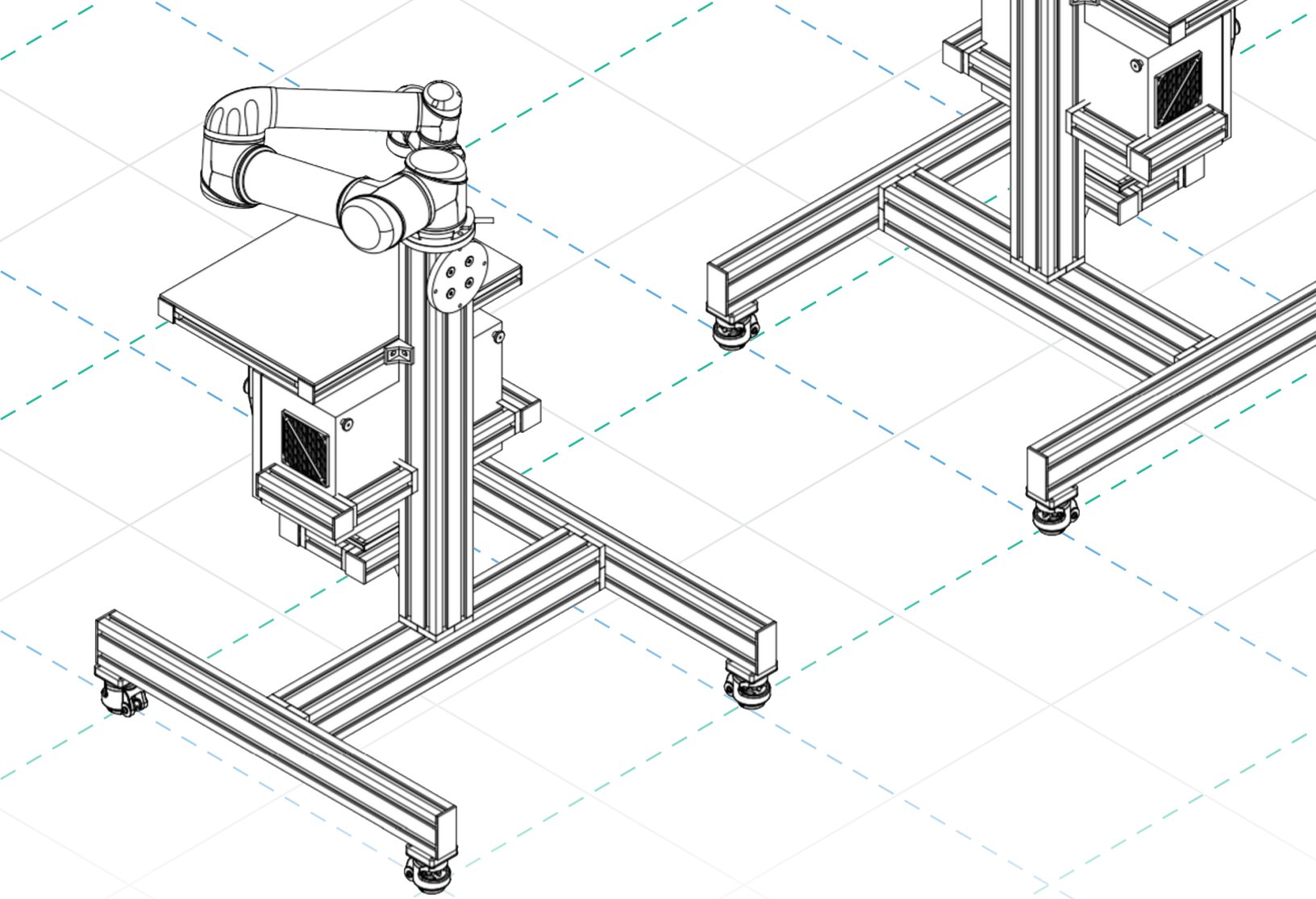

ROBOT REDEPLOYMENT 101

FREE YOUR ROBOT, INCREASE COBOT UTILIZATION & GET FASTER ROI'S

PRESENTED BY:

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INTRODUCTION

Over the past years, we have seen collaborative robots automate a new set of tasks that are inclusive of small/medium businesses but large enterprises like Toyota and Boeing are also benefiting from them. The goal of such projects has always been to be more productive, solve the labor crisis, and get the fastest return on investment possible (ROI). For example, companies can get 6-18 months ROI using collaborative robots like Universal Robots.

Unfortunately, some companies cannot see such quick returns due to the nature of their business and production. As a result, the long time to get their investment back keeps them from leveraging the power of automation.

We have witnessed ***robot redeployment*** as the strategy to enable those manufacturers the ability to leverage and afford the automation investment needed to contend with their competitors. Using the same robot to do multiple tasks or work at various stations is the solution to solve this complex total cost of ownership question manufacturers deal with on a daily basis.

This eBook explores the basis of robot redeployment and offers you the knowledge to start redeploying your robots in your factory.

Flexxbotics

Flexxbotics aims to optimize collaborative robot changeover through intuitive software and hardware robot productivity tools. **Your operators can adapt to changing demand; why should robots be any different?**

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WHAT IS ROBOT REDEPLOYMENT?

Collaborative robots have opened the door for novel and innovative ways to automate a facility. Their relatively easy programming and lightweight nature have laid the framework for end-users to move the robot from one machine to another physically. Gone are the days of purchasing a robot, planting it in front of a job, and repurposing your operators to other non-automated jobs.

Universal Robots has paved the way with a fleet of versatile, fast setup and easily programmable cobots. These characteristics are why moving those robots to different stations during the day is possible.

> *Robot redeployment means just that:* ***moving your robot to different tasks and stations to maximize its utilization time and production throughput.***

Although the mobility of those robots has been promoted over the years, achieving real, fast, and easy redeployment is more complex than that. We will explain why and how to simplify it throughout this eBook.

First, let's talk about how robot redeployment will affect your company's automation efforts. Having a good redeployment strategy and tools will help you:

- *Simplifying robot installation*
- *Maximizing robot utilization*
- *Better management of downtime*

SIMPLIFYING ROBOT INSTALLATION

The first benefit of having a robot redeployment strategy is simplifying and speeding up your robot installation.

As you might not have robot engineers internally, reducing the technical barrier of the robot installation is ideal. In doing so, your actual employees could handle the projects, reducing the upfront installation costs. Collaborative robots are helping as they are easier to deploy and install than their industrial counterparts. But even with this technology, people without robotic knowledge still need to learn robotic terms and concepts like axis systems, TCPs, and many more.

A more straightforward robot installation becomes more accessible to your operators, regardless of their knowledge of robotics and programming. It will also lead to a faster robot deployment and quicker payback.

> ***Remember*** *- Your goal is always to put your robot in production as quickly as possible to start getting your return on your investment.*

To understand how to simplify robot installation, we first need to understand the basis of the installation process.

THE BASIS OF ROBOT INSTALLATION

Your operators will learn that a robot install includes many elements. There are the physical setup, tool setup, user coordinates, safety considerations, and more.

Let's detail them...

Physical Setup

Depending on how you will be using the robot in your production, there are several ways that you can mount the robot. Collaborative robots can be installed in any orientation by selecting the right option in the controller. These are:

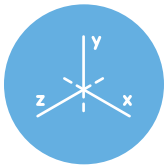
- *Static Mounting*
- *Inverted Mounting*
- *7th Axis Mounting*
- *Angle Mounting*

Whichever you choose, you must make sure the robot will be steady enough to stay precise and repeatable during production.

Tool Setup: TCP, CoG, and Payloads

When installing your robot, you will need to set up its tooling. You should set two elements: Payload, Tool Center Point (TCP), and Tool Center of Gravity (TCG). If you don't, your robot may act weirdly as it will not feel the weight on its wrist flange.

Robot Payload: The amount of weight its arm can support. The payload includes the weight of any end of arm tooling (EOAT) and the bracketing on the robot wrist. So if you are adding anything to the robot wrist, make sure to consider its weight. *Notice - Incorrect payload parameters can result in random protective stops. It can also cause inaccurate and unstable robot movements. Over time, it can also shorten the life of the robot.*



Robot Tool Center Point (TCP): The robot end effector (the tool). Its position and orientation define the tool coordinates. It's essential to determine this point correctly to facilitate programming. This point represents the exact working point the robot will use when working.

Tool Center of Gravity: An important parameter to understand and use, especially when working with force sensors. This parameter is relative to the shape of the tooling. Defining the right center of gravity will avoid weird torque reactions when the robot senses the force at its wrist. This will apply either if your cobot has an internal or external force sensor.

Workspace References

You also want to set up your user coordinate system relative to an external reference point. This parameter is usually attached to an object like a pallet, trays, or any reference point that you want. This reference is essential whenever any element of your robot cell may change in position.

There are many situations where having an external reference point is helpful for faster deployment:

When redeploying the robot to another station to maximize its utilization.

When the fixture for parts and/or trays changes from job to job in the robot cell. In that case, the robot isn't moving, but the position of the parts is.

Stations that need automated operation with the robot but sometimes switch to a manual process.

If the robot needs to be removed from production for maintenance (of the station, machine, or the robot itself)

Those are some situations when having an external reference point is important to restart production without spending hours and days to reprogram.

Safety configuration according to ISO/ TS 15066

When it comes to working with collaborative robots, safety always comes first. When setting up your robotic cell, always ensure that it conforms to the safety standard ISO/TS 15066 (risk assessment). The guidelines cover how to make an application safe for humans interacting with the cobot workspace. Every robot installation should end up with a risk assessment. It is the company's responsibility.

Other Installation Elements

This eBook isn't an in-depth robot installation course. But, there are many more elements to consider when installing a robot. Elements like:

- *Environment setup (ex: virtual planes & workspaces)*
- *Interaction with external Devices (I/Os)*
- *Setting variables, etc.*

These are some of the more essential things in robot installation that you need to consider.

> ***Tip*** *- Using a deployment checklist is a good practice for your staff. Your robot manufacturer should be able to provide you with one. You can also download one from this link.*

MAXIMIZING ROBOT UTILIZATION RATE

Another benefit of mastering robot redeployment is to maximize your robot utilization rate.

First, to better define what robot utilization rate is, let's talk about three critical metrics:

Robot Capacity: The maximum amount of time a robot can run. For example, if you have two eight-hour shifts, the robot has a total capacity of 16 hours.

Robot Utilization: The amount of time a robot is running vs. the robot's capacity. For example, if a robot runs 8 hours with a total capacity of 16 hours, it has a utilization rate of 50%.

Robot Efficiency: The part output vs. time vs. yield - For example, if a robot makes 900 parts in 8 hours and 800 of those parts are accepted, it has an efficiency of 100 parts per hour.

There are several ways to compute the robot utilization rate, but the easiest way is to divide the robot running time by the robot's capacity.

> ***Robot Utilization Rate*** *= Robot Running Time / Robot Capacity*

The utilization rate is the one that will first affect your ROI because, of course, leaving a robot idle is not ideal. You'll need to adjust certain factors in your workflow to use your robot to its maximum capacity.

FACTORS THAT AFFECT ROBOT UTILIZATION

To speed up your ROI time, you need to understand the factors that will affect your robot utilization.

Production Needs

Automating a task that you are not doing full time in your production will be hard to justify. Sometimes, to increase the quality and consistency of the work, a robot could make sense. But your production might not maximize the robot use right off the bat. Therefore, selecting the best utilization rate application is important to start your automation journey.

If your robot is tending a machine, you need to consider the synergy between both. As the machine performs a task, the robot stands idle, waiting after the part. Again, this can affect your utilization rate hence your potential ROI.

Robot Redeployment Time

Two main advantages of collaborative robots are their flexibility and the possibility to move them from task to task. Indeed, it is a great way to make the most of your robot, but you need to consider the redeployment time. The time used to switch the robot between tasks affects your robot utilization rate. Remember, the faster the robot goes back to production, the quicker the return of your investment.

Planned and Unplanned Downtime

Planned downtime is another factor that can affect robot utilization. Planned downtime generally includes scheduled maintenance and reprogramming of the robot cell. It is difficult to eliminate this kind of downtime, but make sure you are prepared for it when the time comes. It is also important to ensure that your employees perform the planned downtime task during the allocated or specified time. We will discuss this more in-depth in the next chapter.

HOW TO IMPROVE ROBOT UTILIZATION TO INCREASE YOUR ROI

As you now understand, increasing your robot utilization will increase your return on investment speed. Here are some ways to improve the previous factors that affect your robot utilization:

Select applications running full time already or that can run even longer. If you don't have such applications, consider using your robot for different tasks by redeploying it – but do it efficiently!

Consider having the robot run during breaks, overtime after the production day, or overnight in a lights-out production. For that, you'll need to consider more technologies and extra development time, but it will be worth it.

Minimize the time for your robot redeployment. To do that, you need to systemize your deployment process, train your team and use easy and fast deployment systems like Flexxbotics' products.

Keep your scheduled maintenance on track and be efficient doing them.

Take note of all problems of the robot cell as they occur, either mechanical or software. Then, adjust and optimize your robot cell at each of those events. You'll then end up with a fully optimized cell that will run as efficiently as possible.

You see, to maximize your return on investment, you need your robot to run smoothly as often and as long as possible. This will help you benefit from your automation investment and increase your utilization rate.

BETTER MANAGEMENT OF DOWNTIME

"Our line is down." These are the four most disruptive words a manufacturing manager will hear in their facility. The chaos of diagnosing the problem, constructing a solution, and implementing the solution can instill a significant amount of unwanted stress. This is why most manufacturing organizations have detailed plans to handle downline situations.

So this begs the question, should robots have similar contingency plans? The answer depends on several factors, such as robot utilization and manufacturing demand for your robot. If both those numbers are high, then a detailed, rigorous recovery plan must be part of your manufacturing process.

Even the highest-performance robots will have downtime issues at some point in their deployment life cycle. A multitude of factors can cause robot downtime, including:

- *Joint Replacement*
- *Mechanical Drift*
- *Accidental Setup Displacement*
- *Misaligned Parts*
- *Robot Fault*

Most of these problems are a natural part of automation. While preventative measures can help stave off these problems longer, at some point, the manufacturing/automation team will come across them.

HOW TO REDUCE YOUR PRODUCTION DOWNTIME

We understand that speed and efficiency are the most crucial aspects of a successful line-down preventative plan. Every minute the production line isn't running is losing you money.

Having a spare robot is a good preventive measure if a facility has multiple robots. However, an extra robot alone is not enough to complete your preventative measure. Replacing a downed robot with another robot during a joint replacement, for example, is based on the manufacturing concept of exchangeability. The ability to replace one robot with another requires an exhaustive and complex process that ensures both robots have similar accuracy and repeatability.

In our case, we can also leverage robot redeployment systems. Hardware/software solutions like the *Flexx Reference* can provide your robot with quick and easy relative offsets. Imagine the tool providing real-world positional memory for y our robot.

You can set your feature offset and click update in UR's Polyscope to update your whole program relative to the new reference, whether the robot is calibrated or uncalibrated.

Talking about offsets, let's better understand the concepts behind a redeployment system.

HOW TO DO A GOOD ROBOT REDEPLOYMENT

Being able to redeploy your robot needs a specific strategy and method. The goal is to move the robot back and forth at a station without having to reprogram it. To do so, its position needs to be perfect, or the program will need to adjust to its new position. This is when we talk about robot offset.

WHY BOTHER ABOUT ROBOT OFFSET?

Robot offset is calculated by making the difference between the joint positions before and after the relocalization. Then, using kinematics, an offset (small position change) can be applied to every robot position. There are many ways to re-position the robot at its place, but not all methods are equal in terms of ease of use, accuracy, and price.

We will explore those methods, but first, let's define our criteria:

Ease Of Use: To maximize productivity, redeployment has to take as little time as possible. The process should take minutes, not hours, and be simple enough for non-technical staff to perform it. This way, you get back to production faster!

Accuracy: Ease-of-use shouldn't affect the accuracy, another important component of redeployment. An effective cobot redeployment needs to balance these two, trying to achieve high mobility without sacrificing precision.

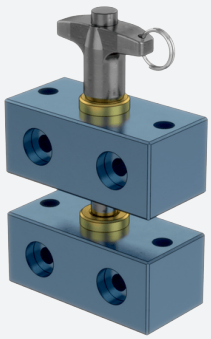
Cost: The redeployment solution's cost is also important to consider to get a fast ROI. First, you need to determine your specific needs for your cobot application. Ask yourself these questions:

- *How frequent should the redeployment be for a good ROI?*
- *What are the required levels of precision/accuracy of my tasks?*
- *What is my budget?*

DIFFERENT ROBOT OFFSET METHODS

There are different ways to find, calculate and apply robot offsets. When it comes to choosing an offset technique that fits your needs, there are three main methods or technologies available:

- *Mechanical Robot Offsets*
- *Visual Robot Offsets*
- *Software + Mechanical Robot Offsets*



Mechanical Robot Offset Systems

The most common idea to get the robot offset is to use a mechanical mechanism like a pinning system. This method is often the preferred one.

But, designing and manufacturing a precise enough system often is more complex than initially expected. You also need to think about how this repositioning will translate into the program itself!

A mechanical do-it-yourself offset system will present tolerance stack-up issues. For example, a displacement of 1-2 mm in a pinning setup can displace individual waypoints 5-10x that amount. So designing your mechanical fixtures may be more complex if you want to achieve high accuracy. It will also require qualified engineers to deliver the project.

Visual Robot Offset Systems

The visual offset method relies on a camera combined with special tags to reference the robot program. The relative position of the camera to the tag is what will get the difference between before and after.

As the visual system resolution defines its precision, less accuracy is one of the main weaknesses of this offset method. Moreover, vision systems are very sensitive to variations of lights, which can be an issue in a manufacturing environment. Finally, the cost of a vision system is often on the high side.

Software + Mechanical Robot Offset Systems

An alternative method consists of combining a software layer with a unique mechanical fixture device. This combination helps to achieve the highest levels of accuracy and simplicity. In addition, the software component makes sure to handle any slight variation and eliminate to the maximum the need to adjust the robot program.

As an example, Flexxbotics has developed such a system for Universal Robots. Flexx Reference uses a precise lockout designed to make repositioning quick and straightforward. In addition, it allows you to program multiple reference points around your workstation, minimizing the redeployment time from hours to minutes.

Each offset method has its strengths and weaknesses. You should aim to balance simplicity, accuracy, and cost depending on your application needs.

Flexx Reference

TIPS FOR ROBOT REDEPLOYMENT

Redeploying a robot can be overwhelming if you're doing it for the first time. It involves a new set of programming and logistic challenges. Without the proper process and tools, redeploying a collaborative robot can take days.

There are many steps to consider:

- *Moving the robot from one station to another in an efficient manner*
- *Have a way to reference the parts to be fed to the robot*
- *Have a way to reference the robot program to the machine*
- *Being able to quick-connect everything*

Mobile Robot Stand: The most efficient way to move the robot from point A to point B is to use a mobile robot stand. There are many models in the market for you to choose from. You'll want one that is steady enough once in place.

Reference The Parts: Another point to consider is installing the parts or trays of parts on the stand. This way, their positions relative to the robot remains the same, and it eliminates the need to reference the parts picked at every redeployment.

Reference the Program: Initially programming your robot relative to a reference can save you valuable time and money. Since you moved the robot, it is most likely not at the same position, so you'll have to modify the program.

Those modifications are one of the bottlenecks of cobot redeployment. Depending on the program's complexity and the skill of your programmer, retouching these waypoints can take anywhere from hours to days.

QUICK CONNECT IS A MUST

When redeploying your robot, the time to production at each setup is crucial. This is how your robot will become the most efficient. To simplify the setup, having an interface between your robot and your CNC is important. You'll then have one standardized UI and middleware that can make all the necessary connections/ communications for the robot to machine.

For example, in a CNC machine tending application, using a system like *Flexx CNC* would simplify your connections and offer you a unified interface for all the peripheral signals needed.

The Flexx CNC Interface is a standardized middleware and URCap designed to make a Universal Robot easily communicate with multiple CNC machines.

Flexx CNC

WHAT ARE THE FINANCIAL BENEFITS OF REDEPLOYMENT?

So what exactly are the financial benefits redeploying a robot can provide in your facility as a business owner or floor manager?

Consider the simple example of two machines (Machine A and Machine B) and one robot on Machine A.

Machine A has the following job parameters:

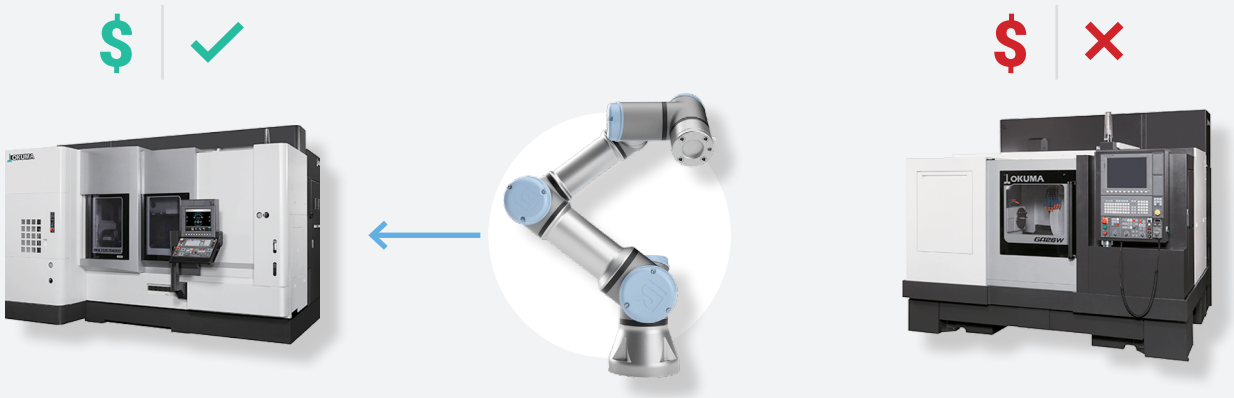
- 1 Job (with a robot)
- 100 pieces
- Cycle time of 5 mins
- Setup time of 30 mins with a robot
- Operator costs $20/hr
- The total job takes 8 hrs to run
- Each machine costs $170/job *(setup time costs $10)*

Machine A

The operator on this shift spends 30 minutes or about ~$10 dollars attributed to this job because the robot is tending the machine while it is running.

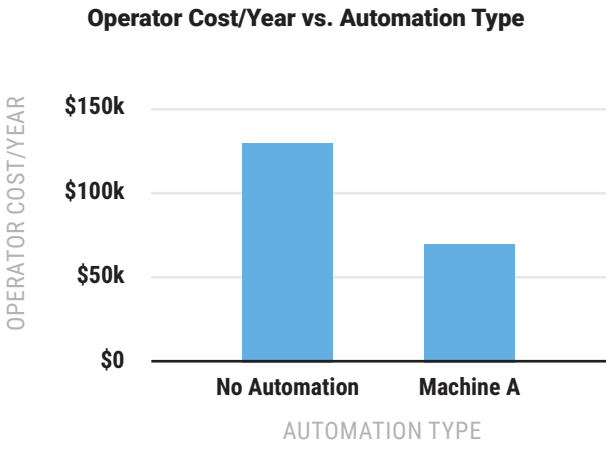
Without the robot, $160 would have been attributed to the job while the operator was tending it. Assuming the average collaborative robot integration and equipment costs are around ~75k, you will achieve your ROI in about ~500 jobs or if you run the job once a day in about 1-1.5 years.

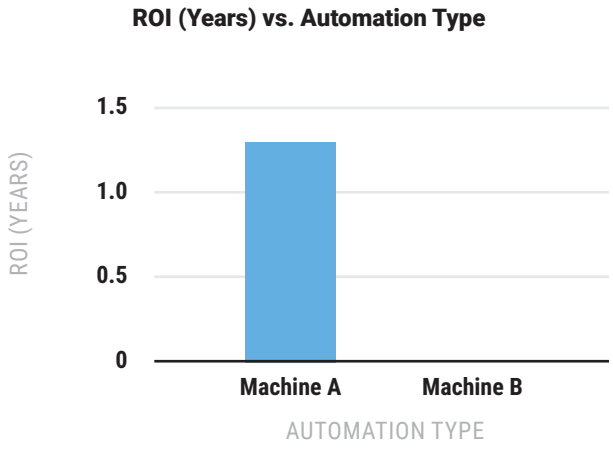
SITUATION 1: FIXED ROBOT ON ONE MACHINE

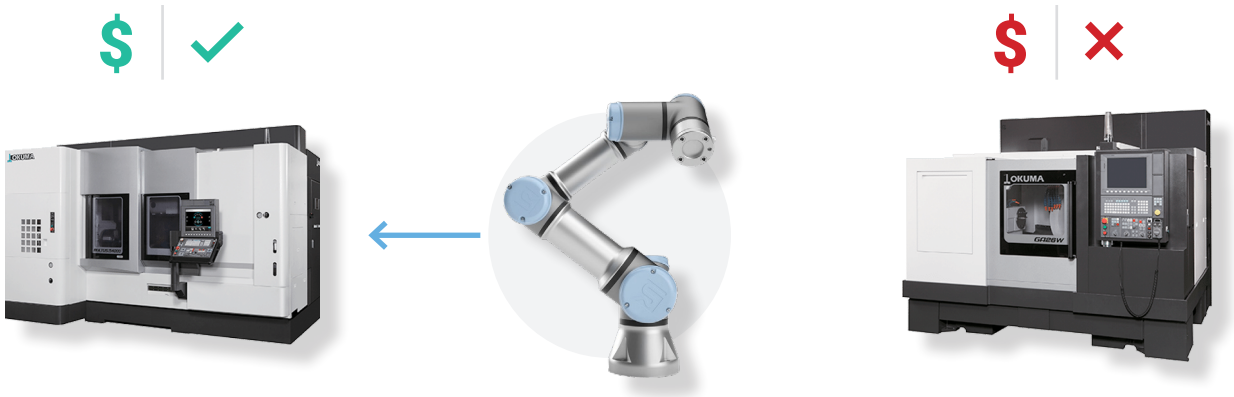


JOB NAME	PIECES	AUTOMATION COST	SETUP TIME (MINS)	CYCLE TIME (MINS)	OPERATOR WAGE (PER HR)
Machine A	100	$75,000	30	5	$20
Machine B	100	0	30	5	$20

AUTOMATION TYPE (2 MACHINES)	OPERATOR COST (PER YEAR)	ROI (YEARS)
No Automation	$128,967	N/A
Machine A	$69,350	1.26







Machine A *Fixed Robot* *Machine B*

There's an evident problem with the scenario above;
Machine B is not benefitting from the automation capability of your robot. Machine A has now seen higher throughput of material from more consistent manufacturing and, while it has taken on more demand, may still have downtimes.

During those downtimes, for example, waiting for the next production batches, your robot will sit unused. So...

What if... the volume of Machine B does not justify the purchase of its own individual fixed robot?

What if... you could repurpose your one robot from Machine A to Machine B during Machine A's downtime?

What if... you could accomplish it for under 10k?

Let's evaluate the financial implications of splitting the robot's time on multiple machines.

For simplicity purposes, assume Machine B's job has the same number of pieces, setup time, and cycle time. Machine B now receives the same automation benefit as Machine A with a mobile robot solution.

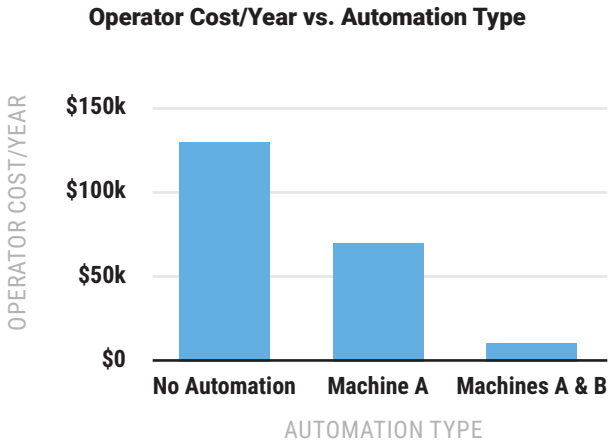
SITUATION 2: MOBILE ROBOT ON TWO MACHINES

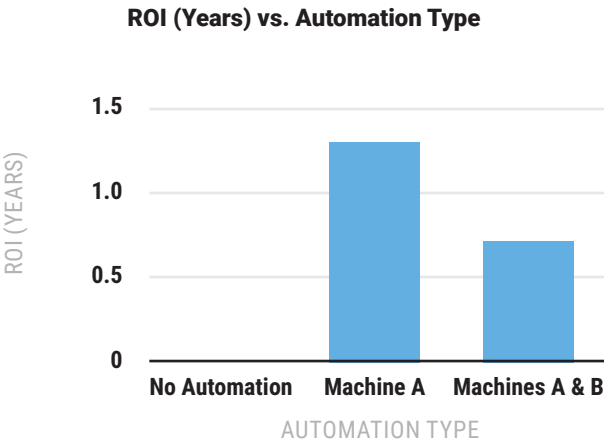
Machine A *Mobile Robot* *Machine B*

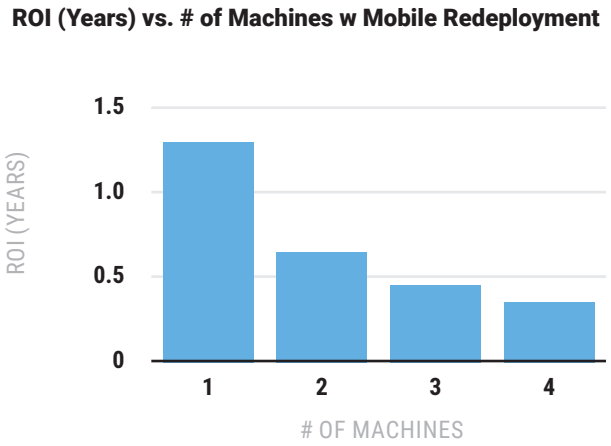
JOB NAME	PIECES	AUTOMATION COST	SETUP TIME (MINS)	CYCLE TIME (MINS)	OPERATOR WAGE (PER HR)
Machine A	100	$75,000	30	5	$20
Machine B	100	0	30	5	$20

AUTOMATION TYPE (2 MACHINES)	OPERATOR COST (PER YEAR)	ROI (YEARS)
No Automation	$128,967	N/A
Machine A	$69,350	1.26
Machines A & B	$9,733	0.71

As predicted, your operator cost goes significantly down the more you automate. What's more important is the time it takes to an even ROI. So how long do you want to wait for your automation investment to start making you money?







The financials are clear to repurpose your robot on multiple machines. Depending on how many machines you can automate with one robot, you can increase the timeline of your ROI by 45-75%. If you needed justification for your next robot capital investment, the above should help make that decision easier.

CASE STUDIES

Let's now talk about real-life companies that saw the benefits of robot redeployment using systems like Flexxbotics.

AIM Processing, a custom plastic injection molding company located in Longmont, Colorado, specializes in small plastic parts. Over the past 25 years, they have grown into the market leader and go-to authority in custom molded plastic parts. With 37 presses running 24-7, they complete work for more than 100 companies in various industries throughout the U.S. and around the world.

The quantitative business case for a robot on a single job can be a tough sell when run sizes are short. In our automated facility, a common visitor question is, *"how long do you have to wait to get your money back on one of these?"*. The answer is, *"Forever … if it sits unused! If you DO use it and continue to invest into the applications, you would be surprised how quickly the payback comes in."*

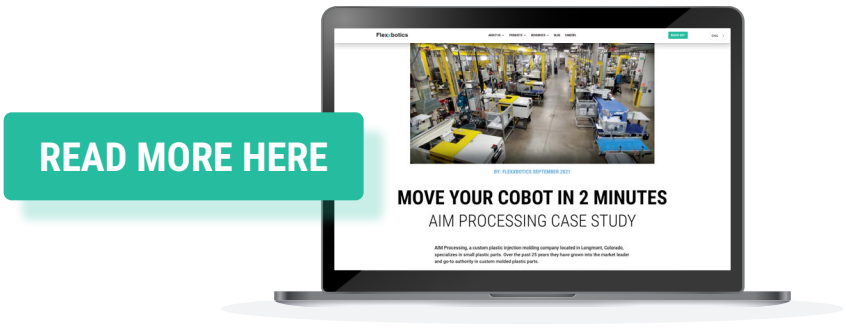
For us, understanding the barriers to automation adoption was the key.

One of the barriers was the time & skill level necessary for redeployment. The move to modularity increased setup complexity in many applications. If the setups were complicated, only the manufacturing engineer would feel confident setting it up. But reteaching positions and waypoints every time was time-consuming and an effort that distracted us from new development. The more applications we developed, the more our manufacturing engineer would become the “setup person” and less of a developer. If we had any hope of getting our money back on our investment, we had to reverse the complexity cycle so that anyone on any shift could redeploy our UR5e.

We contacted our UR5e integrator, In-Position Technologies, to seek redeployment advice, and Seth Leinbach described the Flexx Reference. We trust them and their experience, so we were plugging it in within a week.

We had the upfront time investment to set our positions and waypoints relative to the Flexx Feature – no different than without Flexx Reference. Once it looked like it was working, it was time to test. Teardown a running configuration, move it, set it up again, and hope it starts right up. We moved the cobot just an inch, locked it & updated the Flexx Feature. It worked – accurate to 0.5mm, and it took just 2 minutes!

With this success under our belt, we took it to the next level by adding a second Flexx Feature. One is keyed off our pick-up location. The second is keyed off our drop-off location. The total time to update 2 Flexx Features was only 4 minutes!



PORT ERIE PLASTICS CASE STUDY

Port Erie's Plastics, an injection molding company, located in Northwest Pennsylvania, has been growing rapidly over the past two decades. Port Erie's business requires high adaptability of their manufacturing and automation equipment to adhere to the ever-changing demand of their customers. Different manufacturing jobs have to be set up regularly with increased safety, quality, and speed. One misstep in any area can have substantial consequences for Port Erie Plastic's business. Mike, Automation Engineer for Port Erie Plastics, knew these challenges well and was always looking to improve his job changeover process.

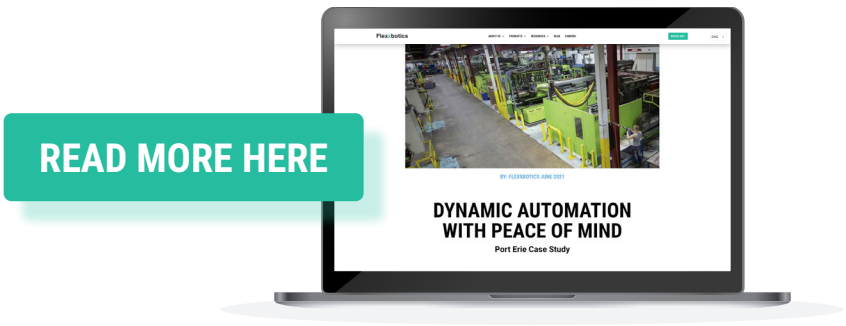
No better scenario displayed the need for adaptability than a recent highly critical job that came across Mike's desk. In 2021, Port Erie Plastics was deemed an essential workplace due in part to a set of products for customers involved with responding to the Covid-19 outbreak. One particular customer had several molds running around the clock trying to meet demand. As a result, the customer required Port Erie to build new molds with increased production capabilities.

Mike now needed to redeploy the Universal Robot (UR) which was running a 2-cavity mold onto the new 4-cavity mold work cell. One of the biggest hurdles

with robot redeployment is the need to accurately set moves and waypoints relative to how the robot was originally programmed. Mike knew, based on the size of his program, touching up each waypoint and move could take days. Therefore, he needed a quick way to offset these moves and waypoints so the robot could quickly execute the job.

Luckily, both of Mike's 2-cavity and 4-cavity machines and his Universal Robots were equipped with Flexxbotic's Flexx Reference solution coupled with mobile carts based on the advice from Ben Mintz, Key Account Manager for Neff Automation. Ben, who has worked on multiple projects with the Flexx Reference, had this to say: *"The Flexx Reference coupled with a mobile cart allows any Universal Robot to easily and efficiently be repurposed anywhere on a manufacturing floor. So it made perfect sense for Mike to integrate this kind of setup for his site."*

Because of the experience Mike had utilizing the Flexx Reference, he responded to questions regarding the timing with a high degree of confidence that it would only be a matter of hours to shut down, move, and reinstall the cell rather than days. The redeployment took under an hour, with the Flexx Reference offset taking only 5 minutes. The redeployment and the job were successful as the heats came upon the press.



Our mission at Flexxbotics is to free your robot from the complexities surrounding a dynamic robotic work cell.
At the core, we are a robotic process improvement company looking to break down the technical barrier needed to make your automation equipment as active as your operators.

We believe in three maxims that drive and influence every product we build:

EVERYONE SHOULD HAVE THE PRIVILEDGE TO OPERATE A ROBOT

EVERY ROBOT SHOULD ALWAYS BE ACTIVE

EVERY ROBOT'S ROI SHOULD ALWAYS BE MET

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