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Guide to Implementing Industrial Robots

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Industrial Robots

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Aim of this Guide

This Guide aims to raise awareness on the best practice associated with the setting up of an automated process, with specific focus on industrial robotics for use in manufacturing and associated industries. The Guide sheds light on some of the key issues to consider when evaluating whether or not a business should automate and the processes involved when the decision to automate has been taken. These issues include:

(a) the range of benefits associated with having an automated manufacturing system;
(b) the challenges that an automated system presents in terms of its setting up and running; and
(c) the process involved in evaluating a business' need for automation, the cost associated with the automation process, the potential risks and opportunities of implementing an automation system and how to effectively manage an automated system.

Robotics

In this Guide, 'robotics' refers to the use of robots in an industrial and manufacturing setting. There are many definitions of the term 'robot' but this Guide will adopt the International Standards Organisation definition as detailed in ISO 8373:2012[1]: an "automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications".

1 International Standards Organisation. Robots and Robotics Devices – Vocabulary. s.l. : International Standards Organisation, 2012. ISO 8373:2012 (en).

Introduction

The first historical references to robotics and automation date back to the ancient Greeks and, over the centuries that followed, there have been numerous references to 'automata', mechanical machines that move on their own. The term 'robot' was first coined by the Czech playwright Karel Čapek in his 1921 play, Rossum's Universal Robots. However, it wasn't until 1938 that the first recognised industrial robot was produced by the Meccano Company. This had a single motor and was controlled by punch tape.

▼ **Figure 1.1** Meccano Robot Manual

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An Automatic Block-Setting Crane

Meccano Model Controlled by a Robot Unit

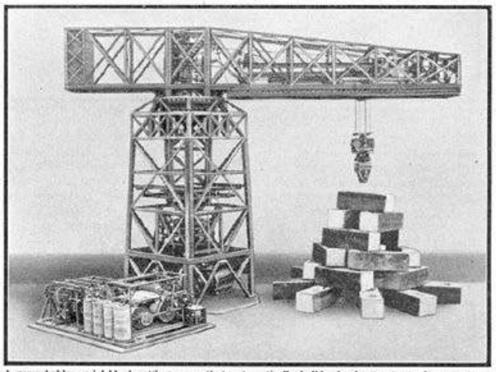
THE model illustrated on this page is a blocksetting crane of splendid design, but unlike other examples of this popular type it actually builds walls, simple dams or breakwaters automatically. Without any aid from its designer, it lifts up miniature blocks from piles arranged near it and places each in position with such uncanny certainty that anyone watching it at work might almost think it capable of thinking.

The builder of this astonishing model is Mr. Griffith P. Taylor, Toronto, who appears to have had a Wellsian vision of "Things To Come" in a world in which human labour will not be necessary for building up the creations of engineers and architects. He has named his model "Robot Gargantua." Its "brain centre," as it may be called, is the unit shown on the left in the illustration. This controls every movement and carries out each in its turn.

Although the chief interest lies in the robot mechanism, the crane itself incorporates many ingenious and novel constructional features. For example, the boom swivels on a vertical pillar, inside the main tower, that is provided with two roller bearings, one fixed to the underside of the boom and the other to a point on the pillar itself and near its lower end. This arrangement is sometimes used in the construction of actual cranes of this kind, but is seldom adopted by model-builders. Another feature of the crane is that all the levers by which its various operations are controlled are grouped together at the base. The chief purpose of this is to enable them to be connected easily to the robot mechanism. The block-lifting gear and hoisting trolley are operated through a gear-box placed at the top of the boom pillar, and slewing of the boom is carried out through separate gearing situated at the base of the tower. All the movements are driven by a single motor mounted in the base.

The robot unit is designed so that it can be used to control automatically, not only the crane illustrated here, but also any other type of machine, such as an excavator or a dragline, that incorporates not more than five different operations. It works by moving the control levers of the crane in their proper order.

The robot is driven by the same motor that operates the crane. Its central feature is a roll of paper punched with holes set out on a pre-arranged system. The roll resembles on a miniature scale those used for operating player pianos. It is drawn slowly over a brass drum and there passes under a row of spring brushes, which are connected in separate electric circuits and press lightly on the paper. When a hole passes beneath one of the brushes, this makes contact with the drum, and so completes the electric circuit through it. This current operates a solenoid that is used to move one of the control levers of the crane by means of a special differential drive operated by the crane motor.



A remarkable model block-setting crane that automatically builds simple structures. Its movements are controlled by an ingenious robot mechanism, which is seen at the base of the tower on the left of the illustration. The model is the work of Mr. Griffith P. Taylor, Toronto.

A revolution counter gives the number of revolutions of the shaft of the robot and also of that driving the crane. The counter is used in preparing the paper roll, which is done in the robot itself.

The method by which the exact positions of the holes is determined is very complicated, but an outline of the process will make it clear. A simple structure is first designed and a plan drawing made, after which the layout of blocks from which the structure is to be built is considered. The number of revolutions of the robot and crane driving shafts required to transfer each block to its allotted position is then determined. In a similar manner the movements of the trolleys and of the grabbing and hoisting tackles required for the positioning of each block are calculated. These calculations are then tabulated, and the machine set accordingly.

Suppose the hoisting of a block is found to require 150 revolutions of the driving shaft. The lever that controls this operation then must first be moved to start the crane working, and after 150 revolutions have been made the position of the lever must be reversed to stop the operation. The roll of paper is placed on the rollers and set in motion. As the counter registers each required number of revolutions, as set out on the tabulated list, the mechanism is stopped and a hole is punched in the paper in such a position that the appropriate brush makes contact with the drum. In a similar manner holes are punched to control other movements, and thus the complete sequence of movements required to build the structure is recorded on the paper roll. The time taken to erect the brick structure shown in the illustration was 50 minutes.

There was little development in the field of industrial robotics until 1956 when Joseph Engelberger developed a hydraulically powered robot for General Motors. Together with George Devol, he founded what became the first industrial robotics company, Unimation, in 1962.

▼ **Figure 1.2** Unimation Robot (Image from the Collections of The Henry Ford)

From the Collections of The Henry Ford (76.115.1/THF126342)

With the increased use of silicon and microprocessor controllers, it was inevitable that robots would follow suit and in 1974 both Kuka Robotics in Germany and ASEA in Sweden created the first robots of this type that became the forerunners of what we now use in industry.

▼ **Figure 1.3** ASEA IRB6 – the world's first microprocessor controller robot

Today, there are many different types of robot in use across a huge range of applications and environments as shown in Figure 2.1. The most commonly recognised robots are those used on automotive body assembly lines, but industrial robots can be used to paint, glue, cut, assemble, move and manipulate a wide range of products across an equally wide range of manufacturing sectors.

Automation is used widely across a diverse range of industries. In the manufacturing sector, automation is synonymous with the use of robotics whose use, according to the International Federation of Robotics, offers a number of advantages including:

(a) reduced operation cost;
(b) improved product quality;
(c) improved quality of work for employees;
(d) increased production output;
(e) increased manufacturing flexibility;
(f) reduced waste;
(g) improved health and safety;
(h) reduced labour turnover;
(i) reduced capital costs; and
(j) a saving on space.

It should be noted that whilst many applications of robotics will exhibit some or all of these characteristics, there are other beneficial attributes that may be evident in some applications. These include:

(a) improved company image;
(b) positive cultural change; and
(c) technology advances.

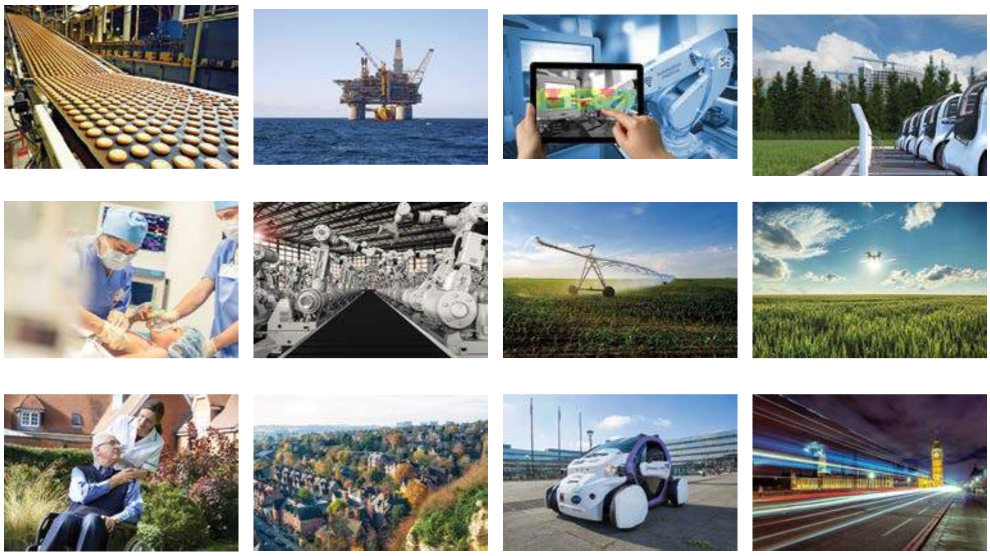
It is important to determine what advantage your company is trying to achieve through the application of robotics and automation.

SECTION 2

Robotics

2.1 Industrial robot applications

▼ **Figure 2.1** Robot applications

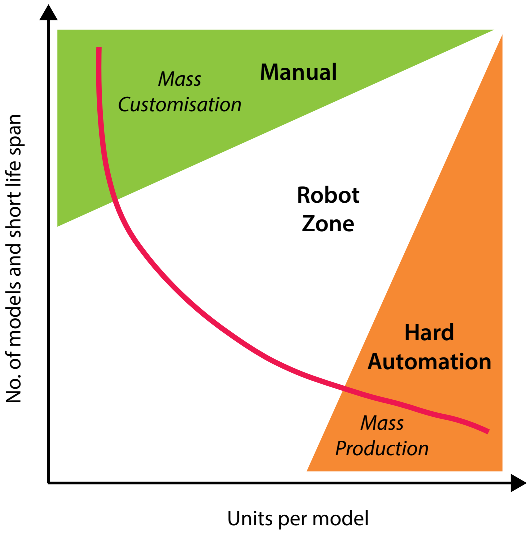


2.2 The benefits of industrial robots

2.2.1 Volume versus flexibility

The traditional view of industrial robots is that they are only for volume manufacturing but with the integration of sensors and flexible tooling, this is no longer the case. Indeed, as Figure 2.2 shows, industrial robots are now able to carry out a wider range of tasks than before, including those that could be categorised as low volume and high variety.

Figure 2.2 Volume versus variety mix for robotics



2.2.2 A word about jobs ...

There is significant evidence to show that robotics and automation can, in the long term, create significant growth in an organisation's value and output and so in turn create new jobs (through maintenance as well as day to day running of the robots or in new roles created as a result of the automation) both internally and in the wider economy. Between the years 1993 and 2007 annual GDP growth and labour productivity increased by about 0.37 and 0.36 percentage respectively across 17 countries studied – representing 10 % of total GDP growth in those countries.[2] There is acknowledgment that "while technology has potentially contributed to the loss of over 800,000 lower-skilled jobs (in the UK) there is equally strong evidence to suggest that it has helped to create nearly 3.5 million new higher-skilled ones in their place"[3]. Evidence also strongly suggests that an investment in automation of £1.24 billion over the next decade could safeguard 73,500 UK manufacturing jobs and create over 30,000 jobs in other sectors[4]. Another forecast projects productivity improvements of 30 % over the next 10 years, spurred in particular by the uptake of robots in small- to medium-sized enterprises (SMEs) as robots become more affordable, and adaptable.[5]

2.3 Potential barriers to automation

As with the introduction of any new technology or process, there are some potential barriers or risks to overcome when implementing a new automation system. Some common issues are highlighted below but there may be others that are particular for an individual application. To ensure these risks are fully understood and mitigated against, it is recommended that a Failure Modes Effect Analysis tool is used during the development of a robotic solution.

2 Graetz, Georg and Micheals, Guy. Robots at Work. London : London School of Economics, 2015.
3 Sproul, David, Knowles-Cutler, Angus and Lewis, Harvey. From Brawns to Brains: The Impact of Technology on Jobs in the UK. London : Deloitte LLP, 2015.
4 Barclays Bank. Future-proofing UK manufacturing. London : Barclays Bank, 2015.
5 Boston Consulting Group. The Robotics Revolution. s.l. : Boston Consulting Group, 2015.

2.3.1 Technical risk

It is very important to understand the technical risks involved in implementing automation for a process. Whilst most processes can be automated, there may be significant technical risks in doing so and carrying out a thorough analysis of the risks involved is imperative even if the task seems relatively routine. The assessment of risk is particularly important for complex technical tasks that are often exhibited by the high mix and low volume scenarios that many small-to medium-sized manufacturers operate. In such a scenario, the product design stage will play a large role in determining the feasibility of using robotics to automate a process.

2.3.2 High variability

Traditionally, robotic and automation systems have been used in applications with high volumes and low variability in product variety and input quality. Whilst this is still the case in most situations, significant advances have been made in technology to allow for variability. Figure 2.2 shows that there is significant potential for the use of robotics and automation in applications with a high degree of variability.

2.3.3 High initial investment

This is a potential barrier but should be considered against the long-term returns that may be achieved. With the unit cost of robots dropping significantly (and forecast to drop a further 15-20 % over the next five years from 2017), the real cost is in the integration of the system. With a rigorous implementation program, costs during this phase should be controllable. However, high initial costs may be exacerbated by the longer time period between deciding to automate a process and that automation being in place compared to the hiring of additional labour.

2.3.4 Payback period

For many organisations a payback period of two years is the norm, however, a well-maintained robotic or automation system should be able to provide a minimum of five years' service, with many systems continuing to operate ten years after initial installation. As such, a longer term view should be taken on the returns achieved and balanced against the initial investment costs.

2.3.5 Health and safety concerns

In principle, the use of robotics and automation should achieve a higher level of safety than manual operations as they will remove manual handling or other potential sources of injury. Unfortunately in doing so, they create their own hazards. However, the rate of fatalities and injuries caused by an automation system is very low compared with the rate arising from human error or a deliberate intent to defeat the safety systems in place. As such, if designed and installed in accordance with current regulations and risk assessment methodologies, robotic and automation systems will improve the working conditions and safety of employees.

2.3.6 Skills level

A lack of appropriate skills, both at implementation and in use, can cause significant barriers to the success of a robotic or automation system. Unfortunately, these skills are not easily gained, although organisations such as the High Value Manufacturing Catapult and the British Automation and Robotics Association are trying to address this by offering courses that embed the appropriate skills into an organisation. Systems integrators can also be engaged to help organisations and their input can be a crucial factor to success although it is worth understanding their experience level before engaging them.

2.3.7 Floor space required

Although this seems contradictory to one of the advantages listed earlier, it should be noted that in some instances the use of robotics and automation may require more space than existing manual operations.

2.3.8 Company culture

Resistance to change or a fear that robots will 'steal' jobs are often cited as reasons not to install automation. As discussed in Section 2.2.2, employees should not fear the use of robotics, as in the long term they have been proven to create more jobs than they displace. However, this fear and a general resistance to change can cause significant problems to ensuring effective implementation of automation systems. In order to overcome these issues, staff involvement in the automation process needs to start very early on – with the need for robotics and what it means for their jobs openly and clearly explained.

2.3.9 Working environment

In most cases, robotics and automation systems are very tolerant to the working conditions they are placed in. However, in certain applications (for example, casting, forging or wet environments) certain precautions need to be taken. Indeed, in certain situations it may not be possible to install automation given the extreme nature of the working environment.

SECTION 3

Financial considerations

3.1 The business case

Financing your plan to automate is often seen as one of the biggest barriers. The information in this Guide includes some advice to help you make the best business case for your automation plans, thereby convincing banks and financial directors to invest in your project. There are three important steps: first, consider every factor that might affect the business case for your project; second, understand the return on investment (ROI); and third, prepare the business case.

3.1.1 Factors to consider

Whilst this list is not exhaustive, here are some important factors to consider when determining the cost of implementing and running an automated or robotic system.

(a) What does it cost you now to carry out the process? This includes:

- **i** manpower (including overhead costs);
- **ii** materials (including consumables);
- **iii** utility costs;
- **iv** training; and
- **v** insurance provisions (particularly if there is a risk of injury to an employee).

(b) Investment costs – this includes:

- **i** not just of the equipment itself but the effort required by you to work with suppliers to install;
- **ii** disruption to normal operations during installation;
- **iii** training; and
- **iv** changes to existing upstream or downstream processes.

(c) Ongoing costs such as:

- **i** manpower (including overhead costs);
- **ii** materials (including consumables);
- **iii** utility costs;
- **iv** insurance provisions (if required); and
- **v** maintenance.

3.1.2 Return on investment methods

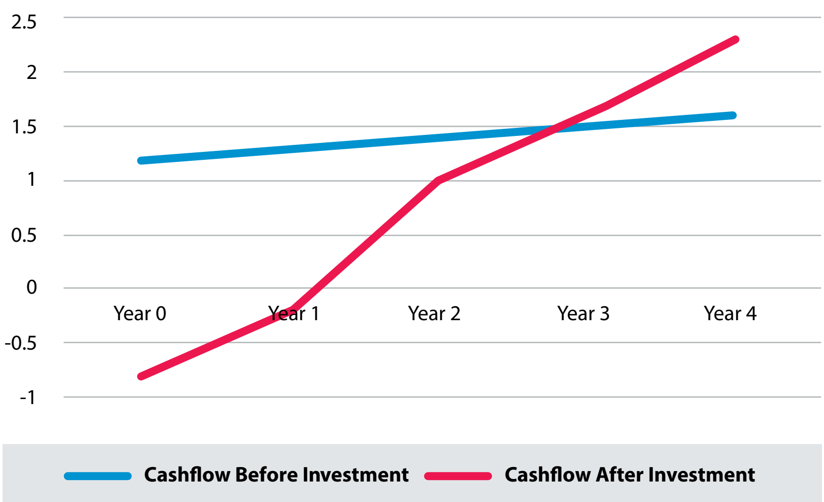
There are a number of different ROI techniques that companies use, so it's worth checking if your organisation has a preferred approach. However, in all cases, the ROI calculation attempts to determine the gain made from the investment to the organisation. A simple ROI calculation is the form:

$$\text{ROI} = \frac{(\text{Gain from investment} - \text{Cost of investment})}{\text{Cost of investment}}$$

Factors that may also be considered in the ROI calculation include the cost of money in the future (i.e. interest and inflation), long-term costs and returns.

Such calculations are often backed up by analysis tools such as payback calculations, an example of which is shown in Figure 3.1, where the cash flow after investment passes that without investment before three years. This indicates that the investment and added value created by it pays back the initial investment cost before the end of the third year after investment.

▼ **Figure 3.1** Example return on investment calculation



3.1.3 Preparing the business case

Individual companies and bank managers will have different requirements for business cases presented to them so it's worth checking what is required first. However, as a general rule of thumb, it might be useful to:

(a) describe the problem you are trying to solve;
(b) describe what the automation will do and the expected benefits that will be realised;
(c) describe what it is you want to invest in and why;
(d) describe what the financial and other benefits will be;
(e) define the risks involved and how they might be mitigated;
(f) describe the ROI calculations (include any assumptions you've made); and
(g) define a high level implementation plan.

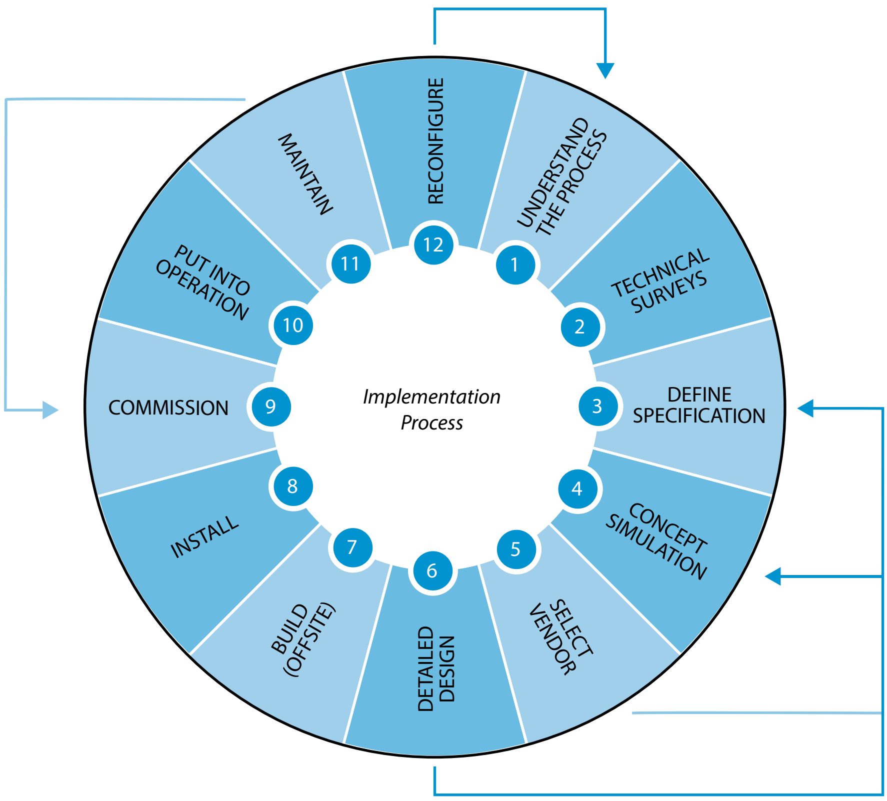
If you are approaching a lender then you will almost certainly need to show your business accounts and long-term business plan.

How to implement an automated process

4.1 Implementation process

Figure 4.1 shows the stages involved in implementing an automated process. Although we show this as a process, in practice this is not necessarily iterative in nature; particularly between steps 3 and 6, which may involve you going back several steps to redefine the specification based on something you find during the concept simulation, vendor selection and detailed design phases.

▼ **Figure 4.1** Implementation process overview



4.1.1 Requirements capture

Unfortunately, there are many failed implementations of robots and automation that should not have failed. Their failure can be attributed to an inadequate understanding of the process being automated at the start of the design process. As a result, the system was designed for a task that it was unsuitable for or could not complete, with the robot or automation taking the blame for the failure. However, if a detailed requirements capture process had been undertaken at the beginning of the process it is likely that a far more successful outcome could have been achieved. To be successful you should gather as much information as possible, including:

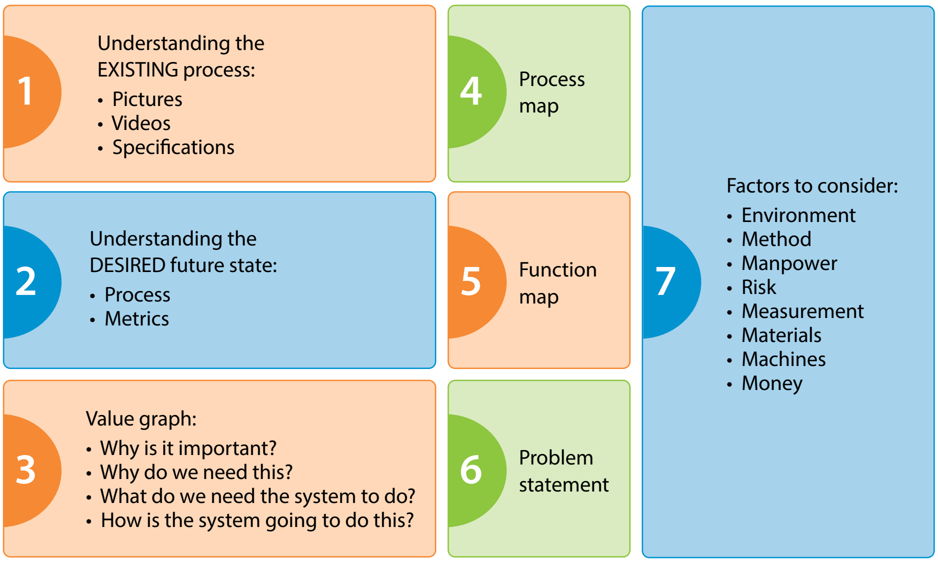
(a) the current state of the process;
(b) understanding the handling characteristics of the products in the process;
(c) the problem you are trying to solve with automation or robotics; and
(d) the desired future target.

In doing so you should never assume that:

(a) the end user knows what they want;
(b) the end user knows what's wrong; and
(c) the end user knows what the solution is.

Within this process, there are seven steps (Figure 4.2) to fully capturing the requirements of the robotic system that should be used to influence the design of the system, the partners you work with to deliver the system and how you operate it in the longer term.

▼ **Figure 4.2** Requirement capture steps

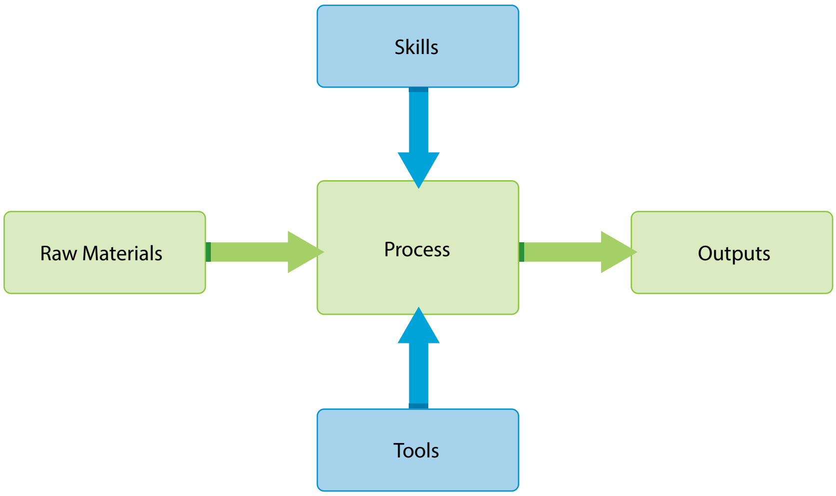


Step 1 Understand the existing system or process

Firstly, it is important to understand the existing process in as much detail as possible. To do so it is useful to create a clear and simple-to-follow process flow to capture the entire process sequence from incoming raw materials to finished outgoing product.

With the process flow in place, the next step is to capture all the inputs and outputs of the process as shown in Figure 4.3.

▼ **Figure 4.3** Inputs and outputs from a process



Capturing the system specifications is equally important since these define the parameters that your new automated system will have to work within and to. Such parameters could include:

(a) material flow;
(b) part flow through the process;
(c) frequencies;
(d) throughput rates;
(e) variants;
(f) sizes;
(g) weights;
(h) part condition requirements; and
(i) orientations.

Step 2 Understand the desired future state

Once the existing state is fully understood, it is important to define what the desired future state is expected to be. At this stage, you should fully define all the input and output parameters for the future system. In essence, these can be the same as those for the existing state but there may be differences and it's important to capture these now so that the system is designed to meet these. It may also be useful to define what an expected future process might be, although this should be seen as an 'artist's impression' rather than the final article.

Step 3 Understanding what's important (value graph)

The development of a value graph can be useful in the system's development to focus on the important aspects of the system. If used this should be generated by a group of the project's stakeholders as early as possible in the project's development. It focuses on three fundamental questions: Why? What? How?

Why?

Why does the customer think that the problem needs solving?

Keep asking 'why' so that you can identify the fundamental customer needs, i.e. the reason people really want the system.

What?

What value or quality does the customer want from the product/process?

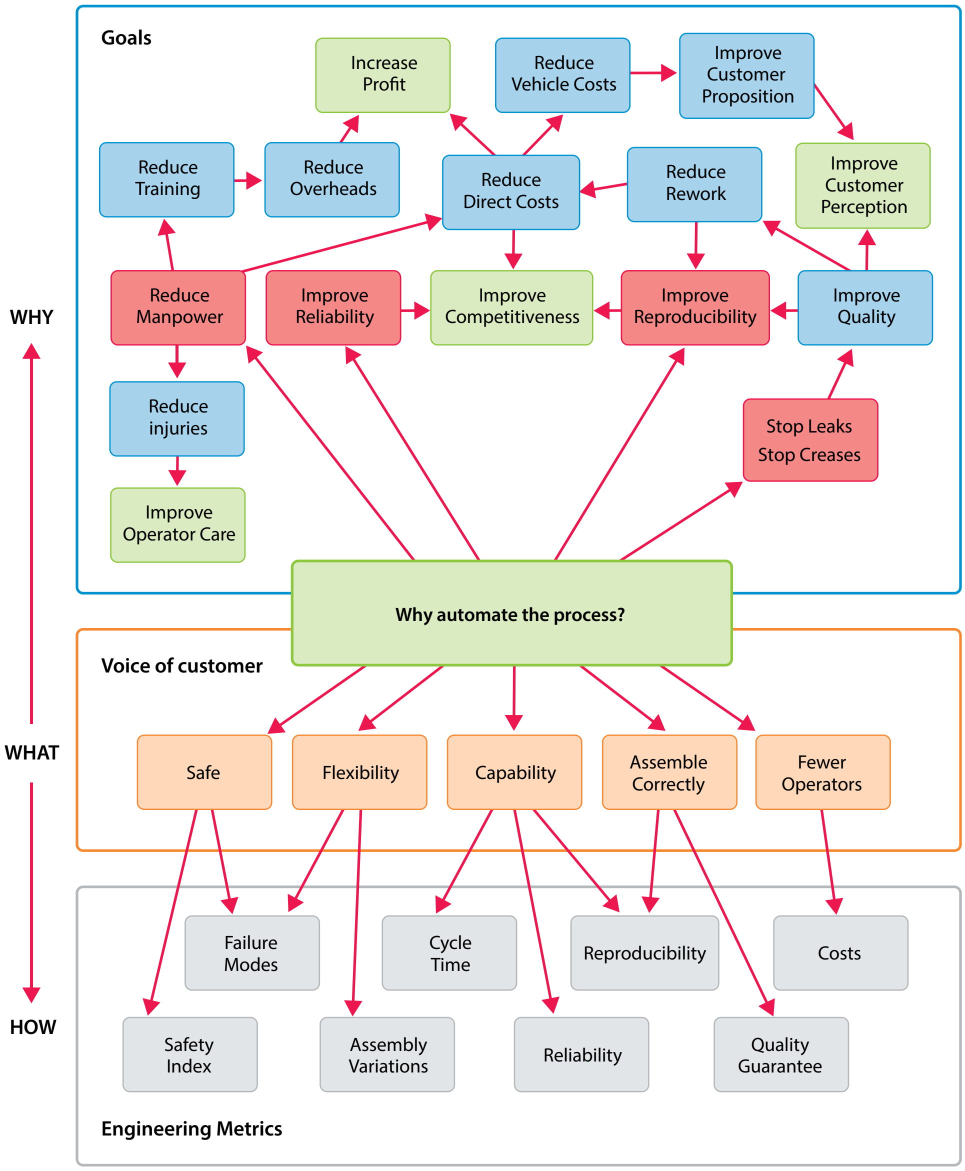
How?

How can we measure 'success' i.e. whether the solution meets the user's needs and delivers the 'what'?

Define the 'Hows' in quantitative values, if possible.

The result of working through Step 3 should be a chart that looks similar to Figure 4.4.

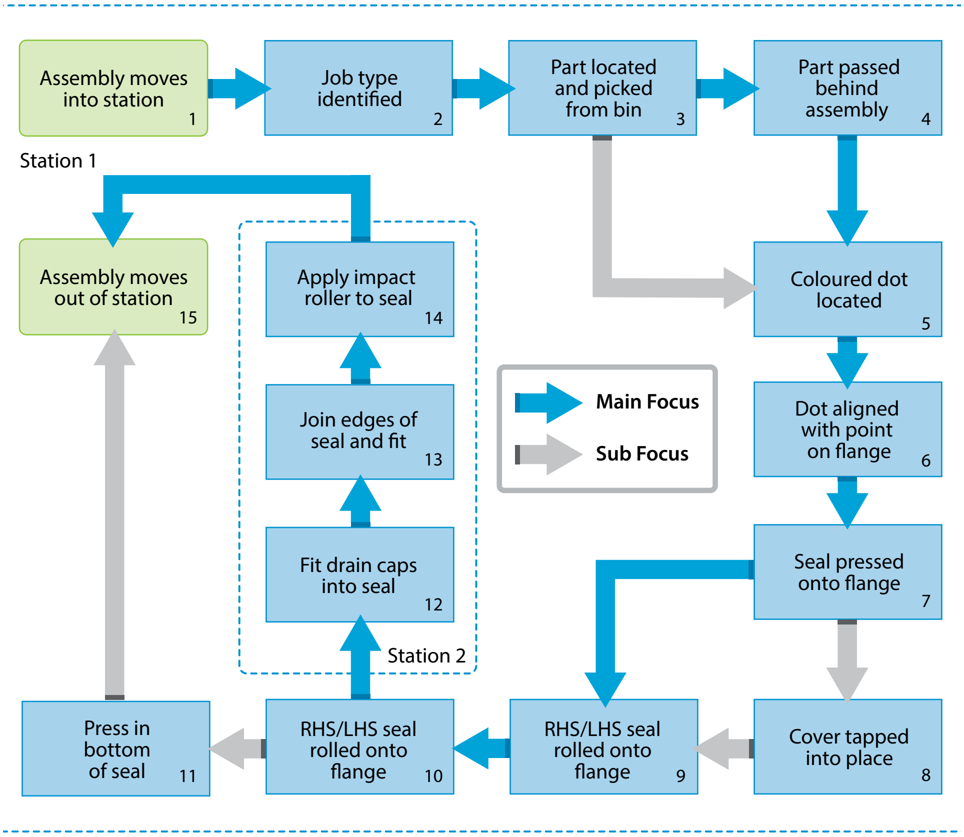
Figure 4.4 Sample value graph



Step 4 Process map

At this stage it may also be useful to define what the future state process flow should look like. An example of a future state process flow is shown in Figure 4.5.

Figure 4.5 Sample process map



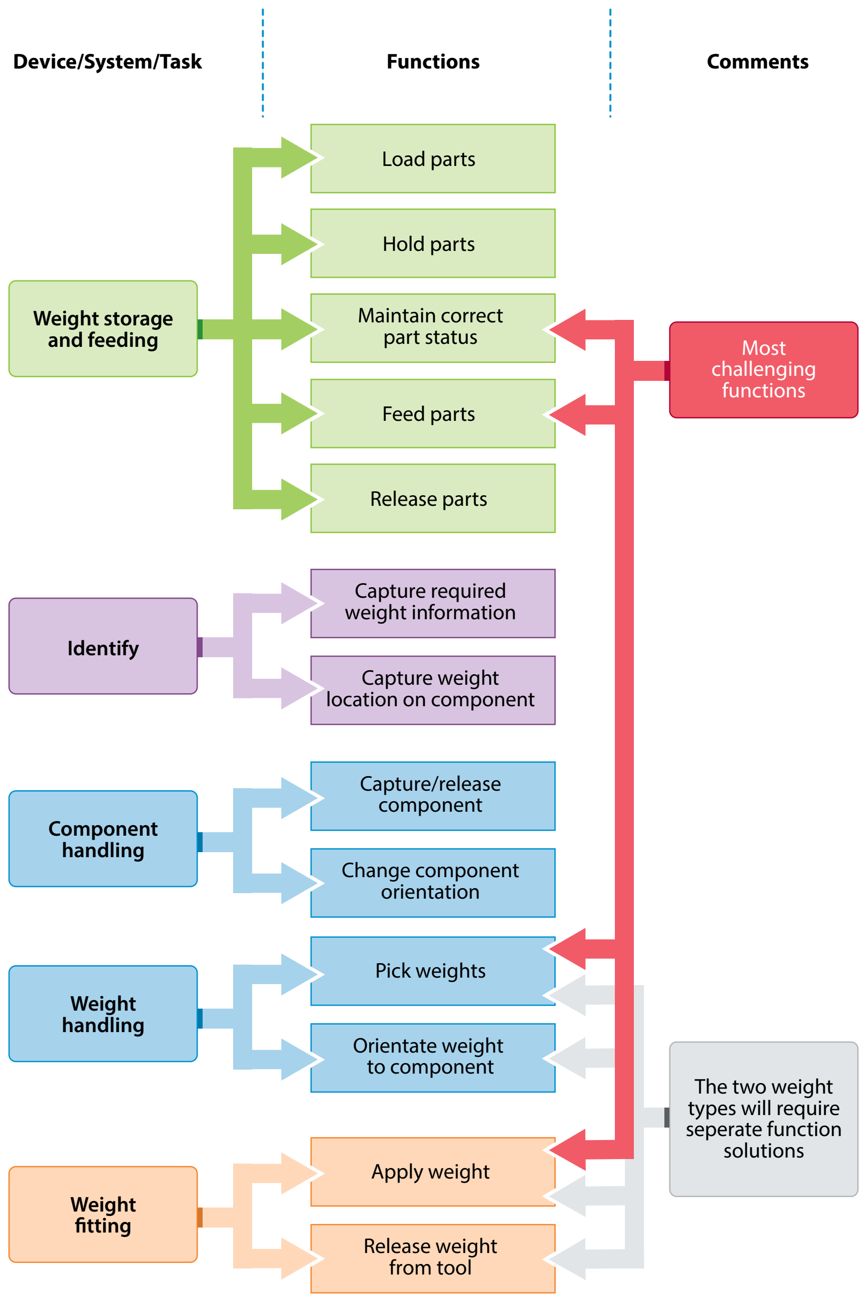
Step 5 Understand the technical challenges (function map)

Once the value graph has been developed, it is worth then considering what the most important functions of the system need to be and the technical challenges associated with them. This can include what effect the implementation of robotics will have on product design. To do this you should start by analysing the future process map closely and extract the main tasks. These tasks can then be grouped based upon their nature, such as 'identifying', 'handling', 'transporting', etc.

Each task should then be broken down further into its constituent functions where each function should be unique and preferably defined by a verb and noun (for example, 'hold parts').

From here it's important to highlight the most technically challenging of these to focus on and comment on why this is the case. This is making use of the principle of 'fail hard, fail fast' so that when you are at the end of the process and time is of the essence, you've got only the less challenging bits to solve. An example function map is shown in Figure 4.6.

▼ **Figure 4.6** Sample function map



Step 6 Problem statement

Having been through the process of understanding the existing situation and the desired future state, it's then often useful to collect this information into a single problem statement document that sets the scope for the project, is used by all stakeholders (to check understanding) and ensures you stay focused on delivering the solution whilst limiting project scope creep. An example problem statement is shown in Figure 4.7.

Figure 4.7 Sample problem statement

Problem overview:
Automate fitting of bonding and stamping balancing

Expected advantages:
Higher quality in part fitting, no manual operators required

Actual status:
Manual operators attach balancing weights to wheels; operators hammer stamp weights onto steel rims or use a tool to press bonding weights to inside wall of alloy rims; axial location of weights is determined by a two-plane automated dynamic balancing machine; balancing machine marks the target location on the tyre for the operator.

Problem:
Manual fitting of weights can result in misalignment which results in imbalance and requires rework.

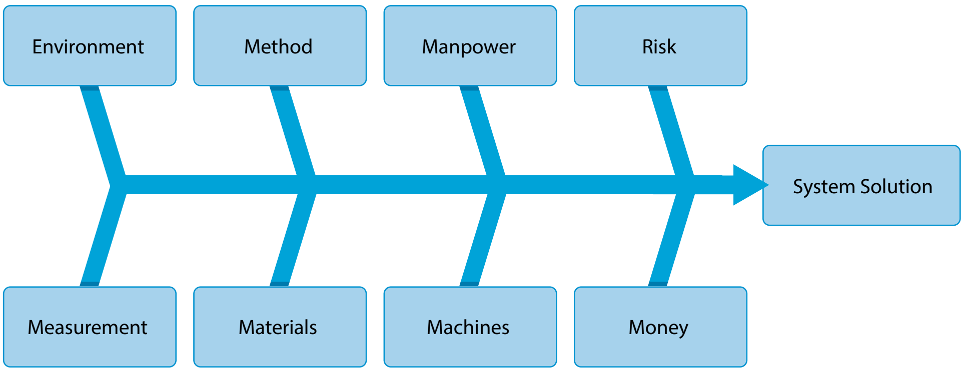
After development:
The weight fitting process will be fully automated with all manual operations eliminated. Process speed will be increased and rework eliminated. Prototype systems will achieve a cycle time of 0.4 min/wheel.

Technical challenges:
Technical challenges are likely to include:
- Weight storage/delivery
- Weight identification
- Weight picking/placing/feeding = Most Difficult
- Weight fitting
- Wheel identification
- Wheel handing/rotating

Step 7 Key factors to consider

A simple way to capture all the factors that may affect your automation system is to use a 'fishbone' diagram such as the one shown in Figure 4.8.

Figure 4.8 Key factors to consider



Looking at each branch:

(a) Environmental factors:

- **i** how will the environment around the robot or automation affect it;
- **ii** will the system need special protection against heat/cold/damp/etc; and
- **iii** is the environment unstructured or structured? (See Figure 4.9).

▼ **Figure 4.9** Unstructured environment versus structured

(b) Method factors:

This relates to the process that is being looked at and how it affects the automation. This includes:

- **i** how easy is the task to complete;
- **ii** what is the skill level required by a human operator; and
- **iii** can the process used be simplified?

(c) Manpower factors:

- **i** what skills does the organisation have or need for installation, operation and maintenance of the system; and
- **ii** is the culture of the organisation receptive to automation?

(d) Risk factors:

- **i** have you captured all the risks involved with the implementation of a robotic or automation system;
- **ii** do you have a mitigation plan in place for the risks; and
- **iii** how long will it take to get the system working effectively?

(e) Measurements (KPIs):

- **i** what KPIs will the system be measured against and does everyone agree these are correct quality rates, take times, repeatability;
- **ii** what happens if the inbound materials rate changes (i.e. fluctuations in supply chain); and
- **iii** can the system cope with changes in demand (up or down)?

(f) Materials:

- **i** how will the quality or condition of supply of raw materials affect the system;
- **ii** are they variable;
- **iii** how are they presented; and
- **iv** how are the products produced handled at the end of the process?

(g) Machines/processes

How does the system interface with other machinery or processes?

(h) Financial resources

Are there any restrictions on service, utilities, consumables or investment costs that have to be considered?

4.1.2 Technical surveys

Having fully understood the process you are planning to automate, you can now start investigating ways to implement it. It is tempting to skip the previous step, but if you have, then the technical survey and the subsequent steps are unlikely to give you the optimal results.

Things you might want to investigate are:

(a) what are your competitors doing (i.e. benchmarking);
(b) what technology solutions or products are on the market already that you can use;
(c) what research is being carried out and by whom; and
(d) who can you approach for expert support and advice? Some key contacts include:
  i the High Value Manufacturing Catapult;
  ii the British Automation and Robotics Association; and
  iii GAMBICA.

Although there may be nothing available that completely solves your challenge or matches your application, there are ways of mitigating against this – including using internet and journal searches, as well as attending trade shows and conferences. But a word of warning on these: not everything is always as it seems so ask lots of questions to ensure that the technologies you're considering truly fit your needs.

4.1.3 Define the specification

Understanding the problem you would like automation to solve is crucial to a successful implementation. However, just understanding the problem is not enough; you need to be able to communicate this to other stakeholders particularly if you are planning to use an external vendor to design and install your system.

Even if you plan to implement automation yourself, having a well-written User Requirements Specification will ensure that what you put into operation delivers what you expected and solves your problem.

Many organisations purchase and implement automation without a detailed specification. This then makes it very difficult for any vendor or external supplier to understand what you require and as a result means that it is likely to become a source of problems either during project execution or at the end of the project when requirements have not been met.

4.1.4 Concept and simulation

The initial concept design is often based on experience and this is where a system integrator, robot supplier or consultant can help you to develop a concept. However, there is often the opportunity to examine new and different concepts; you don't necessarily have to be bound by previously implemented designs.

Concept design is an iterative process – so be prepared to examine several designs before deciding on the optimal choice. What is important here is to efficiently measure each concept against the requirements you've previously defined so that it solves your problem. Tools such as TRIZ or a Pugh Matrix are often good approaches to use.

Once you have a concept design, it's a good idea to use 3D CAD tools to visualise the layout and workflow. Whilst many 3D CAD packages have built-in kinematic models, it might be useful to simulate the system in a fully kinematic simulation environment. Again, your system integrator, robot supplier or consultant should be able to support you with this. A fully kinematic simulation will allow you to check for access/reach issues, interactions between the robot and other devices and cycle time concerns.

Some systems allow for 'virtual commissioning' to be carried out through the simulation. This allows all of the programs and control parameters to be built and tested in the simulation before being downloaded to the 'real' world. This can significantly reduce the time taken to build, test and commission the real system.

4.1.5 Select the vendor

Selecting the right vendor is critical to the success of the installed system. Your chosen vendor has to not only be the right choice from a financial and technical perspective, but they should also be the right 'fit' for your company. In other words, making a decision based on prices or specification alone may provide the cheapest (although this is often a false economy) or a high-performing system but the journey to get there may be fraught with difficulties and disagreements.

You should also consider the vendor's experience and background – particularly if the automation process project is a complex one. Knowing that your vendor has the right experience and mindset is as important to success as the system that they design. It is also prudent to check on the financial 'health' of any prospective vendor.

The use of a Vendor Selection tool will be of great benefit as each vendor will reply to your specification in a different way. The use of such a tool also allows you to score each proposal on the same criteria making assessment and selection easier. During the selection process, you may need to seek clarification from a vendor or you may find that one vendor offers an alternative solution. In this instance it would be unethical to share such information with competing vendors.

4.1.6 Detailed design

Once a vendor has been selected it is recommended that the customer and vendor project manager hold a kick-off meeting to review the entire project in order to ensure that there are no misunderstandings. During this meeting, a project plan and review schedule should be produced. It's worth making sure that all meetings between the customer and vendor are recorded in minutes in case there are any disputes later in the project.

Most projects normally enter a design phase when the initial concepts are detailed and the electrical and control systems are defined. Further simulations may still be required at this stage. Throughout the design stage a Functional Design Specification is developed detailing the mechanical, electrical and control systems. This is a living document that develops over time and may be subject to several Preliminary Design Reviews before a Critical Design Review takes place. At this stage the design is 'frozen' and procurement and construction may commence.

4.1.7 Offsite build

When construction commences, this can be carried out at the customers' site but is usually done at the vendor's site where they have the expertise, tools and materials to hand. This ensures that existing operations can proceed without distraction.

During the build process it's advisable for the customer to visit the vendor frequently to view the new system as it develops. This not only allows progress to be checked but also offers the customer the opportunity to see the systems first hand and highlight any changes that may be needed. These visits could also include members of the customer's production and maintenance teams to allow them to gain first-hand experience of the system.

The outcome of this stage should be the conducting of a Factory Acceptance Test (FAT). There may be pressure from the vendor to rush this test but this should be resisted as any problems identified at this point are more easily rectified than on the customers' site. When conducting a FAT, it is a good opportunity to introduce operators to the system and train them on its use. This is a very useful way to highlight problems that may have been missed in the design phase. In order to effectively do this, it's highly likely that sample parts will be required to be used so that the system's functions are adequately tested.

4.1.8 Installation

Installation and commissioning are often considered to be the same activity, but in this Guide they are split into two distinct activities as there are some clear differences between the two.

Installation is the process of getting the equipment in place and making all necessary connections between them. It's tempting to think that the installation phase is the complete responsibility of the supplier but there are a number of factors that the customer needs to consider at this stage; such as:

(a) the health and safety of the vendor's staff on-site;
(b) adherence to regulations such as Construction & Design Management (2015) and others;
(c) lifting equipment provision;
(d) access to site;
(e) disruption to other activities; and
(f) method statements and risk assessments for the work being carried out.

It's often best to discuss these subjects with the supplier at an early stage to avoid any confusion or delays at a later stage.

4.1.9 Commissioning

Commissioning is distinct from installation because it prepares the system for use in the production environment and optimises all parameters and features for the inputs and outputs that the system encounters in that environment.

This can take some time if the system is dealing with a number of parts or situations so it is worth planning these to minimise commissioning time. It's also worth remembering that a ready supply of parts and production operatives will be required at this stage. The output of this stage should be a Site Acceptance Test, which is the last chance to confirm that the system operates as expected before final handover to you.

4.1.10 Operation

So finally, your new automation system is fully installed and commissioned and final acceptance has been completed; it's time to start using it! But there are a few points to be aware of before getting too carried away. The most important of these is that you ensure that you, as the user, have all the documentation you need to comply with the Provision and Use of Work Equipment Regulations (PUWER). Whilst your chosen supplier can support with this, the onus is on you as the owner and operator of the system to ensure this documentation is created and maintained.

This documentation should also include the Certificate of Conformity (or CE mark) that the supplier should attach to the system and provide to you. But a word of caution here – it's a good idea not to allow the supplier to hand this over to you until you are fully satisfied that they have provided what you asked for (i.e. the system is doing what it should) and you have been fully trained in its operation and maintenance.

Another important point to consider is the training of your production and maintenance team to properly use and service the equipment. But simply training your staff is not enough. For the system to be really effective, it's a good idea to ensure that your workforce understands why you have introduced automation, particularly if staff have been displaced or redeployed as a direct result. You should also consider whether you will be introducing the system in a phased ramp up or in one go (a big bang); the latter is not advised but may be unavoidable.

4.1.11 Maintenance

Now that the system is in use and providing the benefits that you expected, it's time to think about what happens if something goes wrong, or more importantly, how to ensure that the system remains in full working order.

Maintenance issues might have been addressed during the specification phase, but if not, now is a good time to approach your vendor about this. Things to consider include:

(a) warranties (extended or normal);
(b) planned preventative maintenance;
(c) reactive maintenance programs; and
(d) spares holding.

The robot supplier or system integrator may even be able to provide you with a preventative maintenance program that they will charge you to carry out. However, it's also worth considering what you can do as preventative maintenance without resorting to specialist help. This may be as simple as cleaning the robot or as complex as recalibrating the robot itself. Your vendor should be able to assist and the robot (and system) documentation should list preventative maintenance steps.

4.1.12 Reconfiguration

Now that your automation system is up and running for a while, is it time to sit back and relax? Apart from maintaining the system to ensure it is effective it's likely that at some stage in the future you may need to reconfigure the system in some way, either for a part change, new product or to carry out a completely different task.

The process to achieve this should be relatively straightforward if you've followed the steps to an initial implementation as described in this Guide. As with the initial setup, fully understanding what is required from the new system and what the existing system is already doing is crucial to achieving a successful reconfiguration. Once this is done, you can follow the steps previously discussed to reconfigure your system.

IET Standards

Guide to Implementing Industrial Robots

This Guide raises awareness on the best practice associated with the setting up of an automated process, with specific focus on industrial robotics for use in manufacturing and associated industries. The Guide sheds light on some of the key issues to consider when evaluating whether or not a business should automate and the processes involved when the decision to automate has been taken. These issues include:

a) the range of benefits associated with having an automated manufacturing system;

b) the challenges that an automated system presents in terms of its setting up and running; and

c) the process involved in evaluating a business' need for automation, the cost associated with the automation process, the potential risks and opportunities of implementing an automation system and how to effectively manage an automated system.

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