COMMON CONSIDERATIONS INTEGRATING **ROBOTICS IN** MANUFACTURING

By Dan Sula and L. John Shipley, P.E., CAP

800-852-0994
pattiengineering.com
info@pattiengineering.com

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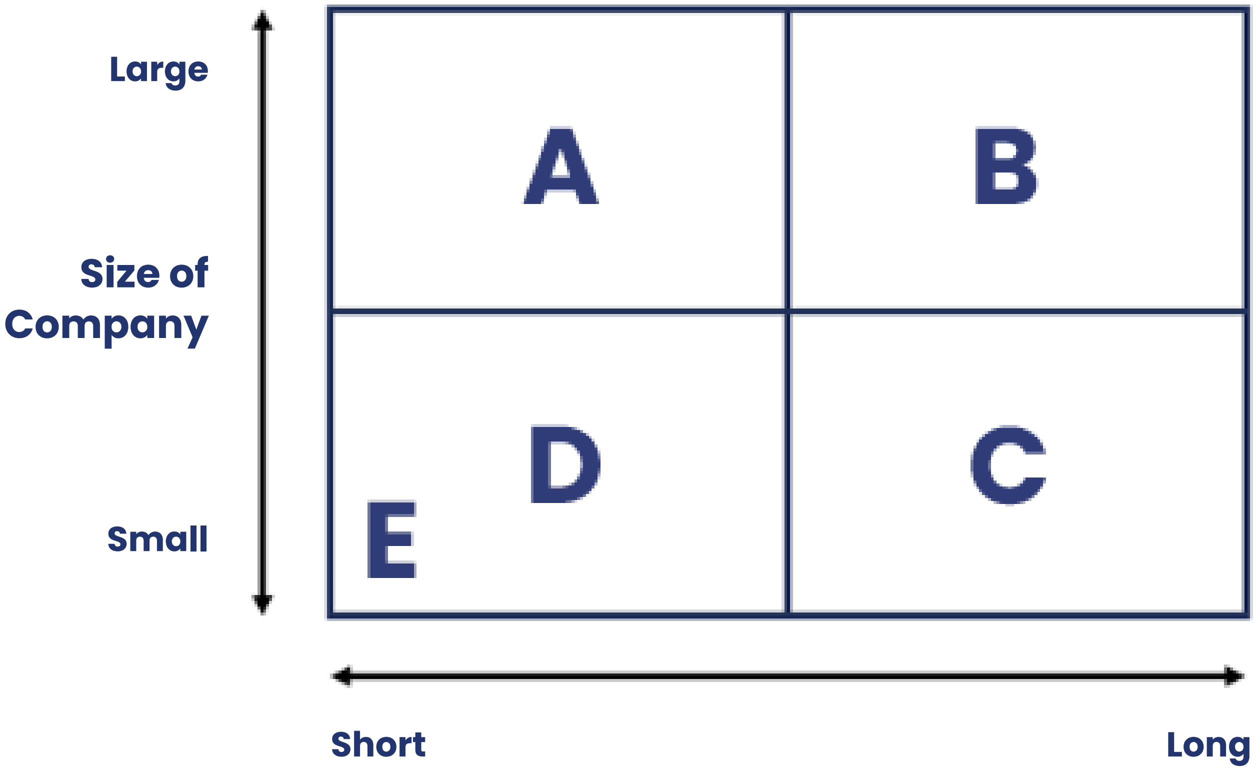


Figure A: Company's History of Automating

Introduction

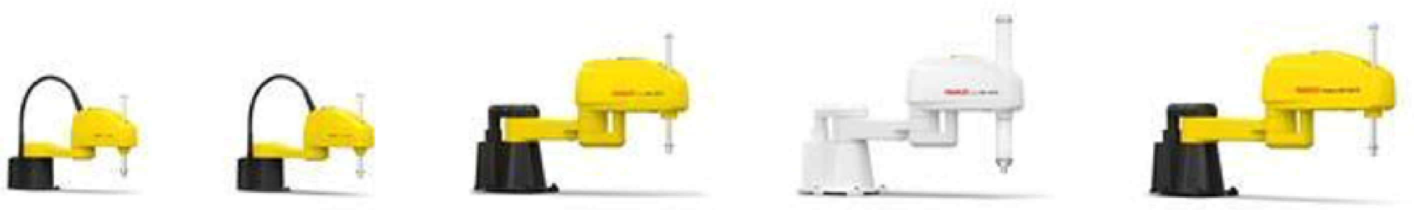
This eBook focuses on the companies that fall within the **D-E range** of the figure A. These are small-to mid-size companies with limited to no background in including robotics in their workflow. This eBook serves as an introductory guide, with a focus on answering the common questions that arise from those who are new to robotics integration in the manufacturing environment. The selected questions and their answers come from robotics integrators with decades of experience in the field.

Background Information

In today's manufacturing environment, common goals include maximizing throughput of quality products with an eye on safety and with sufficient human labor to consistently complete the work. Often, some of these goals can be achieved by simply streamlining a process - breaking something complex down into a linearized flow through the manufacturing floor. A linearized flow simplifies the process as much as possible, reducing the opportunity for different quality mistakes to occur.

However, linearizing a manufacturing process only offers a certain amount of improvement, and may require more space, time, or resources to complete than might be available to the plant manager.

Manufacturing environments with limited resources are more common than their counterparts, and plant managers are often faced with the difficult task of maintaining an assembly process with inherent weaknesses. While a fully-optimized manufacturing line maximizing automation and robotics might be a long-term goal, in reality, robots are well suited to answering the problems that arise in these more limited circumstances. In a limited environment, the introduction of a robot can enable those initial goals discussed to still be met - reduction of unskilled human labor, substantial throughput gains, better consistency and quality of product, and a safer work environment.



Collection of FANUC SCARA robots

How are Robotics Used in Manufacturing Today?

At first glance, robots are often considered for their **potential to increase throughput** compared to human labor. However, there are several additional reasons to consider adding a robot to a workflow:

- **Difficulty in finding human operators** to do the work. The best-suited work for a robot is often the same work that people do not want to do at all. The work can be repetitive, fatiguing, and generally dull. The addition of a robot to complete the less mindful portions of a task results in an improvement in production goals, but also improves the work experience of the human labor tending the area.

- **Dirty, poor-quality work environments.** Robots can be used to complete work in areas of a manufacturing line that are somewhat of a health hazard for humans to be working in all day long.

- **Less scrap due to better consistency** of work.

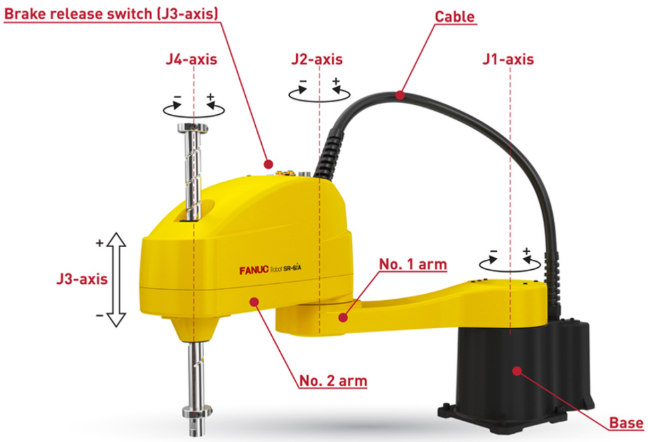
- **Reduction of worker health liability concerns.** Robots can do work that has previously resulted in health issues for operators (for example, back problems or carpal tunnel syndrome).

- **Greater utilization of machines.** Because a robot can generally do work faster than human counterparts, the machines with which they interact increase in their general utilization, resulting in greater throughput.

Common Robotics Terms

Axis: Each robot joint is called an axis, or a degree of freedom. The more axes the robot has, the more sophisticated the movements it can complete.

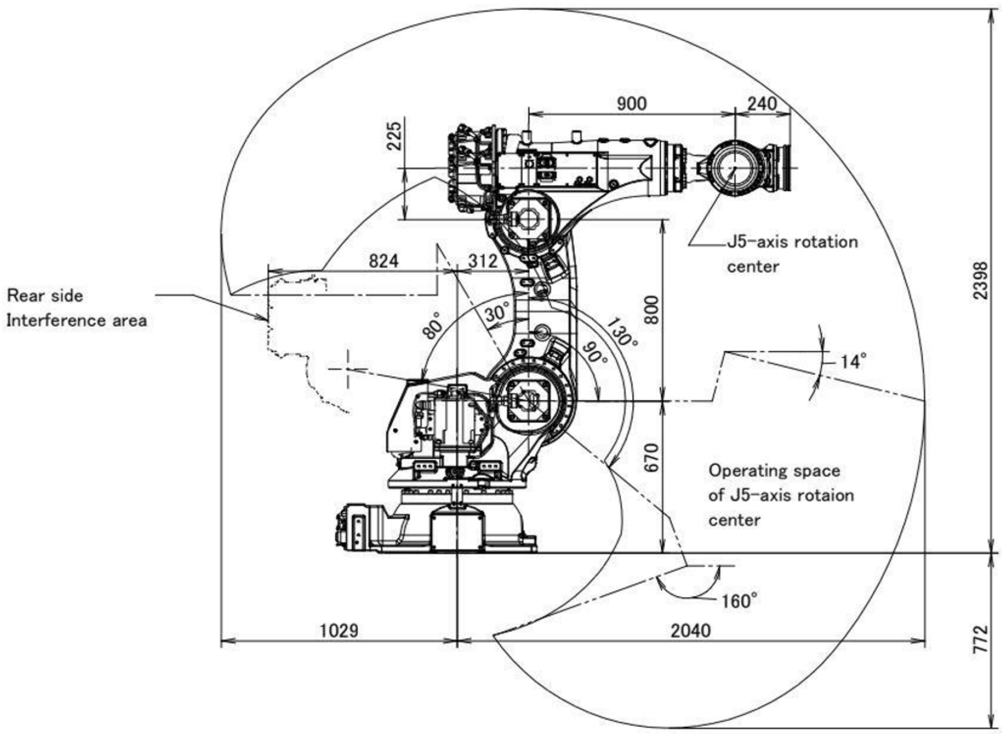
Controller: One of the main components that make up a robot, the controller executes the robot's application programming. Though not always, the controller is often detached from the mechanical unit allowing the controller to be safely accessible to maintenance personnel outside of the envelope.



FANUC SR-6iA robot graphic showing the 4-Axis manipulator

FANUC R-30iB Plus A-Cabinet controller and standard teach pendant

Envelope: The working envelope describes total reach in all directions and dimensions of space.



FANUC R-2000iC industrial robot six axes of rotation; maximum load capacity at wrist: 190 kg; maximum reach: 2040 mm. Diagram on the right indicates the axes of rotation for each joint, as well as the working envelope

FANUC CR-7iA/L cobot inspecting a bumper. EOAT includes 2D iRVision camera and lighting

Gripper: A gripper is the equivalent of the robot's "hand." It is a type of **end-of-arm tooling** (EOAT), which is the portion of the robot that interacts with the parts. There are a large variety of types of EOAT to choose from, depending on the needs of the application.

Ingress Protection (IP) Rating: This rating system is used to classify a device's resistance to environmental assaults. The first number of the rating indicates its resistance to dust/solids in the air. The second number of the rating indicates its resistance to water. As an example, an **IP67-rated robot** is rated for some dust protection and temporary water immersion.

Foundry-Rated Robot: Made of specialized heat-resistant steel and component sealing, these robots are capable of working in the harsh environments found in foundries, especially at high temperatures.

Food Grade-Rated Robot: A food-grade robot is a higher IP-rated robot designed for food processing applications. Its exterior is made of a USDA-approved finish. Complete sealing ensures that the seams do not harbor bacteria and it is built to withstand frequent washing.

FANUC LR Mate – 200iD/7WP R-2000iC/210WE wash down (waterproof) robots

Mechanical Unit: One of the main components that make up a robot, the mechanical unit is the physical part of the robot that moves the gripper and payload per a robotic application executed by the robot controller. The mechanical unit is typically comprised of servo motors, gear trains, and the housings linking them. The mechanical unit determines the robot's working envelope.

Payload: The payload consists of what the robot is doing or manipulating. For material handling applications, the payload might be a production part, a pallet, or something similar. Normally, robotic system designers look at payload as a set of weights, inertia, and external reaction forces applied to the robot during the execution of an application. The mass of the gripper is generally included in the payload weight. Most robot manufacturers publish the maximum payload for their robots. A best practice is for robotic system designers to add safety factors to these maximum payload ratings to ensure the appropriateness of the selected robot for the intended application.

Robot Transfer Unit (RTU): There are robot applications that require the robot to be able to move the entire mechanical unit from one position to another, essentially extending the reach of the robot. An RTU, sometimes referred to as a 7th axis or linear rail, allows the mechanical unit to move via servo control within the application programming giving greater application flexibility.

FANUC Tablet Teach Pendant

Teach Pendant: Though not used with all robots, a teach pendant is a common human interface attached to the robot controller which allows qualified operators and maintenance personnel to interact with the robot during application setup or while the robot is functioning. The teach pendant is typically attached to the robot controller and is tethered on a long cable to allow the operator to enter the robot's work envelope during periods of setup or maintenance.

FANUC Food Grade DR-3iB robot packing cookies with vacuum EOAT, 2D iRVision and line tracking

Two Major Types of Robots - Industrial and Collaborative

This section of the eBook is provided to give the reader a high-level background on the two major types of robots in use. In reality, robot types, particularly industrial robot types, are vast and varied, and beyond the scope of this eBook.

In the world of industrial robotics, there are two broad types of robots: the traditional, **industrial robot**, as well as the newer, **collaborative robot** (nicknamed the "cobot"). Both are used to reduce labor costs and scrap and increase throughput, quality, and safety. However, each type has its own best-suited applications and work environments.

What is an Industrial Robot?

Industrial robots are a mature technology that has been implemented in the manufacturing environment dating back to the automotive industry's early adopters in the 1960s for use on assembly lines. By the 1980s, robots were commonplace in automotive factories, and by the 1990s, industrial robots were being used across a wide variety of industries and applications.

Work Environment

Industrial robots are used to complete repetitive or dangerous tasks in a safety fenced-off area. Traditionally, the fencing for industrial robots is a physical barrier, but newer sensor technology has allowed "virtual fences" to become a viable option under certain circumstances. This is further discussed in an earlier blog post titled, "Uncaging Your Industrial Robots."

Because they are sequestered and can generally work uninterrupted, industrial robots have a higher throughput potential than other robot types. They come in all shapes and sizes, and can be selected for a large variety of payloads. Common applications of industrial robots include:

- **Welding** - can include otherwise difficult materials such as aluminum and stainless steel
- **Palletizing/Depalletizing** - movement of product onto or off of a pallet
- **Assembly** - efficient assembly of components
- **Painting** - application of sprays
- **Pick and Place** - movement of parts from one location to another
- **Inspection** - selected movement of a subset of parts for further review

FANUC P-250iB/15 robot painting automotive bumpers

FANUC M-410iC robot with vacuum EOAT palletizing boxes

Programming

Industrial robot programming is typically done using a handheld device such as a teach pendant or via computer programming. In addition, the use of simulation tools has both simplified the process of programming an industrial robot as well as helped uncover potential design stress points. The topic of industrial robot simulation tools is discussed in further detail later in this eBook.

What is a Collaborative Robot (Cobot)?

Collection of some FANUC collaborative robots

In the past decade, the dramatic evolution of sensor technology has given rise to a new type of robot, the collaborative robot (cobot). Equipped with advanced environment sensors, cobots are designed to work in close proximity to people in a shared workspace.

Close Proximity to Humans

Cobots are able to monitor their working environment and modulate their speeds as needed when a human is nearby. This feature offers the cobot enormous flexibility for applications to which the traditional industrial robot is not suited. A slower robot presents a lower safety hazard to nearby personnel.

Ease of Programming

The cobot has also been developed for ease of implementation. Cobot programming can be as simple as leading it through a path while recording to teach it the motions needed for its intended application. This has reduced the need to have an experienced engineer on staff to support the cobot.

Cobot Work Environment

In settings without sufficient room to set up the guarding and caging needed for industrial robots, a cobot can be an appropriate solution. A cobot and a human can work side by side, or even work together on the same difficult assembly where extra “hands” (robot support) can make the work much easier for the operator.

CR-35iA collaborative robot - six axes of rotation; 35 kg payload; maximum reach: 1813 mm

Because cobots are designed to work in the vicinity of humans, they do not operate as quickly as their industrial counterparts. Their speed is reduced to a safe collaborative mode speed limit when a safety area scanner detects a human nearby. The cobot will stop if the onboard force sensors detect an unexpected contact while moving through its path. While operating speeds can increase once they are alone, a cobot's maximum working speed is never as fast as that of an industrial robot. As an example, FANUC Robotics publishes a safe collaborative mode speed limit for CRX collaborative robots moving in collaborative mode of 1,000 mm/s. Actual maximum safe collaborative mode speed limits must be determined by a safety risk assessment.

Cobots are also more limited in their lifting capabilities, maxing out at 50 kg loads. This is largely due to the force monitoring being continuously performed by cobots. By minimizing the amount of force that cobots can exert, safety hazards to personnel are reduced.

In addition, cobots are not as robust as industrial robots. They are not as well sealed from environmental contaminants (dust, dirt, water, etc.) as they are optimized for working in the vicinity of humans.

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Chapter Two

Essential Considerations when Implementing a Robotic Solution

This section of the eBook addresses common questions by those who are new to robotics and interested in implementing them in their workflow. While many considerations are application-specific, the general discussion of each point will help the newcomer address the key aspects of implementing a robotic system.

Designing the Right System

Robotics versus Other Automation Approaches

Robots are particularly suited to applications that answer "yes" to the following questions:

- Is it dangerous for an operator to complete due to high likelihood of potential accident/injury (i.e. heavy lifting, finger injuries)?
- Does it happen in a poor human working environment (i.e. extreme temperature, exposure to explosive gases, poisonous dust or other chemicals)?
- Is the task particularly dull?
- Is the motion of the task reasonably simple?

FANUC painter robots with intrinsically safe manipulators

Sometimes a different automation solution may be more appropriate to solve the problem being addressed. For more common applications, there may already be "off-the-shelf" solutions that can be purchased. As an example, for the application of unloading injection molding machines, there are already several systems in the marketplace that have been designed to complete this task. Therefore, recreating a custom solution with a robot is likely not cost effective.

Knowledge of marketplace solutions can be found by discussion with a system integrator. They may have relevant experience from prior exposure to different projects with diverse clientele. Attending a trade show of different OEMs showcasing their products is another way to become familiar with current marketplace solutions.

Robot Interaction with Production Parts and Processes

Robots typically interact with parts or processes at the end of their arm, via the selected EOAT. Some examples include basic and magnetic grippers, welding torches, force sensors, torque sensors, and vacuum suction cups. They can be powered via electricity, hydraulics, or pneumatics depending on the application.

FANUC CRX-10iA sanding a cabinet door with a pneumatic spindle EOAT

Selecting Between a Collaborative and Industrial Robot

FANUC CR-15iA collaborative robot; maximum load capacity at wrist of 15kg, maximum reach of 1441 mm

FANUC M10iD-12 industrial robot; maximum load capacity at wrist of 12kg, maximum reach of 1441 mm

The decision to implement a collaborative or traditional industrial robot largely depends on the nature of the environment in which it has to work. Some considerations in the decision are as follows:

1. Safety Fencing Requirements
A cobot is often the best choice for an environment where a human will be in close proximity on a regular basis. However, while a cobot removes the space requirements for fencing and guarding, ensuring a safe work environment is still required. Since humans are capable of interacting with a robot in nearly infinite ways, it can be challenging to truly ensure that all scenarios have been considered in the cobot's vicinity. Therefore, any robotic system that can be implemented with industrial robots rather than cobots will be inherently safer.

2. Speed and Risk Considerations
If an industrial robot can be placed to do the required work, it is most often the best overall solution. Human risk is reduced (discussed above), and furthermore, the robot can generally work at faster speeds with better throughput, cycle time, and fewer rejects. Machine utilization will generally be higher because the robot can work at its full speed generally uninterrupted.

3. Dual Application Requirements
Cobots can be the right choice in the event that the robot will split its time in different locations. Due to their reduced guarding requirements, cobots are simpler to move from one location to another.

4. Payload and Cycle Time
Cobots are generally smaller in size and designed for handling smaller payloads at slower speeds and cycle times. As a result, they require less special work environment setup. If a heavy payload or long reach is involved in the application, an industrial robot is most often best suited.

5. Electrical
Depending on the application, the electrical voltage at the location may limit choices. Some cobots can operate on 110V AC, and therefore may be the right choice should the factory not wish to add higher voltage to their facility.

6. Grip Force Requirement
Some cobots are limited to only the use of electric grippers. Pneumatic grippers are generally less costly, handle higher grip forces and are typically more common on industrial robots. Therefore, depending on the application and budget, an industrial robot may be the best choice.

7. Cost versus Payload
For the same payload, cobots are generally more expensive than industrial robots. While they are becoming increasingly popular, they remain a newer addition to robotic technology, still occupying a somewhat niche market. They incorporate more safety features and sensing technology, a more user-friendly programming interface, and greater flexibility of use. These features all add to their cost when compared to their industrial robot counterparts.

FANUC CRX-20iA cobot loading and unloading a machine tool with a collaborative electric gripper

Robot Operating Conditions

- **Ambient Temperature**

General operating temperatures for robots are 0 to 45 degrees Celsius. FANUC's Roboguide simulation software allows a user to specify the ambient room temperature and it will determine if the robot will overheat for its particular application.

- **Moisture and Humidity**

Resistance to environmental humidity is addressed in the robot's ingress protection (IP) rating. The second digit of the IP rating specifies a particular robot's resistance to water. The numbers vary from 0 (no special water protection) to 9 (rated to work in high pressure and temperature water jets).

- **Acidic and Alkaline Environments**

Food-grade robots (IP rating of 67 or higher) are built to handle acidic or alkaline working environments and frequent washing.

- **Payload**

Industrial robots are available to carry payloads from 0.5kg to 2300kg. Cobots have a smaller payload range of 3kg to 50kg.

FANUC M-1iA/0.5S with a 0.5 kg (1.1 lb) payload

FANUC M-2000iA/2300 with a 2,300 kg (5,060 lb) payload

- **Handling Multiple Types of Parts**

It's not unusual for a robotic solution to interact with several different sizes/types of parts. Robots can also be redeployed to different products or different product lines, should processes change. To do so, the EOAT may need to be changed to address a different type of part and the robot will need to be reprogrammed. The new application should be fully evaluated to ensure the reapplication of the robot is indeed a good fit and meets applicable safety guidelines. In some cases, the same robot may handle multiple parts utilizing a tool changer to change the EOATs designed for the different parts.

Other Design Considerations

- **Utilities**

Depending on the nature of the project, additional electrical service or compressed air may be required to support the robotic solution.

- **Floor Strengthening**

The payload, the inertia (mass) of the robot, and its required accelerations can demand a stronger subfloor with associated padding to properly support the system. Without proper flooring in place, it's entirely possible for a robot to move too fast with too large of a payload at too far of a distance from its center (large moment of inertia) and rip out the floor and fall over.

- **Environmental Isolation**

Sometimes the robot system must be designed to work inside an explosive environment such as paint booths, airbag assembly, or in National Electric Code-defined hazardous locations. In these cases, the robot systems are generally kept to low voltages and have negative pressure on the mechanical unit to minimize potential sparks.

Putting it all Together – Determining the Best-Suited Robot

The numbered points below serve as an overall guide in the robotic design process.
They will help guide the reader to the right type of robot for their particular application.

1. Identify the primary goals for the robotic application. Some examples:

- Reduce labor
- Improve quality
- Improve throughput / reduce cycle time
- Improve overall equipment efficiency (OEE)
- Reduce injury
- Other (specify)

2. Assess the environment

- Very little floor space with many people in close quarters:
  - Consider cobot

- Dusty, dirty, wet, explosive, extreme temperatures (hot/cold):
  - Foundry rated, intrinsically safe rated, IP67 rated

- Cleanroom or food-grade environment:
  - Food-grade rated

3. Determine motion complexity

- Is complex orientation required?

Yes: → 6-axis robot required
No: → Proceed to the next step

4. Evaluate envelope and part size

- Is there a long envelope or large part to process?

Yes: → Consider an additional part positioner OR
→ 7th axis robot transfer unit
(a linear guide that allows a robot to move along a particular length)
→ Consider an additional positioner for rotating parts

FANUC M-710iC/70T top loader robot doing machine tending

5. Assess part weight handling

- Determine the weight of the heaviest parts:
    - Specify a payload at least three times the weight of the heaviest part
    - Account for the gripper's weight
    - Include a 50% safety factor

6. Specify robot reach

- Estimate the longest move
- Add a 50% safety factor
- Identify where the envelope is needed most

7. Select robot mounting type

- Floor
- Floor with robot transfer unit (RTU) for further movement along floor
- Rack - reaching downwards from a high platform
- Wall - reaching from side
- Inverted or ceiling - hanging/reaching downwards

Guidance Through the Design Process

Finding a trusted advisor, an expert in the field of robotics integration, is foundational to the process for those without sufficient experience. Suppliers with knowledge in the field will be able to offer insight. Sometimes a manufacturing manager will visit similar operations at different facilities to obtain ideas for solving the defined problem. A robotics integrator can be a key resource to ensuring a successful project implementation as they have a broad range of experience in adding robots to a workflow.

Consider an Engineering Study

If the defined problem is particularly unique in nature, it can be highly beneficial to obtain an engineering study from subject matter experts. These individuals will spend time and resources fully defining the problem. They will consider multiple options for a solution, leveraging their own expertise and prior experience to do so. As a result, an engineering study dramatically reduces the risk of the project. Some robotic integrators will often complete an engineering study and put the cost of it towards the implementation of the solution - a deposit of sorts.

Preparing for Installation Downtime

Downtime associated with a project's implementation is unique and depends on the nature of the project. It can be minimized by completing as much of the implementation process as possible prior to installation.

For some projects, downtime can be as minimal as a few hours. This can be particularly true for placing cobots within a workflow as they are designed for ease of implementation and simple programming. For example, if a cobot is being brought in to do human-sized work that can be done with parallel pinching grippers, or a vacuum gripper, then the cobot can be installed and running very quickly.

For more elaborate applications faced with days or weeks of downtime, the use of robotic simulation tools can lessen the downtime tremendously by dealing with a majority of the implementation concerns, as well as robotic programming, ahead of time. Robot modeling software has increased a great deal in capability, offering very realistic robot models in a digital environment.

Return on Investment and Financing

The decision to improve a process using automation begins with **defining specific quantitative goals.** Some examples include:

- Parts per hour
- Percent material utilization
- Percent machine utilization
- Quality: reject reduction
- Safety: reduced workman's compensation costs

Defining specific goal metrics allows for an easy calculation of a return on investment (ROI). For example, if one of the goal metrics is an increased number of parts per hour, this can be used to predict an increased number of parts per week, per month, or per year. From there, that increase in parts may translate into an increase in revenue over the same time period. The revenue increase further defines the scope of the project, helping to define the best-suited robot for the application as well as projecting an appropriate overall budget.

This topic has been further addressed in a previous article: Robot ROI Checklist.

The Association for Advancing Automation (A3), formerly the Robotic Industries Association (RIA), also has a helpful ROI Robot System Value Calculator.

Paying for a System

The following are some means of raising the capital required to install a new robotics system. As mentioned earlier, a well-defined ROI is the first step in the entire process, including securing funding.

- A smaller-size company may work with a bank for financing.

- Some automation companies (Siemens) may have programs in place to loan money to new customers to purchase their equipment.

- Investing in an engineering study that fully considers the specific application can be worthwhile. Often, an integrator will discount the total cost of the project by the cost of the engineering study. As a result, the project is better defined and has less risk for the same final price.

Throughput

Throughput gains are very much an application-specific discussion that is important to consider when developing the ROI of a project. Specific requirements for throughput can be a key determinant of the robot that should be selected for the project. In general, an industrial robot will have better throughput potential than a cobot.

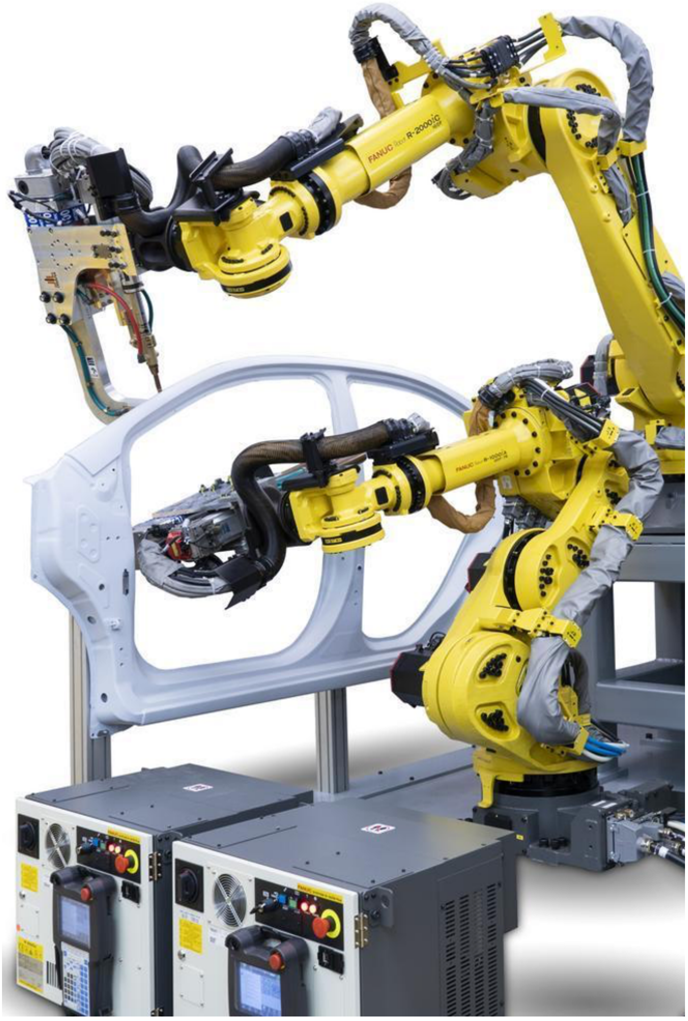
Use of Raw Materials

This discussion is also application specific. However, it is a critical piece to consider when predicting an ROI for the project.

For some applications, less raw materials are used through automation than otherwise. Less use is common for well-designed painting or spraying jobs. In general, the robot's application of paint, caulk, or other material, will be more consistent and accurate than a human operator, leading to less overall raw materials use.

Robot Maintenance

While application-specific, routine maintenance of a robot should address the parts of the robot that are regularly bending, flexing, and in contact with production parts. In general, this includes cables, brakes, bearings, and even connectors. In addition, wear will occur in the locations where the robot is in direct contact with the parts with which it interacts - the EOAT. These fingers, magnets, or vacuum cups (as examples) will wear out over time and need to be replaced. For welding-specific applications, spot welding contact tips should be checked regularly. In the case of arc welding, the torch should be routinely checked for bending.



FANUC R-2000iC and R-1000iA robots with spot welding EOATs and cable management systems

Predictive Maintenance Software

FANUC's Zero Downtime (ZDT) predictive maintenance software is a cloud-based software solution designed to monitor and predict equipment failure before it occurs. ZDT is a subscription-based maintenance solution that works by gathering real-time data from connected robots. Example information collected includes motor performance data, sensor readings, temperature, and cycle time. The data is sent to FANUC's Analytics Center (cloud-based) for storage. Data collection is ongoing, allowing for historical data analysis to benchmark current with past performance. Machine learning algorithms are used to process the collected data, looking for patterns and deviations from expected results. Models are built based on historical data and observed patterns. The models can then predict when specific components of the robotic system are likely to require maintenance or replacement or will fail. This information is then conveyed to the customer.

Robot Support and Training

If working with an integrator, their engineers will typically conduct some informal training on a newly installed system. The training normally includes basic operation (how to start and run a program), but also a basic maintenance routine to include the parts of the robot that need to be very regularly checked (i.e. suction cups in contact with production parts).

Further robot operations training is typically available through the manufacturer. In the case of a FANUC robot, a beginner course offers basic instruction on how to start up a program and move a robot around using a handheld device called a teach pendant. A teach pendant allows the operator to interact with the robot more closely for setup and debug purposes. It has a user-friendly interface that provides the operator with specific information needed to set up and/or debug a robotic application.

FANUC ARC Mate-100iD robot with a torch/wire feed EOAT arc welding parts on a 7th axis positioner (Note that operator is shown holding a tablet teach pendant).

Outsourcing Maintenance and Procurement of Spare Parts

Robotic manufacturers will typically provide the option to purchase a service contract.

System Lifespan

While application specific, a well-designed industrial robotic system, working in the middle range of its capacity will typically last somewhere between seven to ten years. Since cobots are still relatively new, it is difficult to make a statement on their expected lifespan. Regardless, regular maintenance of moving portions of the robot and the EOAT in regular contact with the parts is needed for optimum performance and lifespan.

Another important consideration is that the system only needs to last as long as the time it takes to pay for it or to meet any established ROI goals. Anything beyond that timeframe is over and above the minimum requirement set by the project's initial goals.

Robotic system lifespan can be better predicted than ever before using robotic simulation software. In today's simulation tools, robot models are detailed and include lifespan information for each joint. Therefore, the software is capable of estimating the life of each joint and motor in a robot as it is designed to be used. If the proposed robot is overloaded on one particular joint or motion, a small design change can address the issue before the system is even implemented.

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Chapter Three

Programming and Simulation Tools

A robotic application can be complex. It is generally managed via the robot controller which executes application-specific robot programming. The type of programming required varies with the robot type being installed and the tasks it will be completing.

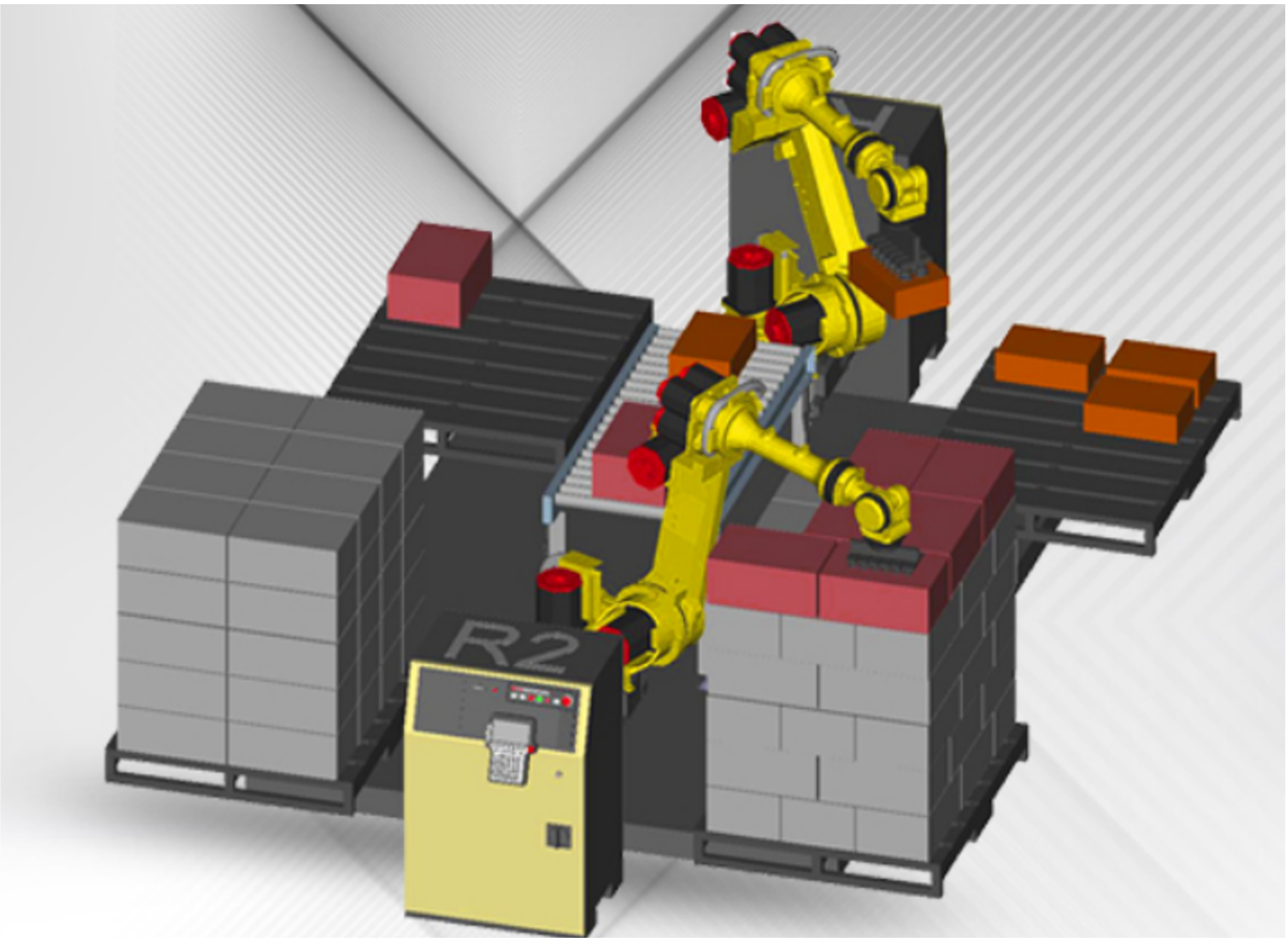
Cobots are typically designed for ease of setup and programming, as well as their general suitability to work in close proximity to people. It is common that cobot models can be placed in “program” mode and simply guided by hand through the motions that are needed for their work. This process is called lead-through programming and makes cobot programming very simple to learn and accomplish. Using the teach pendant, an initial reference (home) position is defined. Then, important next step positions are added to the program by moving the robot to those particular positions. Options to operate EOAT are also defined at those particular program positions. An example of such an operation would be to close a gripper at the location of an item about to be picked up. The entire intended motion of the cobot can be programmed in this manner.

Industrial robot programming can be a more involved process. All robot manufacturers use structured text programming languages for robot programming. Instructions can be written using a handheld device (FANUC also uses a teach pendant) or by computer. Programming training is offered by robot manufacturers and if the user is working with a system integrator, they may offer training as well.

Robot Simulation

Robotic simulation software has been developed to streamline the programming process, predict system stress points and therefore overall lifespan, as well as reduce the downtime needed for installation. ROBOGUIDE, developed by FANUC, is the leading example of robotic simulation software: a robot model (called a digital twin) is used in a three-dimensional virtual environment. Both the robot and the simulation environment can be customized to recreate its real working environment and set up virtually, allowing the user to program and test the robot prior to installation. FANUC’s robot models include lifespan information for each joint of a robot. In addition, ROBOGUIDE can predict if the robot controller servo drives are at risk of overheating. Cycle times found in ROBOGUIDE are typically very close to real-world cycle times that can be expected of the particular robot. In addition to virtually testing a robotic system, ROBOGUIDE allows for Ethernet connections for both emulators of external control devices and actual real-world control devices such as programmable logic controllers (PLCs) and human-machine interfaces (HMIs). This feature allows for virtual commissioning of those external control devices with the virtual robotic system.

Process Simulate, developed by Siemens, is another robotic simulation software tool that can be used to create a digital twin of the robot and the robot cell for application development. It can be used to create robot programming and allow for testing and virtual commissioning of the application in the simulated environment.



FANUC's ROBOGUIDE robot simulation software

System Safety

In the USA, it is the responsibility of the owner of a robotic system to complete a safety risk assessment and the owner holds ultimate responsibility for the system's safety.

Safety Risk Assessment

Any manufacturer installing a robotic system must complete a safety risk assessment to meet applicable robotic safety standards and ANSI standards (ANSI/RIA R15.06-2012 and ANSI B11.0-2010). The risk assessment serves to identify all the potential hazards associated with a particular robotic system and should be considered as early as the initial design phase through the operation and maintenance phases of the robotic system.

All facilities that include robotics must complete a safety risk assessment.

The assessment includes the following:

- Limits of the robotic system
- Identification of hazards in the work cell during all phases of operation (setup, regular operation, maintenance, cleaning)
- Identification and evaluation of each part of the safety system
- Evaluation of circuitry: wiring integrity, emergency stop circuits, verification of safety circuit redundancy
- Evaluation of guarding: physical, or sensor-based barriers to isolate robotic work areas

For a cobot, the risk assessment is specific to each application and takes into account maximum allowable impact pressures the cobot makes with a human, and the location on the body that is impacted. More on calculating a safe collaborative mode speed limit can be found in RIA TR R15.606-2016.

Safety Fencing

Industrial robots require safety fencing to protect humans in their vicinity. The requirements for these robots may be based on safety standards such as ISO 10218 for industrial robots and ISO 13857 for safety distances to prevent danger zones.

Requirements should be considered in full detail However, as an introduction, they include:

- Robust physical barriers
- Safety interlocks and sensors
- Safety distances
- Proper demarcation of robot work zone with warning/caution signs
- Highly accessible emergency stop controls
- Proper training for individuals in the vicinity of the work area
- Safety documentation
- Routine maintenance and system inspection

FANUC R-2000iC-165F industrial robot with hard guarding

Cobots, operating in collaborative mode may not require traditional safety fencing. Cobots include built-in force sensing to detect a potential collision. Even if that collision should occur (despite the force sensors), a human should not be injured by it due to the slow operating speed. However, there are certain situations in which a cobot will still require fencing or light curtain. These include a cobot operating at or above head level, a cobot handling something that is itself dangerous (i.e. a hot glass bottle - a person can still be injured by touching it), and more.

The decision to implement a robotics solution does not have to be a complicated one.

As you consider your options, Patti Engineering has expert robotic engineers who can help you make this decision.

Contact Us

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