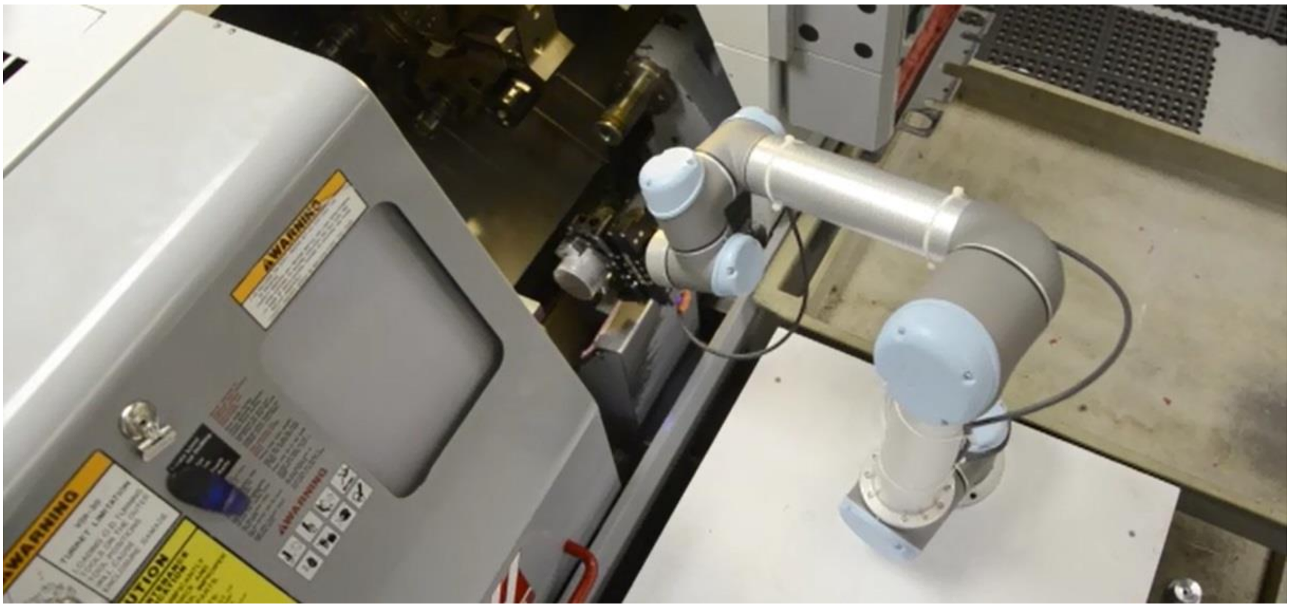
Step-by-Step Guide for Machine Tending



LEAN ROBOTICS

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Lean Robotics: Simplify Robot Cell Deployments

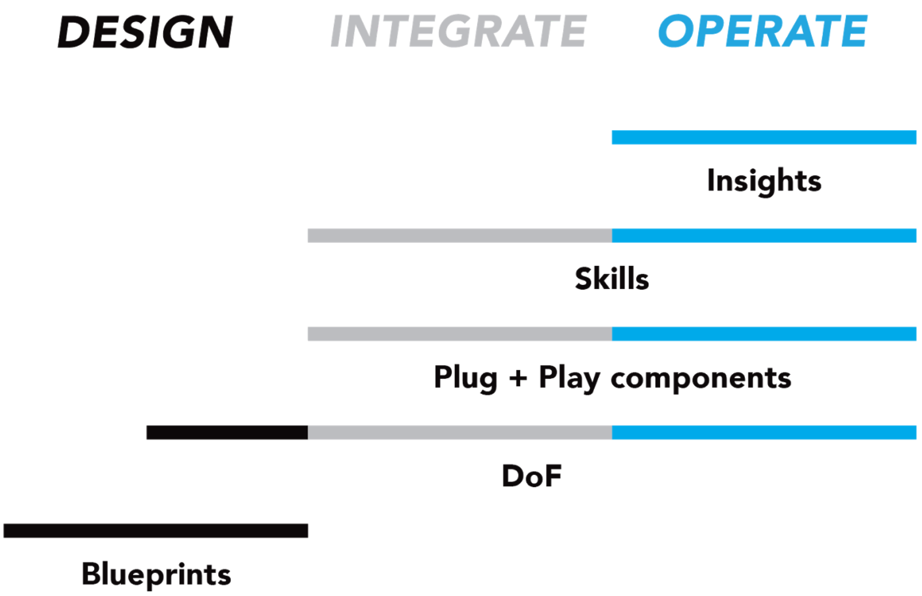
Whenever you ask if robots could work in your factory, the answer you receive is always a hesitant “It depends.” It depends on your factory, your team, which robot you choose, what you want it to do... and a whole lot more.

If you're a first-time robot user, how can you get started? How do you get from your initial idea to a productive, working robot? And if you’ve already got a few robotic deployments under your belt, how can you scale up your robotics efforts throughout your factory—or across multiple factories?

The answers can be found in **lean robotics: a methodology for simplifying robotic cell deployments**.

Lean robotics is a systematic way to complete the robotic cell deployment cycle, from design to integration and operation. It will empower your team to deploy robots quicker and more efficiently than ever before.

Lean robotics divides robotic cell deployments into three phases: Design, Integrate and Operate.



Robotiq’s library of eBooks covers the different phases of the robot cell deployment to ensure that you have access to tips from robotics experts all along.

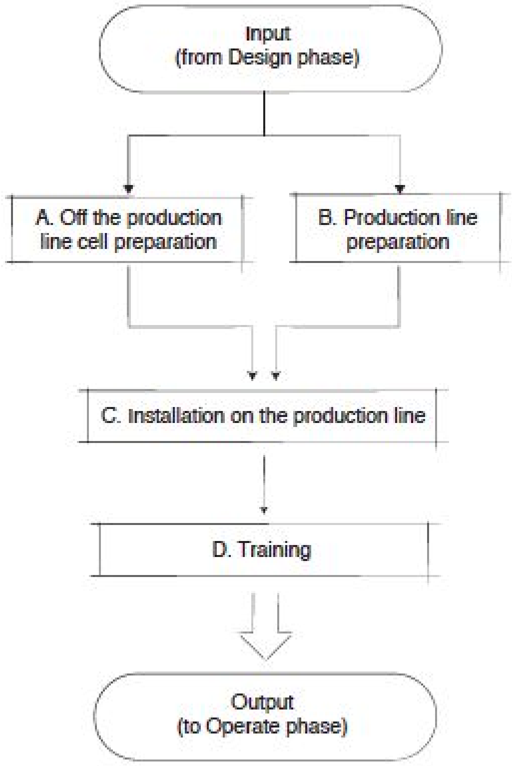
Learn more about Lean Robotics on **leanrobotics.org**.

This Ebook Covers the Integrate Phase

The integrate phase consists of putting the pieces of the robotic cell together, programming it, and installing the cell on the production line.

INTEGRATE

You start the integrate phase with the cell design in hand and the equipment ready to be assembled. At the end of the integrate phase, you'll have a working robotic cell on your production line, ready to start creating value for its customer.



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INTRODUCTION

The question often asked is: Why automate machine tending operations? Looking at industrial manufacturing, we can easily understand why companies are shifting to automated machine tending operations. First, the human resource issue. Good machinists are hard to find (and to retain!). Even if industry works hard to change the perception of manufacturing, what people have seen in the news the past few years makes a bigger impact. Second, in this context, once manufacturers have skilled workers they want to put them to work on what gives added value to their products. And at the same time, giving them challenging tasks is often a good way to retain skilled workers. Third, the product itself. Quality Control is always an issue in an industry and an economy where there is no room for waste (think of all the lean programs that companies are adopting for example). And if it is hard to get and retain skilled workers that means: 1) high staff turnover, 2) lack of product consistency, 3) waste, 4) increased production costs, and the vicious cycle goes on!

In industrial automation, when it's time to automate a process it's sometimes hard to know where to begin. There are plenty of systems integration companies that offer over-the-top kits for specific applications, but what if your application is different? What if you want to build your own custom cell? This eBook will guide you in the process of analyzing, buying and installing an automated machine tending robotic cell. As all machines, robots, programming tools and applications are different, we will explain this subject using general terms.

How to Use This Document

We have put together this document to help you figure out if feeding your CNC machine by robot will be a worthwhile investment. A grid (attached with this document) is designed to be printed or filled out directly on your computer. This grid follows the different sections of this document. So step by step you will be able to go through this document and note your information in the grid. Each point is explained with a short paragraph. Complete the grid by respecting all points to produce a proper analysis of your potential robotic machine tending operation. You should also notice that the grid is designed to analyze the different scenarios for 4 different products. At some point there might be a product that makes more sense to automate than another.

The three different sections are sub-divided as baselines; what you have in stock. The second part is dedicated to determining what is available, do your research and see what looks like a good fit for your application. The third part is basically to evaluate your choices in terms of viability. The entire document parallels a real life machine tending example. Each section will be a part of this real life example. The example can also act as a guide for ideas and suggestions on how to complete your analysis.

1. BASELINES

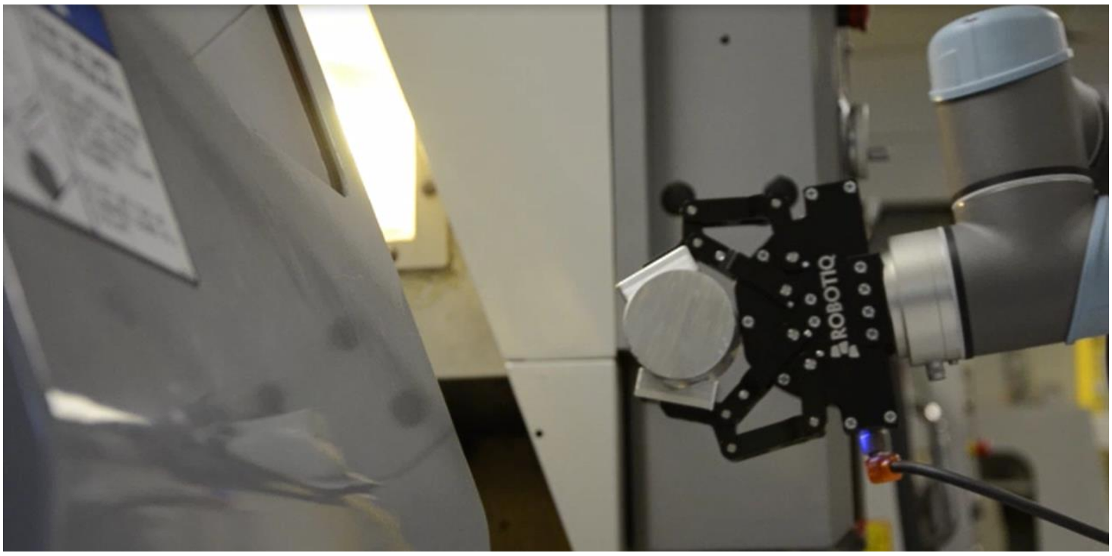
Before going too far in your process you should define your project baselines. This allows you to establish references to make sure this whole process is worth it. This step will focus your thinking on all the factors that are involved in the implementation of a robotic cell. Get experienced machinists and managers involved in order to get the best input from your plant floor. These items can start your analysis off in the right direction starting by evaluating your needs and whether or not a robotic machine tending cell is appropriate for your application.

1.1 General Baselines

Determine the part or the part family that will be machined and the sustainability of it. Plan short, medium and long term and try to figure which product is the easiest to automate. After this step, a couple of parts should be removed from the diagnosis. In fact, you should do a couple of iterations before going all out with the automated process. Begin by integrating the products that have the best possibility to succeed and build up your experience around it. Afterward, introduce more complex parts to the automated machine tending process. The grid has been built to analysis up to four different products.

- **Annual Production:** What is your annual production for this part or what is the planned production for this part? What is the production repetivity?
- **Production Lot Size:** How many parts are machined on the actual CNC.
- **Machine Type/Model:** What kind of machinery do you use to realize this part; milling, turning, wire, grinding. Which CNC model are you using? Is this the best model for your process? At this step, this is the right moment to ask yourself if the manufacturing process can be enhance to be more efficient.
- **Dedicated Machine:** Determine if the machine will do the same part or the same part family. You will save time and energy if you put all the look alike parts on the same machine so you don't have to change tooling and setups. It might also help to look at the process backwards; is the part done on a single machine or on several different ones?

Example: Our annual production is **5000 units** split into **lots of 200 units**. The parts are done on a **Huron CNC turning machine**. This part is **uniquely done on this machine**, but **other production** runs on this machine from time to time.



1.2 Process Baselines

- **Single or Multiple Setups:** Notice how many setups have to be done to complete a part. This should include all the setups on different CNC machines.
- **Loading Time:** To evaluate the potential time savings, you should monitor the time that elapses to achieve one complete machine feeding operation.
- **Spindle Time:** Write down the time the spindle is running during an entire day. Spindle time is also known as ''chip cutting time''. With this value, you can evaluate the amount of time during the day that the machine is working.

Example: The targeted part is done on **2 setups**. The loading time for a regular operator is between **30 and 60 seconds**. The machine is running for **5 minutes** before stopping. The entire lot is done on the first side and then on the second side. The machining time is the same on both sides.

1.3 Part Baselines

- **Part Material:** The material can act as a constraint in machine tending. In fact, noticing this data will help you figure out which way the robot end effector can grab the part.
- **Raw Part Size:** Since we are still looking at baseline data, notice the current raw material you are using. The general dimensions will also help with the robot gripper selection.
- **Raw Part Weight:** The weight of the raw part determines the required payload of the robotic cell.
- **Finished Part Size:** Knowing the finished geometry of the part will help you to figure out the best plan for the robot removal operation.
- **Fragile Geometry:** Are there any fragile geometries or regions on the part that should be avoided during the process?

Example: The part is made from a **2'' round bar** of **6065 Aluminium**. The raw material is cut at **a length of 94mm**. This bar weigh about **300g**. The finished part is **90mm long**, its biggest diameter is at **48mm** and the smallest outside diameter is at **23mm**. There are **no particular or fragile** geometries on this part.

1.4 CNC Machine Baselines

- **Ordering System:** Is there any type of classification done before and after the machining operations?
- **Automatic Vice:** Since nobody will be touching the vice during the machine tending process, you should look for an automated fixture device. There are a wide range of automated vises available, see if yours can be automated.
- **Automatic Doors:** Some CNC machines come with automated doors to access the fixture. Depending on the machine, you can still work with a robot even if your door is not automated.
- **Monitoring System:** You can either use device like: impact sensors or cameras, write down what are the present monitoring or safety devices in the CNC machine.
- **Coolant:** Is there any coolant or oil involved in the process?
- **Automation:** Does your CNC machine have a pallet changer, a bar-feeder, multiple spindles. All these devices should be considered in the analysis.

- **Cleaning System:** Is there any type of cleaning system embedded in the CNC machine?
- **Controller:** Which controller brand are you using?
- **Interface:** What is the communication protocol (DeviceNet, Ethernet, etc.) or the external I/O exits that can be configured? This will allow you to have communication between the robot and the CNC machine.

Example: We are currently using **simple bins** to keep the parts together. There is a **hydraulic vice** in the lathe. The door of the machine is opened **manually** by the operator. There is an **impact sensor** to stop the machine if an error occurs. The process **does use coolant**. There is **no automation device**. An air **cleaning system** can be fitted on the CNC vice. The current controller is a **Siemens**. The controller is compatible for use with a robot.

2. AUTOMATION DATA

Now you have all the data you needed for your analysis. You now have to translate this analysis into an automated process.

2.1 Part Data

The most limiting aspect of machine tending remains the part itself. Either it's the weight, the size or the material involved, every detail counts and can be a real headache if parameters are not well analyzed.

- **Size:** You always have to consider the dimension of the part when you start your robotic cell design. There will be a various choices of robots and grippers depending on the size of your parts. For example if the machine produces parts that can be held in a human hand, the gripper will have the same proportions.
- **Weight:** The weight of the part guides the robot and end effector selection in terms of payload. The gripper should be able to lift the part. The robot should be able to lift both the gripper and part weight. For more information regarding robot and gripper payload, the following article explains it all.

- **Material:** The material composition of the part can limit the use of some end effectors. Most of the time, machine tending will be done with metal parts. If the part is loaded in the machine with a magnetic end effector, it should obviously be magnetic.

- **Fragile Geometries:** Once the part is machined, if there is any fragile part geometry it should not be in the robot or gripper path. Make sure it is still possible to unload the part from the machine once it has been machined. Note that some grippers have force limitation and can grasp thin and/or fragile parts.

At this step you should have a general idea of the size and payload you will need for your robotic cell. Note that as a rule of thumb the bigger the payload, the bigger the robot. If you have a big payload, you will then need a robot with a longer reach, which also means a bigger footprint on the shop floor.

Example: The part is relatively small and light. A gripper with an opening **greater than 60mm** can be used only if the payload allows **at least 1kg**. The robot should be able to get **into the machine and order the part once it is out**. A quick measurement made us think that a robot with an 800mm reach would work with this machine. There are no fragile geometries, so no worries.

2.2 Process Data

By analyzing your process you now have a better idea of what can be done to reduce time waste.

- **Setups:** Knowing the number of setups, you now want to reduce them! Fewer setups mean more spindle time, which obviously increases productivity. You can also gain precious time just by re-thinking the actual machining program.
- **Loading Time:** In the actual machine feeding process, there is usually no gain in switching from a human to a robot. In fact, if you monitor the time that a human takes to grab the part, feed the machine and close the door, the process is probably shorter than with a robot. However, it is an endurance game. The thing is that the robot will always repeat the exact same motions with the same precision and for an infinite number of times (around the clock). You shouldn't monitor time gain by the actual machine tending motion but on a wider window of operation.

Example: The way the part is done, no optimization or setup reduction can be done. The loading time is quite short, but unstable right now. A lot of parts have been mispositioned by less experienced machinist. If the robot can feed the machine at the same rate and insure the process stability, this would be great.

3. ROBOTIC CELL DESIGN

Automating a process might also mean needing to rethink the whole design process. Part fixturing, raw material installation, reducing the number of setups by modifying CNC programming, all aspects might benefit from a rethink. It is hard to guide you in the process of redesigning a part. Make sure to start from the bottom and go through all the details that could cause problems in the machine tending process.

It is sometimes hard to identify the price related to the introduction of a robotic cell on the shop floor. This part of the analysis is where we make the calculation for the general cost of the cell. The sections identified by a dollar ($) sign should be written down on the calculation grid so you can do the math for the robotic cell integration.

3.1 Robot Selection ($)

The robot is the most important investment component of the cell. Contact your local dealer to ask for a quote on the robot of your choice. Make sure to ask about the shipping and other fees like installation to include them in your calculation. Since the robot controller has to be bought with the robot itself, make sure to include the price of the controller in the robot pricing. Notice that most robot manufacturers name their robots in terms of payload in kg. This shorthand might help you to quickly figure things out. Make sure the robot controller can be retrofitted to your CNC machine controller.

- **Collaborative Robots:** The main purpose of these robots is to enhance human-robot collaboration. This means that they are designed to act like humans. They have a human like size and motions. They can also monitor their environment. The robots are working without any fencing and have a smaller footprint on the shop floor. These robots, most the time, are cheaper than the classic industrial robot and are easier to integrate. To learn more about this new kind of robot, take a look at the following eBook on collaborative robots. Make sure to double check that the robot reach and payload suits your applications.
- **Industrial Robots:** And here are the other robots! Basically, any size, any reach, any payload. You have to choose depending on the data you have collected in the previous steps. We have put together a comparative charts to help you with the selection. The charts include robots with 5 to 10 kg payloads and robots with 20 to 50 kg payloads.
- **Pre-Engineered Cells:** Some integrators out there are offering all-inclusive packages. This concept mostly uses collaborative robots fixed on a table or in a closed safety cabinet. This type of cell generally includes the robot, controller and all the necessary accessories for machine tending. You only need to select a gripper and you are all set.

In my own personal opinion, if the part can be handle with a collaborative robot, go for it! This is likely to be the easiest setup, because it will mean faster programming steps, fewer security devices, a more compact cell and a faster payback. As a rule of thumb, if the part requires a payload higher than 10kg, you should go with an industrial robot.

> **Example:** Since the machine is not dedicated to this part, the robot may be **moved from time to time** for small batches or prototypes. The required payload and reach are quite **small** and we **don't have experience** in robot programming. A Universal Robots arm would be the best match. It is easy to use and relatively cheap at around $35,000 US.

3.2 Gripper Selection ($)

There are probably as many robot grippers on the market as there are robots models. The gripper market is huge, so make sure to read our eBook on how to choose the right gripper to get more information. If the machine tending operation uses cooling fluid, make sure to consider the IP rating of your gripper. Below is a list of some gripper types to consider.

- **Parallel Gripper:** Used for production with regular shapes. When the production is steady and there is no variation in shape and size, this can work really well.
- **Adaptive Gripper:** This kind of gripper is mostly used for a high mix of parts. Machine tending is the perfect application for this kind of gripper since the part size and geometries will change in time. The gripper will adapt itself to the part shape without any major customization. Look through the different models to see the different possibilities.
- **Suction Cups:** Suction cups are mostly used with flat parts that can't be grasped by regular grippers.

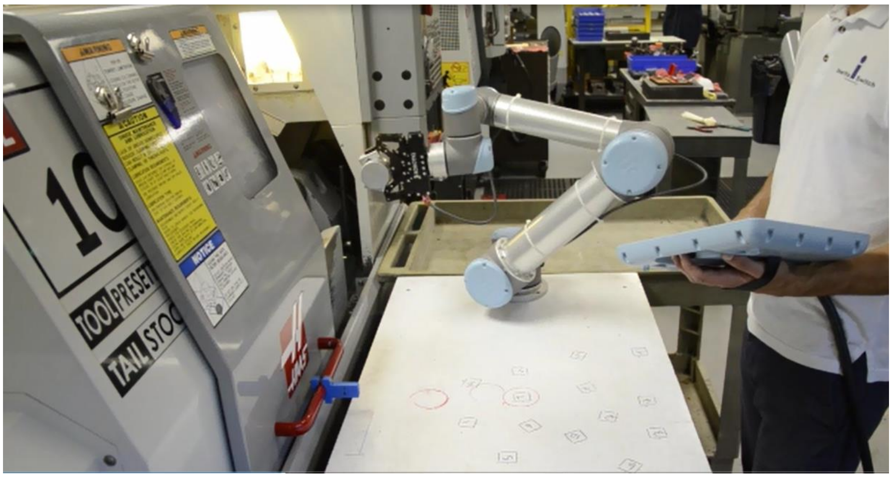
Magnetic Gripper: Magnetic grippers are used with magnetic material such as steel. Make sure you are not manufacturing stainless, aluminum or carbide parts, even once in a while, because this type of gripper won't work with these materials and then you won't be able to use your robot to its maximum potential.

- **Others:** There are plenty of other options than the ones listed. You may also want to customize or build your own gripper to fit your application.

> **Example:** The part is round and in aluminum, so the use of suction cups or magnetic grippers are not available. I am thinking about using the robot to do some **other tasks in the future** and I don't want to spend time designing different jaws. An adaptive gripper would best meet our needs. The average price for this Gripper is $4,800 US.

3.3 Peripheral Devices ($)

- **Ordering System**: Can your present ordering device or system be adapted to an automated machine tending process? There are a lot of different ordering systems available. The most popular are: assigned part position, conveyors and drawers. Think about how you can orient your part, so the robot knows where it is. Look at the different options and see what fits your application the best. Remember to start simple and increase complexity once the robot is running well. If you want to have more complex infeed devices, ask an integrator to analysis your case.
- **Locating System:** This might be considered part of the ordering system, but in some cases even if the parts are ordered, a redundant systems check might be useful to determine if the part is really at the right location. Devices such as vision or force-torque sensors can be used in this situation. You may also consider the turnover or reorientation step at this point. If the part has to be rotated, make sure to have the proper device to locate the part correctly.
- **Automatic Vice:** You may want to invest in an automatic vice if your CNC machine doesn't have one. Fixing a part with a conventional vice take two arms and you don't really want to have a single arm for screwing and un-screwing a vice.
- **Automatic Doors:** This is often a must, though in a few cases it is not essential. Take a look at this video where a collaborative robot feeds a machine with an adapted regular door.
- **Monitoring System:** To run your machine around the clock you may want to monitor its activities. In fact, now machines can be monitored from your smart phone, so if there's a problem you can react remotely and the production can go on.



- **Automation Device:** You may want to use your present automation devices to optimize your process and ensure that your machine is running most of the time. For example, machines using a pallet changer can load the part onto the unused pallet with a robot. This means that there is virtually no dead machine time. The raw parts are ready as soon as the finished parts are done.
- **Cleaning System:** If your part will be covered with coolant, you may want to clean them since they can remain untouched for a long time before an operator gets to them.
- **Physical Barrier:** Depending on the type of robot you choose, security devices such as fencing or physical barriers can be installed. Certain applications use a vision system to ensure worker safety. You should be aware of the rules and regulations applicable in your country in order to design or introduce these types of security devices in your plant.
- **Measuring Method:** Your quality assurance can be ensured by human workers to have a quick feedback for your production and to rapidly make offsets with your machines. However, automated measuring methods can also be introduced to the cell to give feedback to your machines. These types of devices take longer to operate and need a supplementary effort to make sure the offsets are done correctly, but they can inform you instantly when a change occurs.
- **Machine Interface:** Most machines will have different I/O and available communication ports. So you might have to hardwire and program them to perform the right task. Each robot and machine are unique, their fit must be analyzed before buying one or the other device.

Example: To order the parts I thought about placing them on a **table in a predetermined layout**, so the robot would know where to go grab them. The operator can then feed the table with raw parts every once in a while. To classify them after the machining operation, the same table is used. We can build this in house for less than $800 US. No locating device is required. The vice is ready to be automated. The door can **be opened by the robot**. The impact sensors will be the only devices for the moment. We don't want to introduce bar feeders yet. We will upgrade our cleaning device ($800 US) to make sure the **chuck is cleaned** between each part. Since we will be using a collaborative robot, we will **mark the working environment** and a light will be flashing while the robot is working ($200 US). The **operator will double check** the dimensions during production to have quick feedback. To connect the robot to the machine interface including protocol testing, we planned $1000 US.

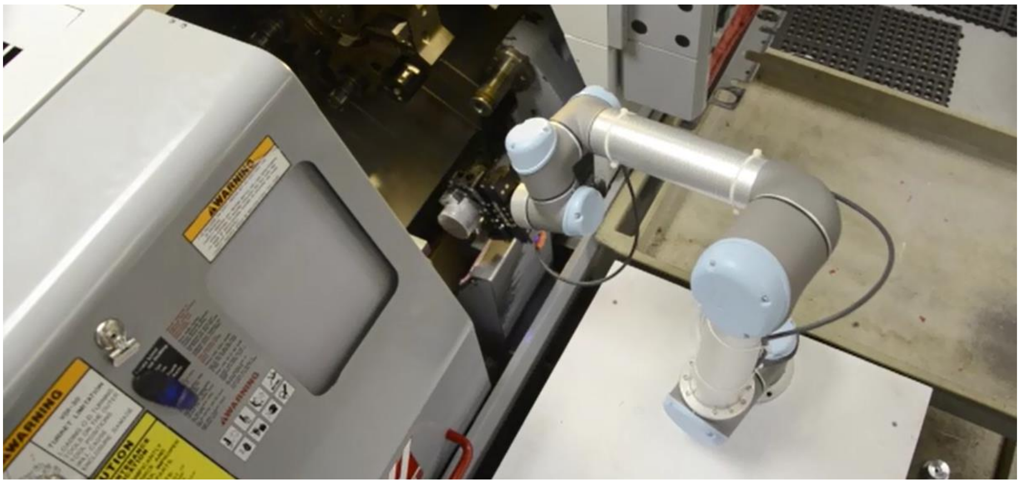
3.4 Introducing the Robotic Cell

- **Robotic Cell Footprint:** Now that you have a better idea of the approximate size of the robotic cell. Do you still have enough space? Look at different positions on the shop floor and think outside the box. Some robot tending operations are done with the robot attached to the ceiling, why not yours?
- **Plant Re-organisation:** To optimize your robot cell integration you might consider changing the location of your CNC machine. While you are thinking about that, can your robot feed two machines at a time? Take a look at this video of a collaborative robot feeding two machines at a time.
- **Integration Cost ($):** All this reorganization means working time, evaluate the number of people involved and their pay rate. You should also consider the shutdown time related to the integration of the robot, the plant reorganization and the eventual debugging time. This might lead you to consider using an external integrator, the cost is higher but there is no need to involve your employees full time in the installation. Depending on your particular case, the robot could be up and running in a shorter amount of time if it is installed by a professional integrator.

- **Risk Assessment:** A robot integration automatically means a risk assessment. Look at the rules and regulations in your region to have the exact information on this process.
- **Evaluate Impact:** It may seem easy but integrating a robotic cell in a plant can be a real concern for supervisors. In fact, employees can have strong reactions to this announcement. Make sure to inform them correctly and to introduce robotics to them as a tool and not a job threat. Read the following article to get more information on the subject.
- **Formation:** Who's going to be the robot programmer? Is there any training required?

Example: The robot has an 850mm radius reach and the different ordering devices are quite compact. I would estimate 6 m^2 (64 ft^2). Only one CNC machine will be fed by the robot but I am thinking about putting two CNC lathes face to face, fed by the same robot if it works well.

We have to consider shutdown time and the time people spend learning how to use the robot (2 operators for one day: +/-$1,000). A risk assessment has be done to respect **ISO-10218**. We do offer training for the employees and provide them blog posts and meetings to reassure them they won't lose their jobs. The robot will help them. The robot is hand-taught. This means there is no need for a specialize skilled programmer.



4. PROFITABILITY

Now that all the prices relating to the project are out there, you can evaluate the total cost of the robotic cell. We are not accountants, make sure you evaluate this investment in relation to your particular financial situation.

- **Starting Investment:** All the prices that have been written down on the grid until now consist of the starting investment. If there are any other expenses related to the robotic cell, they should be considered and added to the grid.
- **Maintenance:** A robotic cell like any other machine needs maintenance, ask your dealer to see if you should consider replacement parts just in case you crash your robot or some other accident occurs. Analyze this process carefully since it can really change the return on your investment. Notice that periodic replacement costs related to the robotic cell should be included in the maintenance fees.

Example: Robot: $35,000, Adaptive Gripper: $4,800, Ordering System: $800, Machine Update: $1,800, Security Devices: $200, applicable taxes and transportation fees: $4,000-$6,000. In house Integration cost: $1,000
Starting Investment: $49,600 US.
Maintenance cost for these devices are negligible. Yearly maintenance is required.

4.1 Return on Investment

A serious return on investment study should be run before the robot is installed. We provide guidelines to evaluate your return on investment. Fill out the appropriate section in the ''Step By Step Grid'' to have a better idea of your return on investment.

To evaluate the return on an investment in machine tending you have to consider the **starting investment**, and the **savings/production enhancement**. Since you have already calculated the starting investment. You want to monitor the savings that are made by the introduction of a machine tending cell in your workshop. To do so you have to consider the actual situation and the potential situation. The following points should be considered in your analysis.

- **Number of Operators:** Evaluate the current situation. If the machine is operated by a single employee, consider this. In the ROI calculation, we often calculate that the same operator will be operating several machines. For example, if one operator uses 2 machines, there is then 0.5 operator on this single machine.
- **Number of Shifts:** For how many shifts does the machine operate?
- **Operator Cost:** What is the yearly cost of an operator?
- **Average Downtime/Scrap Cost:** All cost related to downtime, scrap maintenance, jig improvement, etc. should be considered in the analysis.
- **Yearly Savings:** The yearly savings is the difference between the actual and potential scenario.
- **Yearly Throughput Increase:** Estimate the benefit that can be accomplished from the use of a robot. This might be hard to evaluate when you have never used a robot before. So, you might want to evaluate the situation assuming your yearly production as it stands without any production increase.
- **ROI:** To calculate the time it will take for the payback on your investment, you have to divide the starting investment by the yearly savings and production increase.

Example:

Actual Scenario: **1 employee** operates the machine. **2 shifts** per day and with a yearly salary of **$50,000**. The average cost for **down time is $5,000**, **scrap $5,000**, **jig improvement $5,000**. For a total of **$ 115,000 US** yearly actual cost.

Potential Scenario: A single employee will run 2 machines (**0.5 employee**) on **2 different shifts**. The yearly salary of an operator is **$50,000**. The cost related to **down time is $2,500, scrap $2,500, jig improvement $15,000**. For a total of **$70,000 US** yearly potential cost.

Yearly Savings: $ 115,000 - $ 70,000 = **$ 45,000 US**
Yearly Throughput Increase: $ 0

ROI: $49,600/$45,000= 1.1 years.

This all means is that in 1.1 years, the robotic machine tending cell will pay for itself. Afterwards, the cost of operation is really low and this is where you can really see the production enhancement. In other words, in this case, the first year is basically to pay for the cost of the robot. Subsequent years are all profit.

This is still a rough estimate and calculations appropriate to your particular situation should be done to make sure that you consider all your actual parameters. You also have to consider that this calculation does not consider all the value added to your process. Things such as quality control enhancements, maintenance frequencies and setup enhancements that are now done by the operator since s/he has been liberated from certain redundant jobs. These factors are hard to evaluate and incorporate into a direct calculation.

CONCLUSION

This eBook was designed to help you see the different advantages of integrating a robotic machine tending cell in your workshop. The process might seem long and complex, so make sure to go through the different steps and note all the information you can get on the different devices you will be looking at. Price estimates and profitability studies can help you figure out if the investment is really worth it. Keep in mind that machine tending can be the step up that your company is waiting for. As your employees are redirected to more important jobs such as quality, setups and maintenance your products are getting added value without extra man hours. With increasingly demanding customers and shorter lead times, maybe it is time to make your machines work around the clock.

Ask...

You should definitively ask your gripper representative or application engineer if your applications are suited for certain types of grippers. Some gripper manufacturers can make customized grippers or gripper parts (customized fingertips, customized opening range) depending on your request. You should definitively tell the representative what your applications are and work around them instead of adapting your operations to the robot and gripper.

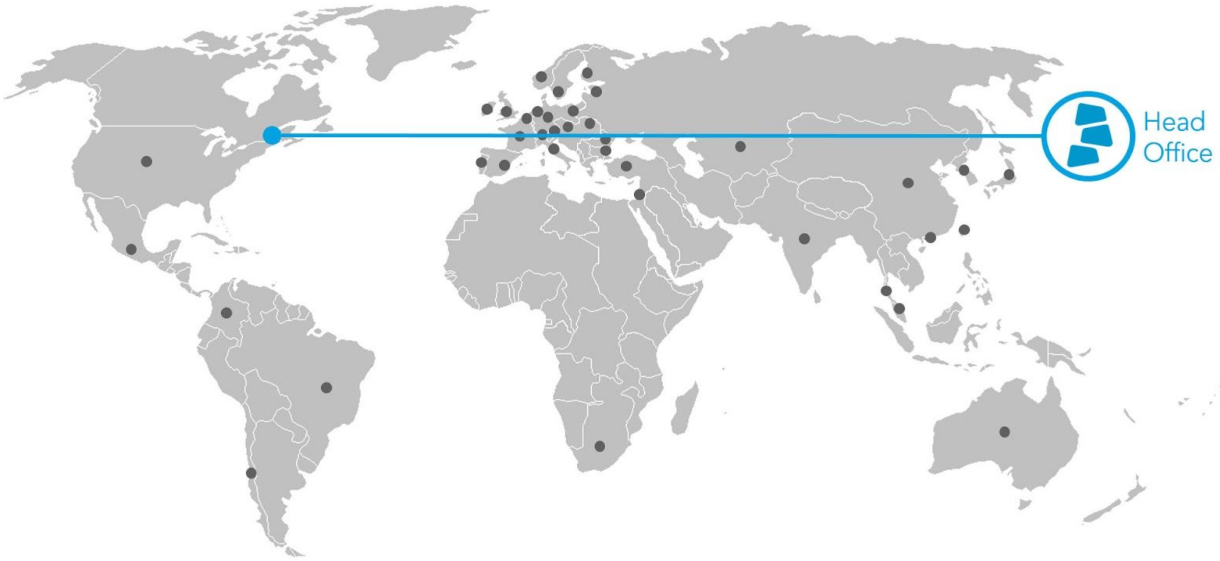
For further information, feel free to visit our website: **www.robotiq.com**

About Robotiq

Robotiq's Lean Robotics methodology and products enable manufacturers to deploy productive robot cells across their factory.

They leverage the Lean Robotics methodology for faster time to production and increased productivity from their robots. Production engineers standardize on Robotiq's Plug + Play Components for their ease of programming, built-in integration, and adaptability to many processes. They rely on Flow's software suite to accelerate robot projects and optimize robot performance once in production.

Robotiq is the humans behind the robots: an employee-owned business with a passionate team and an international partner network.



Let’s Keep in Touch

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D o F

Robotiq’s community where industrial **automation Pros**
share their **know-how** and **get answers**

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	1 Product name/no.	2 Product name/no.	3 Product name/no.	4 Product name/no.
1.1 General Baseline				
Annual Production [Unit]				
Production lot size [Unit]				
Machine Type/Model [Describe]				
Dedicated Machine [Yes/No]				
1.2 Process Baseline				
Single or Multiple Setups [Describe]				
Manual Loading 1st Setup [sec]				
Spindle Time 1st Setup [min]				
Manual Loading 2nd Setup [sec]				
Spindle Time 2nd Setup [min]				
Manual Loading 3rd Setup [sec]				
Spindle Time 3rd Setup [min]				
Spindle % (spindle time/24h)				

ROBOTIQ	1 Product name/no.	2 Product name/no.	3 Product name/no.	4 Product name/no.
1.3 Part Baseline				
Part Material [Describe]				
Raw Part Size [LxWxH]				
Raw Part Weight [lbs/kg]				
Finished Part Size [LxWxH]				
Fragile Geometry [Yes/No]				
1.4 CNC Machine Baseline				
Ordering System [Yes/No]				
Automatic Vice [Yes/No]				
Automatic Doors [Yes/No]				
Monitoring System [Describe]				
Coolant [Yes/No]				
Automation [Describe]				
Cleaning System [Yes/No]				
Controller [Describe]				
Interface [Describe]				
2.1 Part Data				
See Section *2.1 Part Data* of the document.				
2.2 Process Data				
See Section *2.2 Process Data* of the document.				

ROBOTIQ	1	2	3	4
	Product name/no.	Product name/no.	Product name/no.	Product name/no.
3.1 Robot Selection				
Robot Brand/Model [Describe]				
Robot Price [$]				
3.2 Gripper Selection				
Gripper Brand/Model [Describe]				
Gripper Price [$]				
3.3 External Devices				
Ordering System [Describe]				
Ordering System Price [$]				
Locating System [Describe]				
Locating System Price [$]				
Automatic Vice [Describe]				
Automatic Vice Price [$]				
Automatic Door [Describe]				
Automatic Door Price [$]				
Monitoring System [Describe]				
Monitoring System Price [$]				

ROBOTIQ	1 Product name/no.	2 Product name/no.	3 Product name/no.	4 Product name/no.
Automation Device [Describe]				
Automation Device Price [$]				
Cleaning System [Describe]				
Cleaning System Price [$]				
Physical Barrier [Describe]				
Physical Barrier Price [$]				
Measurment Method [Describe]				
Measurment Method Price [$]				
Machine Interface [Type]				
Machine Interface Integration Price [$]				
3.4 Introducing the Robot Cell				
Robotic Cell Footprint [Square Unit]				
Plant Re-organisation [Describe]				
Integration Cost [$]				
In-house Cost [$]				
Risk Assessement [Yes/No]				

ROBOTIQ	1 Product name/no.	2 Product name/no.	3 Product name/no.	4 Product name/no.
Trainning Type/ Person to Train [Describe]				
Trainning Cost ($)				
4. Profitability				
Starting Investment [$]				
Maintenance Cost (Yearly) [$]				
4.1 Return on Investement				
Actual Scenario				
Number of Operators [Unit]				
Number of Shifts per day [Unit]				
Operator Cost [$]				
Average Downtime/Scrap Cost [$]				
Actual Yearly Cost [$]				
Potential Scenario				
Number of Operators [Unit]				
Number of Shifts per day [Unit]				
Operator Cost [$]				
Average Downtime/Scrap Cost [$]				
Yearly Potential Cost [$]				
ROI				
Yearly Savings [$] (Actual Cost- Potential Cost)				
ROI [Years] Total Investment/Yearly Savings				