from a nearby assembly line. In our design, we could place a sensor to detect the presence of a component. However, a nearby component might also fit and make this sensor, allowing the machine to assemble a part with the incorrect component. If we are made aware of this similar nearby component, the issue may be eliminated by placing the sensor in a location that would not allow the similar component to be used. A partially completed PFMEA listing the potential failure modes, the effects of those failures, and a list of previous poka-yokes used that you liked or disliked is a massive help to us. We can mimic poka-yokes we know are effective and avoid previous poka-yoke failures. Just because you can doesn't mean you should. Technology is great, and we strive to stay on the cutting edge. Technology requires training and knowledge for continuous availability, however. If there is only one person to troubleshoot a camera that works on first shift, this could lead to significant unplanned downtime when a camera or light gets bumped around on second shift. New technologies are illuminated during our design process. It is best if the end users know of any new emerging technologies. This allows them to train for these new technologies and helps ensure the start of production is pleasant. As always, we encourage the presence of maintenance, cell techs, and associates at Tri-Motion to run the machine during runoff.

The most wasteful use of your money is in changes. Change is unfortunately pervasive in our business. Making sure our design aligns with your goals is important. Ensuring we have as much information as possible at the project's start will lead to fewer changes along the way. The cost of changes increases as the project progresses. Loading a machine left to right versus right to left likely adds no cost when known at the beginning of the project. Once design has started, switching from left to right to right to left may cause more work for the designer than initially anticipated. If the design is approved and parts require machining, the cost increases exponentially. Likewise, changing during assembly is an even greater expense. Short screen shares and monitoring the design as it progresses are the best ways to avoid these cost increases. The frequency of these informal reviews depends on the project size and how many designers are working on the project.

IV. Knowledge Transfer and Previous Examples

Learning from past mistakes is important, but learning from the mistakes of others is just as valuable and costs less. The key to these lessons is knowledge should be shared. No one knows your process, successes, and failures better than you. Communicate what is working for you, things that have not worked as well, and things that are OK but can be improved.

Unless you are tooling up for a brand-new type of product, you likely have some valuable knowledge about what works and what doesn't. At design review, it's late in the game to hear our customer say, "We tried that before, that doesn't work well." "We were hoping you would design it closer to how we do it now" is almost as bad!

What is your vision, and where do you want us to step in to improve it? *Start with Why* by Simon Sinek is an excellent book on leadership, and it also has many great points that speak to knowledge transfer. Telling us why gives us the understanding to better solve problems down the road, saving everyone time. If you want a machine that runs on 240 VAC, simply request so, and we can make it happen. If we run into a long lead time on a motor, and we can get one get quicker for 480 VAC, knowing you requested a 240 VAC machine because you do not have 480 VAC in the building allows us to skip this solution and find a better alternative. But if you request 240 VAC because you already have a 240 VAC drop in the area, we know it might be worth asking if you want to switch to the 480 VAC motor. Many production plants have their intricacies. One situation we often encounter is that assembly cells run in a clockwise rotation. When faced with a cell designed to run counterclockwise, people feel off. It was not what they were envisioning. Why counterclockwise? Typically, a machine is easier to unload than to load, so running the assembly counterclockwise allows right-handed associates to load with their dominant hand. Knowing why you may have requested a particular direction helps us design the machine the way you want the first time. This saves everyone time and money.

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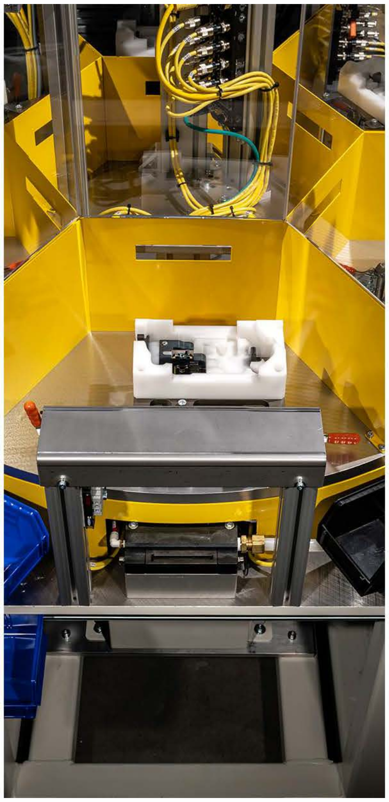
Let us know the challenges your company is experiencing, or more important, the challenges of the specific plant where the machine will be deployed. Japan has vastly different challenges than Mexico. Designing a machine based on the challenges in Mexico will prove a mistake if the machine has planned production in Japan. There are other obvious differences, like local regulations and power sources, that also need to be considered in addition to the cost of floor space and labor.

Words matter. Terms like fully seated imply a tight tolerance or none at all. Words and phrases like that go one of two ways. Either cost estimation reads those words literally, and they cost in a solution more costly than necessary, or they assume it is simply a phrase and cost in a simpler solution. Regardless, terms like this leave a customer comparing quotes that are not apples to apples. Depending on their interpretation of the meaning of fully seated, they are headed down a path of costly or unnecessary additions. Listing your poka-yokes let us know exactly what you are looking for. Are you looking for a camera check or a proximity sensor poka-yoke type?

V. Sample Part Schedule

We use sample pieces throughout our design and build process. They serve as visual aids during design. They are implemented to test the final fit of any nests and trial runs internally within Tri-Motion and externally by the customer. There are six basic levels of parts: prototype, first shots, off-tool, off-process, PPAP, and production.

Prototype-level and first shots help with visualization. They are great for show-and-tell and aid in relaying what the machine needs to do. Outside of communication, they cannot be used to determine any forces required by the machine or trusted for final fit adjustments or trial runs.



Off-tool and off-process are parts made from production intent tooling and the intended tooling in the exact process designed for production, respectively. The use level of these parts depends on the dimensional reports and a risk analysis based on those reports. Ideally, we would not use off-tool or off-process parts for any adjustments to the final fit of a nest, force testing, or trial runs. Timing often dictates the use of off-tool or off-process parts during machining and machine build. The first requirement in our timeline is parts to be used for the final fit of a nest during machining. We use our CNC machines to mill many of our part-holding nests. Once the rough cut is done to the nest, we use a PPAP or production-level part to make the final adjustments needed to the nest. If these parts are not readily available, the nest must be removed from the CNC machine, and the final fit must be done later. This process requires retrieval of the nest and another CNC setup. These are additional unplanned, unquoted costs.

The customer can make assumptions that allow us to hold timing and use off-tool or off-process parts. Using these parts instead of PPAP submission parts comes with its own risk. If we do a final fit to an off-tool part, and the part size changes, we may be forced to rework a final nest or rebuild the nest entirely. Using off-tool parts for trial runs often results in the need to reset many of the sensors used in the process because of changes in the surface texture or size of the parts.

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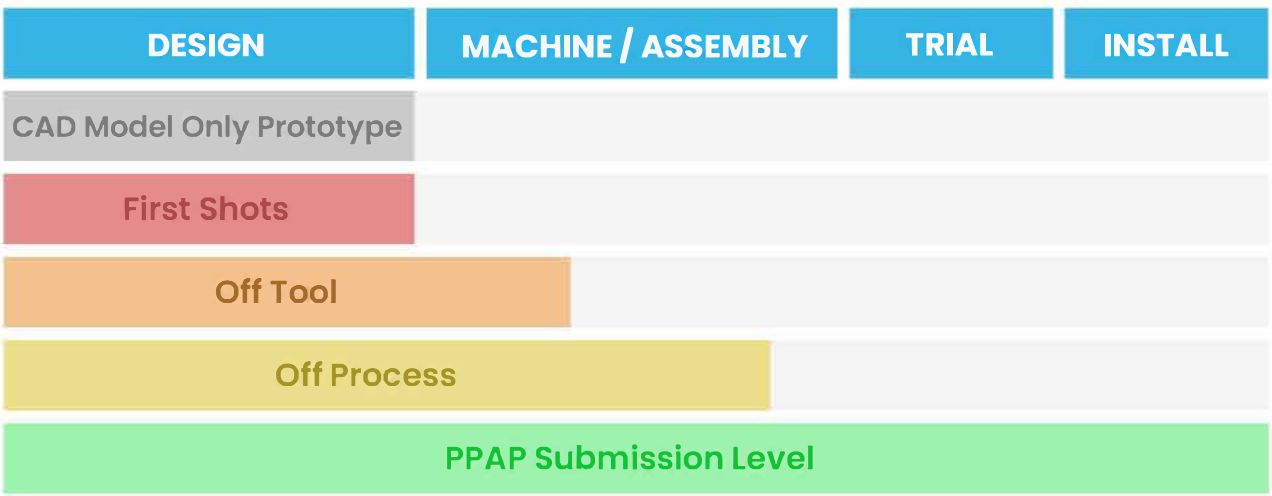
PPAP submission or production-level parts are the only true test of the equipment. These have been confirmed to be dimensionally correct, and they have passed or are expected to pass any life-cycle requirements. These parts will determine the capabilities of the assembly or test equipment.

We look to keep our costs as low as possible, so we do not plan for these tuning loops unless the customer requests. If you know you will not have PPAP-level parts available until after the design approval, then tell us, and we can plan to stay material-safe and cost in a tuning loop late in the plan. Or let us know if you will approve off-tool or off-process parts to stand in their place and are willing to accept the cost and timing impact if rework is necessary. See the chart below representing the risk levels of using parts other than PPAP submission-level parts during the process. We will use any parts you tell us to, but we do not put the cost of the risk of using non-PPAP-level parts into our quote unless requested by the customer. At times, no extra costs are necessary, but when additional work is required, we will be transparent regarding the additional costs.



VI. Clarity Brings Cost Down

A well-written RFQ goes a long way toward saving our customers money. It discusses the type of motions and poka-yokes expected and provides a list of successful poka-yokes and a list of previous failures to avoid. It discusses the driving forces of the production site.

Cost estimation tends to increase the price of a machine whenever there is confusion or an unknown. The idea is to cover for the worst-case scenario. Eliminating unknowns and clarifying exactly what you are looking for allows competitive quotes to be more similar. This ensures a more successful project, with less chance of additions and cost overruns.

We love to develop solutions to problems and are not afraid to conduct research and development to provide the best machine for your application. However, R & D does have an increased cost, so we like to understand the areas in your process where you are potentially looking for these types of improvements. In these areas, please share what you are currently doing and the specific challenges you are facing. We discuss our thoughts on these areas specifically and ensure all parties are on board with our proposed solutions.

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Programming and HMI screens have been an area of increased costs for all machine builders. If you can provide us sample PLC programming and HMI screens you are currently using on similar machines, please let us know. This will reduce the time it takes us to reproduce these screens. It also increases productivity by having similar screen layouts for your associates.

As we get more accustomed to technology in our personal lives, our expectations are increasing in our work lives. The issue that specialty machine builders face is the one-off nature of our business. Designing a vehicle that can alert you when the engine is beginning to misfire is now normal. Adding this type of capability to a single one-off machine is possible. Still, it is expensive because development cost is divided by the number of machines produced. In our case, it is divided by one, as opposed to a vehicle manufacturer who may be producing hundreds of thousands of vehicles per year. If you currently have any of this technology in your plant, providing us with the PLC programming can decrease the cost of your machine. Likewise, if this is a technology you desire to add across your production floor, let us know, and we can develop these types of systems for you.

As the customer, you own not only the machine but also the design of the machine being built. If your supplier is charging you for the design of a machine, then you own the design. Sharing aspects of a previous design not only helps in communicating exactly what you want but also reduces the costs of designing a similar machine. Let us know during the quoting phase if any designs will be made available to lower machine costs.

VII. Budgeting

Correctly budgeting for a new machine is vital. Let us help you set a budget for a future machine. If there is a new application and no previous or recent quotes to base your budget on, please do not hesitate to give us a call. We will do our best to provide an accurate, quick quote. No one likes returning to the steering committee and requesting more money because of an errant budget.

Sharing your rough budget helps us conceptualize a machine that fits your budget. We understand that telling suppliers what your budget is can be scary. However, we realize we are likely quoting the machine against others, and we want to give you our best pricing possible. Budget parameters are a helpful tool for us to fully understand what you are looking for and the upper cost limits of the project.

VIII. Conclusion

Your RFQ is critical to reducing machine costs. Being specific about the poka-yokes desired and the level of tolerances is vital for us to make the best machine for you. Tell us your areas of consistent worry or trouble, and allow us to suggest improvements in those areas. Frequent conversations during design help us avoid added costs of traveling too far from the expected design of all machines.

Taking this extra time up-front will save you money, avoid costly additions, and help us design and build the best machine for your application. We look forward to being a valuable partner in producing a machine that increases your overall productivity and, most important, your bottom line.

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Suggested RFQ Checklist

- **Overview of the machine:** What specific task(s) do you want this machine to perform? How fast do you need it to go?
- **Mechanical limitations:** How much floor space is open for the machine? What is the maximum door opening size to the manufacturing floor? What is the maximum height for the machine? Are there any limitations to moving the machine through the production area? What are your walkway widths, door widths, etc.? What is the floor's maximum weight capacity?
- **Energy supplies available:** What is the minimum air pressure available at the machine location? Is there a maximum CFM limit? What type of electrical power is available at that location?
- **Similar machines:** Please include pictures or CAD models of similar machines you already have. Let us know if you have these CADs available and you are willing to give us copies.
- **Preliminary PFMEA's:** If you have started a PFMEA, please provide us with a copy of it. A PFMEA will reveal the most concerning issues and how you might address those potential failure modes. Remember that we have likely signed an NDA with you, and your secrets are safe with us.
- **Poka-yokes:** List the poka-yokes individually and with tolerance considerations important to you.
- **PLC programming:** Please ask your Tri-Motion salesperson to communicate our PLC programming and the different packages we have available. Let us know if you have an existing ERP system you need the machine to integrate with.
- **Installation and training:** Let us know if you need our support at installation. Would you prefer our presence on your floor to train your trainers on running and maintaining your new machine? We can also be available at your customer's run-at rate if you request this type of support.

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