


UPDATE YOUR ROI FORMULA



A white paper outlining how to evaluate collaborative automation in today's volatile business environment

As businesses around the globe navigate the repercussions of COVID-19, automation has emerged as a critical strategy to ensure business continuity. With an unsure economic future, making effective return-on-investment (ROI) calculations has become more important than ever.

Automation project decisions are complex. Deployment risk, operational risk, ongoing maintenance requirements, and worker anxiety must be weighed against the flexibility, scalability, cost avoidance, and occupational health benefits of automation. With all the factors to be considered, typical ROI tools used to make these decisions can feel inadequate.

Traditional ROI and break-even-point analyses are easy to understand but only account for labor cost savings using static, long-term assumptions to measure expected outcomes. In today's volatile business environment, these methods can lead decision-makers to an outcome that is inconsistent with strategic objectives or that is tied to unrealistic expectations of business stability.

The advent of collaborative automation gives manufacturers new opportunities to calculate ROI. These proven quantification methods use operational key performance indicators (KPIs) to help a manufacturer decide how to prioritize automation projects in today's uncertain world.

TODAY'S MANUFACTURING ENVIRONMENT – A “VUCA World”

Volatile, uncertain, complex, and ambiguous (VUCA) environments demand that managers challenge themselves to anticipate and respond to a “VUCA world.” VUCA management often hinges on enterprise-level values that are receptive to and aligned with change awareness and change responsiveness.





The task of preparing a manufacturing enterprise for this new VUCA world is daunting, but one well-served by collaborative automation.

THE RISE OF COLLABORATIVE AUTOMATION IN A VUCA WORLD

In the globalization era, success in volatile VUCA environments was widely understood.

Manufacturers had to reduce costs in order to compete with others who were doing the same. The global marketplace complied with this initiative with low trade barriers and high investment incentives. This led to massive amounts of automation for long-run parts manufacturing, along with off-shoring or outsourcing tasks that could not be automated. Labor moved from manufacturers in high-cost regions to large plants in low-cost regions. Those manufacturers who did not adjust likely did not survive. Over time, these adaptations reduced manufacturing competency in developed markets.

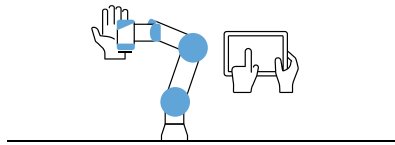
Today, manufacturers are faced with the consequences of those activities, exacerbated by the new realities that borders are not always open and workers cannot always stand in close proximity to each other in large facilities.

For manufacturers to survive and thrive, their objectives are shifting from labor-cost avoidance to retention of skilled labor, quality of product, and business continuity during uncertain times. The task of preparing a manufacturing enterprise for this new VUCA world is daunting, but one well-served by collaborative automation.

COLLABORATIVE AUTOMATION DRIVES NEW ROI MODELS

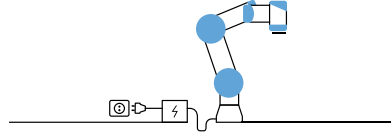
Traditional automation was designed for long-running manufacturing operations with no human workers in proximity. In contrast, collaborative automation was designed with the notion of working “next to” versus “instead of” a human worker. This makes cobots ideal for short-run, variable processes where they can help a human worker complete a task

more efficiently and effectively. This fundamental change requires a new ROI model that is less focused on labor avoidance. Understanding the differences between collaborative and traditional automation is an important basis for this new model.



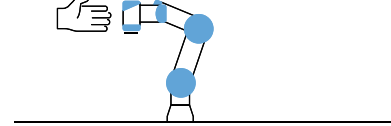
EASY PROGRAMMING

When Universal Robots (UR) delivered the first commercial collaborative robot (“cobot”), it changed the way robots are deployed. Rather than using programming scripts, UR introduced the notion of teaching a robot through physical manipulation of the robotic arm through the workspace. The graphical user interface provides intuitive navigation versus command line prompts, making robot setup and programming possible by those with no prior experience. UR also provides free access to its online academy, with virtual courses that democratize who can become an automation expert.



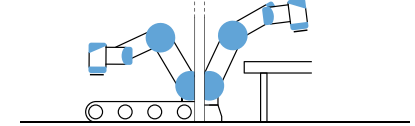
FAST SETUP

This ease of robot teaching leads to fast, easy setup. Due to its hardware design, use of single-phase power, and its overall light-weight profile, setting up a Universal Robots cobot from boxed to ready-to-program generally takes minutes versus hours. In addition, the UR+ open ecosystem for peripheral development has spurred an explosion of development for certified end-effectors, grippers, software, and other building blocks that make integration even easier and more flexible.



SAFE AROUND WORKERS

Traditional automation is designed for strength and speed, which makes it unsafe for a human worker to enter the workspace. Traditional robots are generally deployed within bulky and expensive safety perimeters, using a protective cage or light curtain to protect workers. Collaborative robots, however, are designed to work alongside human workers as they complete light- to medium-duty tasks. UR cobots can detect when the robot or the payload collides with an object or human in its workspace, and react within milliseconds to halt robot movement and avoid injury or damage. This allows a UR cobot to operate without protective fencing after a safety assessment, which can reduce integration costs by as much as 50%.

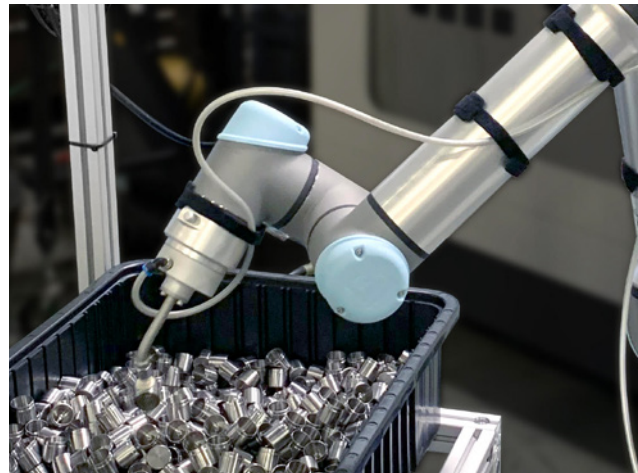


FLEXIBLE AND VERSATILE

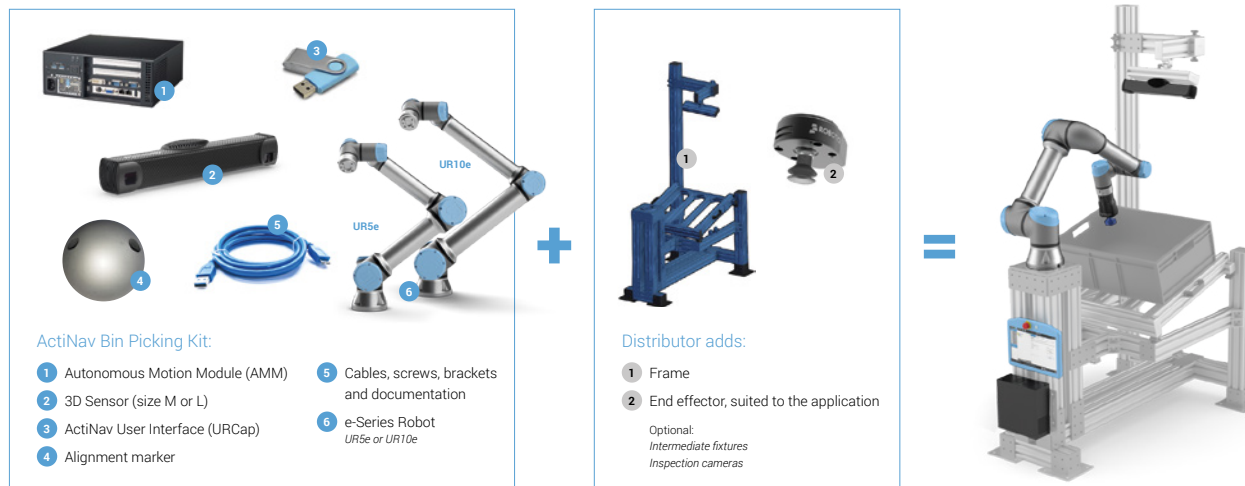
All of these benefits create a robot that is not only easy to set up the first time, but also easy to move from one workstation to the next. With fast setup and limited protective fencing requirements, a UR cobot can be uninstalled, moved to a new work cell, re-installed, and be operational much more quickly than traditional automation. This flexibility maximizes the utility of the investment, giving it a powerful ROI impact..

COLLABORATIVE BIN PICKING EXAMPLE FOR NEW ROI MODEL

The advantages of collaborative automation in a VUCA world can be seen in what has been referred to as the “holy grail” of automation: bin picking. Deploying a robot to pick parts from an unstructured bin and place them with precision on a machine process typically requires complex setup, lengthy programming, and custom-designed hardware elements. The expense and complexity significantly limit the versatility of these cells to be redeployed for another part or process. This provides an ideal example for a new ROI model.



The newly released [ActiNav](#) Autonomous Bin Picking application kit uses technologies from UR+ ecosystem partners to create an automated bin picking work cell that takes advantage of all the benefits of collaborative automation. The combined technologies allow the cobot to detect the orientation of a part in the bin, pick it, and autonomously define its path through the workspace to place the part with precision in the desired machine process. In the entire deployment, the only part-specific element is the CAD file that is uploaded to the robot software. Because of this limited part-specific investment, an ActiNav application kit has tremendous versatility to be cost-effectively re-deployed to new parts or machines.





EVALUATE YOUR COBOT ROI

We can build on the ActiNav example to illustrate methods of quantifying the benefits of collaborative automation. To do this, we'll use a range of operational key performance indicators (KPIs) and a step-by-step approach.

STEP 1: STATE YOUR OPERATIONAL OBJECTIVES

Because the manufacturing landscape has changed significantly, operational KPIs that are focused on cost-down may drive an organization into a dangerous state of no skilled labor, no investment, and an inability to react to a dynamic business environment. Now more than ever, it is important to expand operational objectives past cost-down. Some relevant objectives for your organization could be to enhance business continuity by:

- Optimizing equipment output
- Retaining skilled labor and ensuring their safety
- Enhancing the flexibility of equipment and work cells

Shifting focus to these objectives versus cost-down does not mean that spending will or should significantly increase. To the contrary, organizations that focus on having maximum utility of their equipment and who focus on the wellbeing and retention of their skilled work force can avoid losses and unforeseen costs in a dynamic business environment. The importance of leaning away from cost-down is that their supporting forward-looking analyses often include a set of static assumptions over long periods of time. These are less likely to hold true in today's VUCA world.

STEP 2: USE KPIs TIED TO YOUR OBJECTIVES TO DRIVE INVESTMENT DECISIONS

OVERALL EQUIPMENT EFFECTIVENESS (OEE)

One of the more widely used manufacturing KPIs among the world's top manufacturing enterprises is overall equipment effectiveness, or OEE. OEE is the measure of how well equipment is utilized versus its maximum potential when it is scheduled to run. The benefits of this KPI in today's environment is that it scales with variable loading requirements. That means that if your business demand fluctuates, the KPI follows accordingly and maintains visibility on the "level of goodness" of your manufacturing efficiency. While variations exist, OEE is generally calculated as the product of availability, performance, and quality percentages.

OEE is expressed as a percentage of maximum, where 100% is an equipment cell or process that is always available to run when it is scheduled to, always delivers the maximum units per hour it is designed to, and always produces good parts. These measurements are often combined to form a plant-level OEE measurement. While it varies by industry, typical OEEs can be in the 60% to 70% range, while world-class is 85% and above.



EXAMPLE OEE CALCULATION

An example of an operation where a worker is tending a CNC machine illustrates how a cobot application can be used to improve the OEE of the work cell.

ASSUMPTIONS

- The machine process is scheduled to run for 10 hours per day based on current order volume and delivery commitments for the part = 36,000 scheduled operating seconds per day
- The machine process takes 2 minutes to complete per part and it takes approximately 5 seconds for the machine to reset for a new part to be processed = 125 second cycle time
- $36,000 \div 125 =$ optimal throughput of 288 units per day

OEE FOR A WORKER-TENDED CELL

With this baseline information, we can see how real-world scenarios impact OEE. Assume that within 100 workdays, the CNC machine experienced failures amounting to 10 workdays lost. This results in an availability rate of 90%.

The cell is also tended by a human worker, who is not always perfect at having a new part ready when the machine is reset and ready to process. A human worker has scheduled and unscheduled breaks due to distractions and fatigue that are common in manufacturing jobs. While the machine is ready every 5 seconds, worker

inattentiveness leads to less-than-perfect actual units per hour of 240 versus the perfect utilization of 288. Dividing actual by perfect utilization gives a throughput metric of 83.3%

Finally, let's also assume that the good-part yield rate is dependent on how well the part is placed on the spindle. Generally, a human worker gets this right 95% of the time due to fatigue and distraction.

OEE WITH COBOT DEPLOYMENT

Now let's look at how to size the impact of an automation project to OEE by using the ActiNav example.

Unlike the human tending the machine, the cobot deployment with ActiNav is more often ready to tend a new part, without breaks or distraction. In this scenario, it improves the average cycle time experienced from 150 seconds with a human to 135 seconds with the cobot application. This increases daily throughput to 267 parts per day or 92.6% maximum throughput. Finally, the cobot can operate without fatigue and properly place the part on the spindle more often, producing a 98% good part yield rate.

As shown below, the cobot deployment on the existing cell increases the OEE of this machine process by 10.4%, which is significant.

Overall Equipment Effectiveness Calculation: Worker-Tended Cell vs. Cobot Deployment

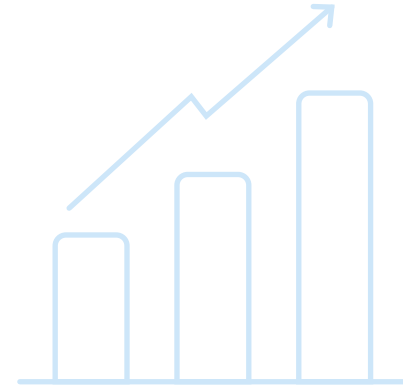
Worker-tended cell:	Availability (90.0%)	×	Throughput (83.3%)	×	Yield (95.0%)	=	OEE (71.3%)
Cobot deployment:	Availability (90.0%)	×	Throughput (92.6%)	×	Yield (98.0%)	=	OEE (81.7%)

The cobot deployment on the existing cell increased the OEE of this machine process by 10.4%, which is significant.

USING OEE TO PRIORITIZE INVESTMENTS

Once organizations adopt OEE as the way to guide improvement programs, they will generally earmark a capital budget for investments in OEE improvement. This dollar amount is allocated towards projects that will deliver the most OEE point improvements per dollar invested, as illustrated in the table below.

Here, a manufacturing enterprise would select low- to medium-risk projects that deliver the most OEE improvement for the \$320K they have budgeted. This method ensures that investments are made that will ultimately improve the availability, throughput, and quality of a manufacturing floor, aligning with the strategic goals of the company.



Manufacturers can analyze and choose low- to medium-risk projects that deliver the most OEE improvement for the budget.

PRIORITIZE INVESTMENTS USING OEE

	Budget	\$320			
Project	Investment (\$K)	OEE Improvement	OEE/\$1K	Deployment Risk	Cumulative Investment
ActiNav: CNC 1	\$100	10.4%	0.104%	Low	\$100
Custom Automation CNC	\$120	12.0%	0.100%	Med	\$220
ActiNav: CNC 2	\$98	9.3%	0.095%	Low	\$318
New Conveyers	\$62	4.1%	0.066%	Low	\$380
CNC 2 Upgrade	\$27	1.5%	0.056%	High	\$407
CNC 1 Upgrade	\$30	1.5%	0.050%	Low	\$437

OVERALL LABOR EFFECTIVENESS (OLE)

Overall labor effectiveness (OLE) takes the concept of OEE and pivots it towards employees. It focuses an organization on decisions that make the best use of its highest-performing personnel while still using the same variables of availability, throughput, and quality.

EXAMPLE OF OLE CALCULATION

Instead of looking at scheduled run time of the equipment, the measure of availability for OLE is the percent of time an employee actually works versus scheduled work time.

ASSUMPTIONS

- Four machine operators scheduled to work 8-hour shifts with 30-minute scheduled breaks
- During a shift, process fatigue and distraction causes them to take an additional 30 minutes each of unscheduled breaks
- 4 workers X 30 minutes each results in 120 minutes of lost work time and an availability measurement of 93%

Team of Workers Availability Example	# of Workers	Minutes	Total Team Minutes
Shift Time	4	480	1,920
Sched Break	4	-30	-120
Sched Work Time		450	1,800
Unscheduled Breaks	4	-30	-120
Actual Availability			1,680
Availability %			93%

OLE CALCULATION FOR TEAM OF WORKERS

Using the method in the OEE example, the processes manned by the team of workers is calculated to have a standard production rate of 1,150 units per day, but the team delivers 990 units instead. One of the workers is experienced and has high attention to detail, so she mounts parts more consistently and finds defects before they are shipped to the next process. Her good-part delivery rate is 99.5%. The rest of the team is less experienced, producing a blended 97% good-part rate for the entire team.

OLE CALCULATION FOR AUTOMATED CELL

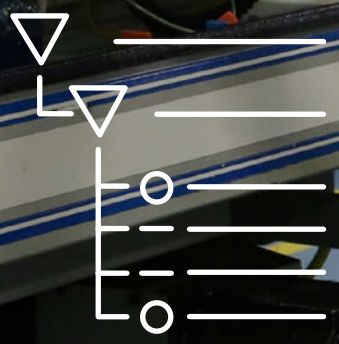
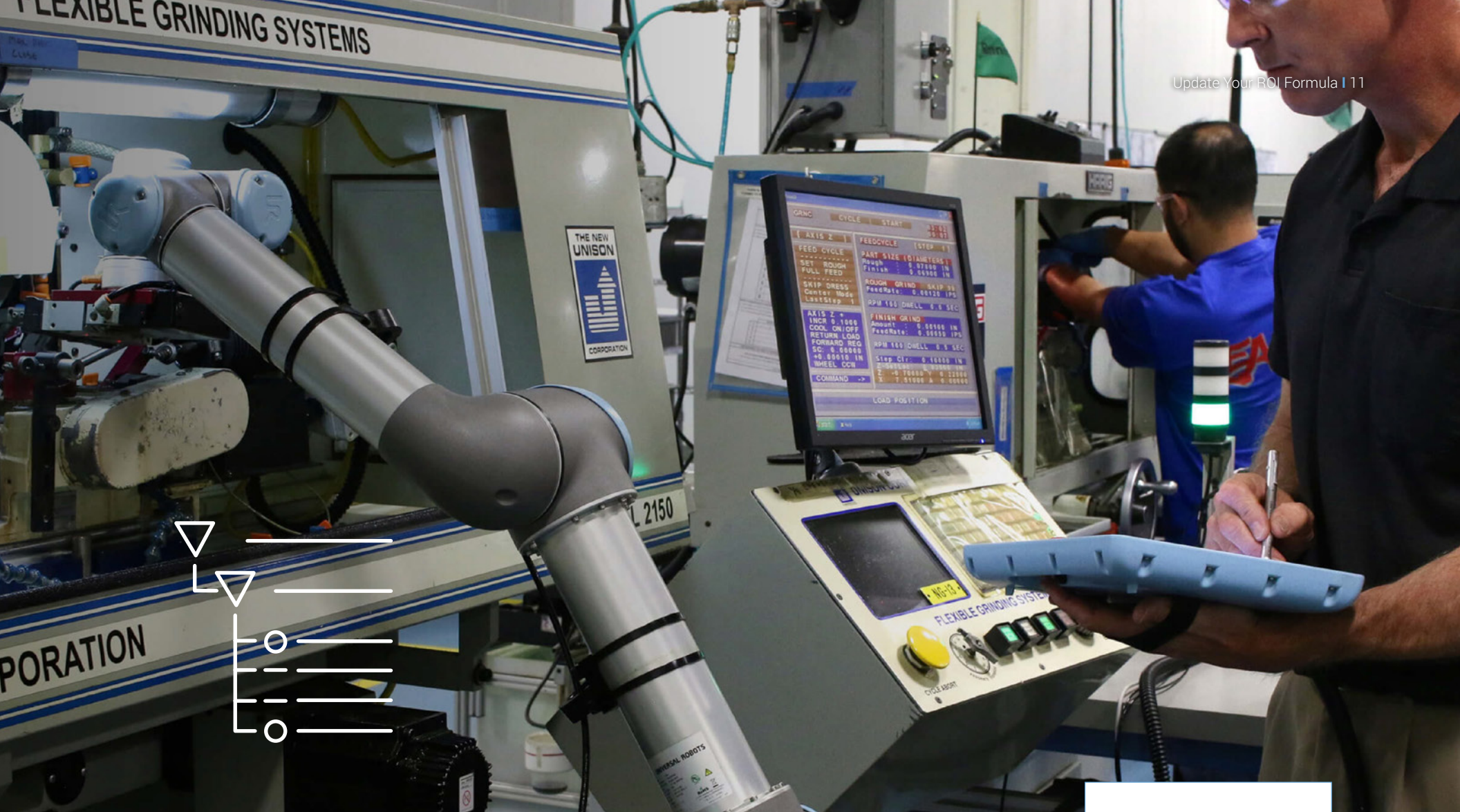
Again, we can use the ActiNav Autonomous Bin Picking application as a project to improve OLE.

Assume the plan is to automate the four CNC machines now tended by the team with ActiNav deployments. Rather than have one worker per machine, the intent is to have the highest-experienced member of the team supervise the cobot deployments for quality and to keep them fed with parts. The other three workers are moved to other value-add processes in the plant.

Since the single worker is not performing the repetitive task of sitting at the machine while loading and unloading the machine, she suffers less fatigue and only takes 15 minutes of unscheduled break, versus the 30 minutes prior. This improves the “team” availability rate to 97%, as illustrated here:

Automation + Worker Availability Example	# of Workers	Minutes	Total Team Minutes
Shift Time	1	480	480
Sched Break	1	-30	-30
Sched Work Time		450	450
Unscheduled Breaks	1	-15	-15
Actual Availability			435
Availability %			97%

Due to the processes being automated, the breaks she takes have less of an impact on units delivered per shift, which improves the units per day throughput to 90% of target. Finally, leaving the most experienced worker to oversee the process has resulted in the much higher quality rate associated with her performance to expand to the entire process, resulting in an overall good product yield rate of 99.5%.



Overall Labor Effectiveness Calculator: Team of workers vs. Automated cell

Team of workers: Availability (93.0%) × Throughput (86.1%) × Yield (97.0%) = OLE (77.7%)

Automated cell Availability (97.0%) × Throughput (90.0%) × Yield (99.5%) = OLE (86.9%)

In this scenario, the OLE of the workers has improved by 9.2% by deploying the automation project with ActiNav and moving the other three workers out of this process.

OLE: THE SUBTLE DIFFERENCE

While OLE may seem like a round-about way of arriving at the same outcome as OEE, the difference is that it puts a focus on positioning the right people in the right process. In this example, the three people who were moved off this process should have been deployed to functions that improved the OLE of their new process team. For example, one of them may have been moved to keep assembly workers stocked with components so that the skilled assemblers could stay at their stations longer without having to lose time fetching parts. Another may have been moved to perform final inspection before packaging, improving the quality of that team.

This KPI shows its value when it is expanded to calculate OLE at the plant or product-line level. Here you can see the true impact of absenteeism, performance, and attention to quality of an organization, and drive it toward improvement.

ABSENTEEISM AND LABOR WELLBEING

OLE is well-complemented with KPIs that track and measure employee wellbeing, fulfillment, and engagement, such as absentee rate, retention rate, and total cost of training. Together, these metrics help build the entire picture of how well a manufacturing enterprise can utilize and retain its best human assets. Studies show that engaged workers are more productive. While it is difficult to predict the benefits that automation will have on absenteeism or employee retention, movement in these measures should be tracked after deployment. Marking improvement through automation deployment could serve as the basis to help select and prioritize future projects.



CONSIDER NEW KPIS FOR FLEXIBILITY

As an enterprise’s strategic objectives change, its KPIs must be defined to achieve that objective. For example, an organization may decide that it is critically important to have a flexible manufacturing capability. That may lead to a goal of a larger proportion of multi-functional equipment cells versus single-purpose equipment cells.

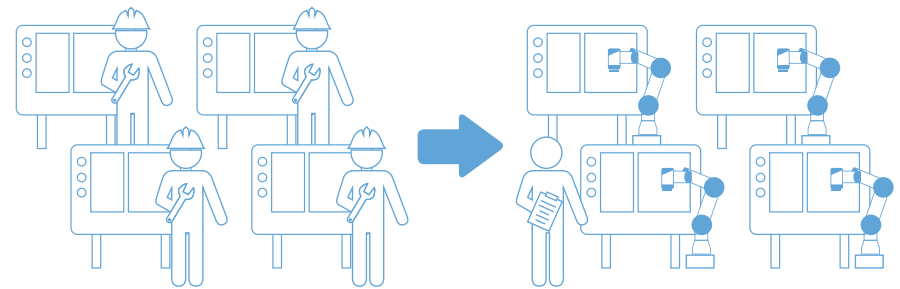
One way they may choose to measure this is by calculating the total **asset value of single-product-use machinery** as a percent of total plant equipment asset value. They could then drive this KPI downward by retiring, modifying, or replacing single-product machinery. They may even abandon low-profit product lines where there is high risk of idle capital equipment in the event of order volatility.

Another approach would be to look at the same concept, but with workers versus equipment. To do this, divide the **total wage spend of single-competency workers** by the total wages of the plant or team. Driving this number downward through cross-functional training or strategic retention programs of multi-skilled laborers positions the company to weather more volatile environments with a more flexible and re-deployable team.

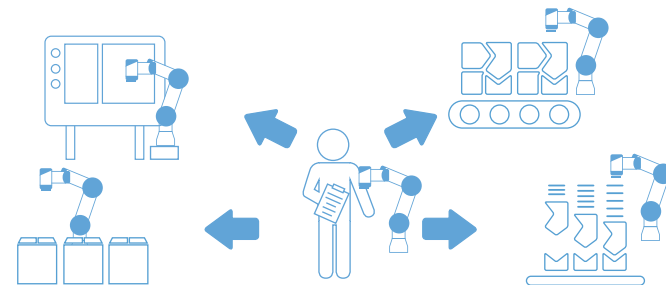
A third approach to enhancing flexibility is how quickly an enterprise or team can scale production up or down with business conditions. One KPI to help measure and drive this flexibility is **marginal units per worker**, which is the number of additional or fewer units that can be produced with the addition or removal of a single worker.

FLEXIBILITY KPIS IN ACTION

For these KPIs, let’s again consider the ActiNav example, where we go from four manned CNC machines to four automated CNC machine-tending applications and a single process expert overseeing the process.



The ActiNav equipment is multi-purpose, as it can be deployed to pick different parts at different machines with minimal changeover time and investment. It thus reduces the percentage of single-product-use equipment. The four machine operators are replaced with a single process expert, who is also trained in cobot teaching, operation, and troubleshooting. This increases the percentage of multi-skilled labor. Finally, the notion that a single person can now tend multiple machines greatly increases the scalability of the operation, improving marginal units per worker KPI.



STEP 3: REGULARLY REVIEW THE IMPACT OF PAST INVESTMENTS

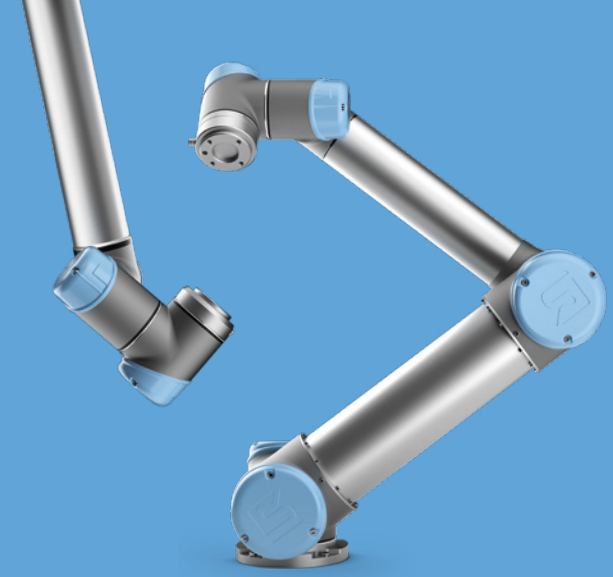
The third and probably most important step to using KPIs for investment decisions is to have a regular and healthy look back on previous investments. With traditional cash-return ROI methods, the old ROI calculation is often long forgotten by the time the payback period ever comes due. People rarely look back to see if they achieved what they set out to accomplish. Having investment decisions based on operational KPIs that are measured and used every day is a much more reliable way to ensure you are receiving your desired return on investment. If a new piece of equipment is supposed to deliver a 5% OEE improvement when it is deployed, you should be able to measure this shortly after its deployment, versus having to wait months or years for the payback period to occur.



THE RIGHT ROI MODEL FOR A CHANGING WORLD

For clarity, ROI and payback-period analyses are not entirely defunct. Going into a new business line, for example, requires a clear understanding of when the income against investment is going to be profitable. Capital budgeting and investment analysis are essential to help decide which of several business opportunities to pursue. This approach is less applicable to operational improvement investments, however.

Manufacturers who are looking to optimize their existing operations in today's VUCA world are better served by setting aside an ear-marked (and adjustable) improvement budget and to prioritize capital investments that deliver the most impact with the resources allocated. This behavior supports the notion of continuous improvement in a world of continuous change. Manufacturers who use traditional ROI tools to justify their improvement projects risk more by using a model that can cause enterprises to become defensive and hesitant in volatile times. After all, the manufacturing world is changing fast and those who can change at the same pace will ultimately be best-positioned to win.



Universal Robots was co-founded in 2005 by the company's CTO, Esben Østergaard, who wanted to make robot technology accessible to all by developing small, user-friendly, reasonably priced, flexible industrial robots that are safe to work with. Since the first robot was launched in 2008, the company has experienced considerable growth with the user-friendly robots now sold in more than 50 countries worldwide.

The company, which is a part of Teradyne Inc., is headquartered in Odense, Denmark, and has subsidiaries and regional offices in the USA, Spain, Germany, Italy, Czech Republic, China, Singapore, India, Japan, Taiwan and South Korea.

For more information, please visit [universal-robots.com](https://www.universal-robots.com)

