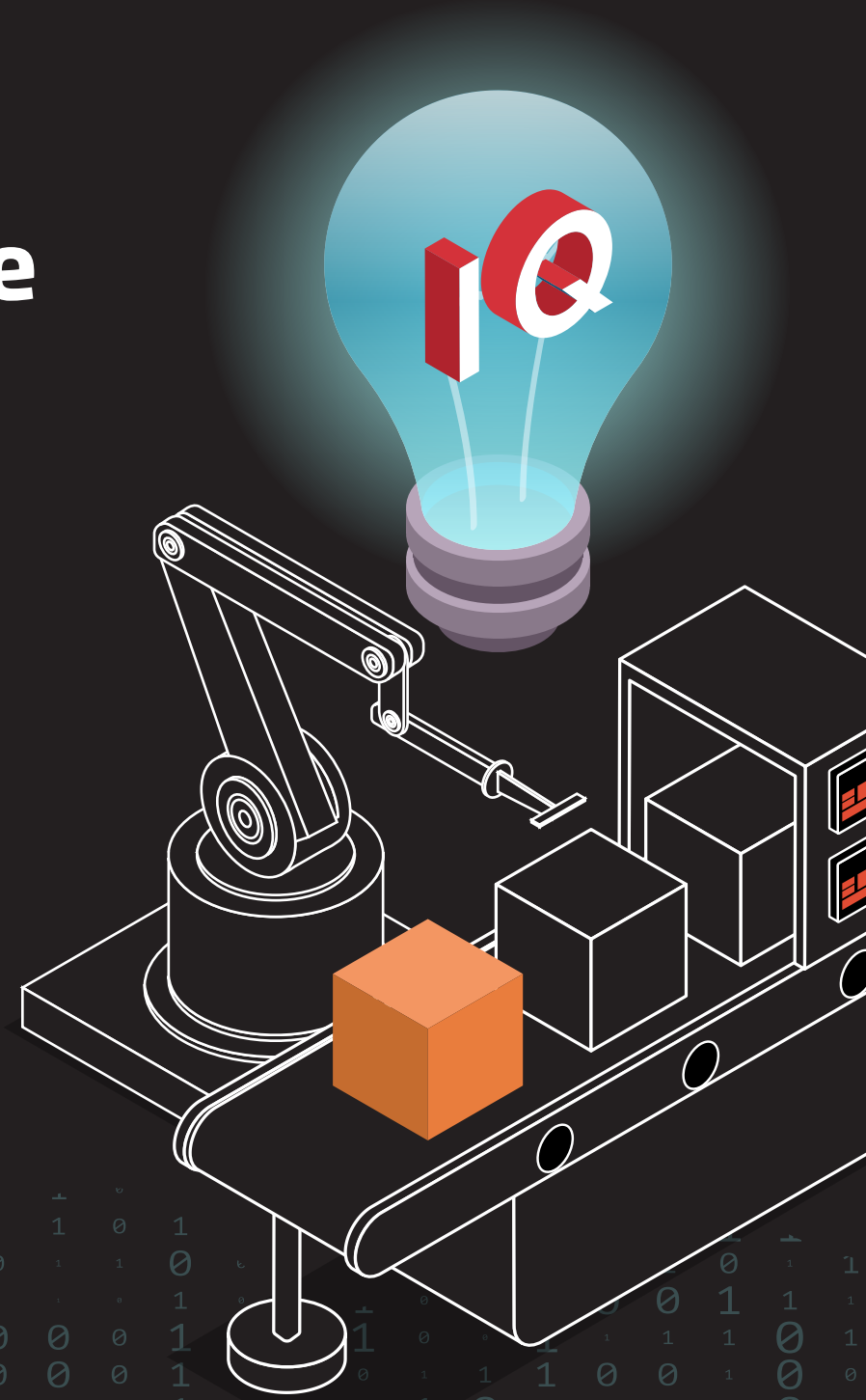
CALCULATOR

AEGIS SOFTWARE

Quantifying Intelligence

How to Calculate Your Smart Factory AIQ



An intelligence quotient (IQ) measures how "Smart" a person is—but what happens when we apply the theory of an IQ, plus Artificial Intelligence, to manufacturing operations? This strategic assessment has been developed for data-driven, Smart assembly factories, with a quantifiable Artificial Intelligence Quotient (AIQ) metric that **reveals strengths and weaknesses, builds roadmaps for improvement and development, increases visibility, and eliminates inefficiencies.**

It is time to put your "Smart," data-driven organization to the test. This calculator guide will detail the areas of the factory that contribute to Smart advantages—and which areas hold business back. Discover how to take a balanced approach towards Smart manufacturing by selecting the right tools to make it a reality. Follow along as you make your own AIQ calculations, and **determine whether your Smart Factory is ready for manufacturing's evolution.**

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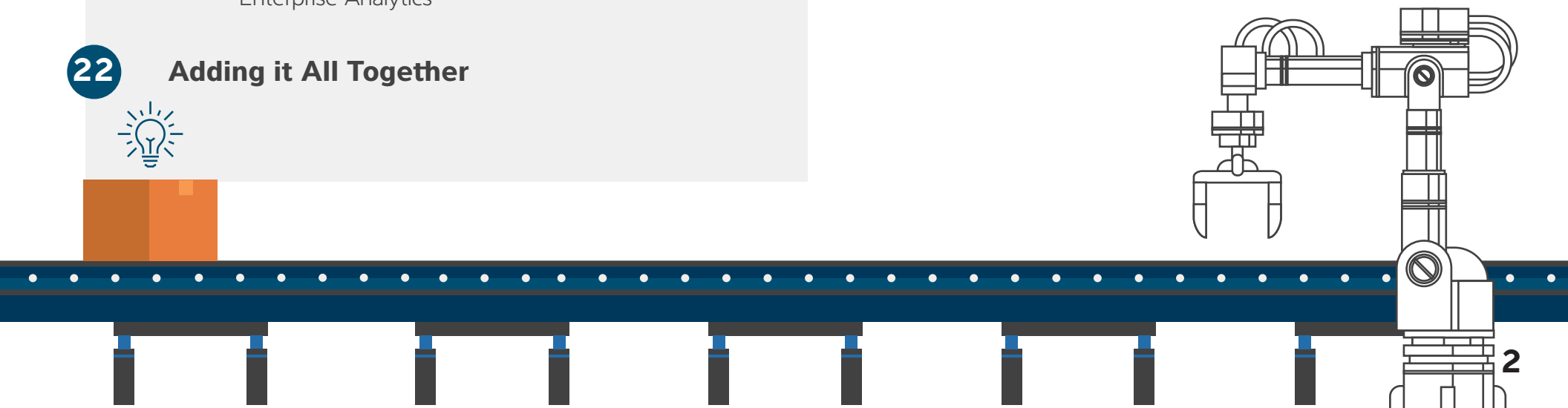
How do we determine AIQ?

To determine the AIQ level of a factory, we will need to establish a set of metrics with two distinct stages.

1 Firstly, consider the Smart potential of data collected and exchanged across the operation.

2 Secondly, consider how that data is used in a variety of Smart applications.

AIQ metrics should be based on rules and calculations that allow for scale. For example, a company twice the size of another is not necessarily twice as Smart.



Taking the AIQ Test

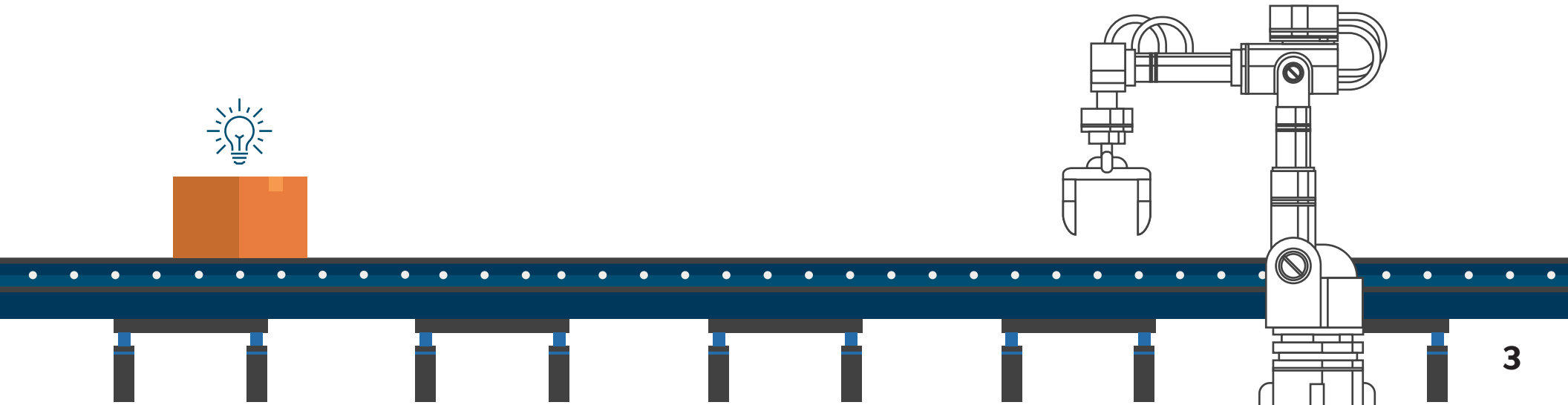
The question is not whether hard or soft automation is Smart or not, but to what extent it is Smart. **Not all Smart solutions are the same.**

Some measure of "AIQ" helps not only to compare an organization's relative merit against peers in the industry, but also helps track progress on the evolution of Smart technology in line with business goals and vision.

Read on to take the AIQ test. Wherever you see a black box, take a moment to make your calculations!

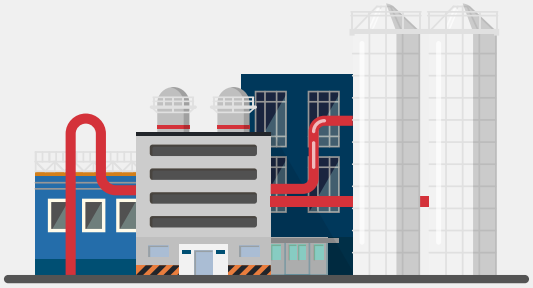
FactoryLogix®

Aegis' vision of Industry 4.0 is centered around soft automation that empowers discrete manufacturing operations to meet modern customer demands while maintaining optimum efficiency, productivity, and quality. If left in the hands of humans who are aided only by aging legacy enterprise systems and point solutions, this would be an impossible task.



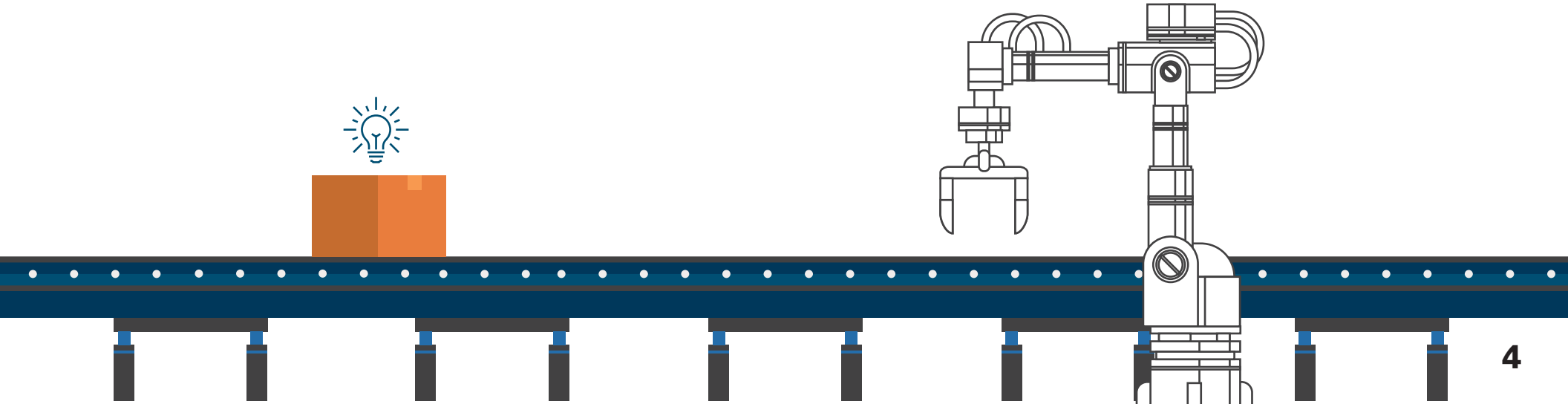
Stage 1: Connectivity

The first stage, connectivity, has many facets of data value associated with each key exchange point or "station" that needs to be measured. These include both automated machine processes and manually executed stations. When completing the first stage of the AIQ assessment, the connectivity AIQ score can be calculated as the sum of the remaining AIQ points across all stations.



EXAMPLE SCENARIO

An initial allocation of 10,000 AIQ points is divided equally between the number of stations. A factory with 50 stations will then, for example, have 200 points per station. We then look at each production station to qualify them against the criteria at that level. If there is a gap, then the number of points for that station is reduced. This reduces the value of potential contribution to the Smart Factory.



Automated Data Acquisition

For automated stations, the initial number of AIQ points depends on achievement of the following criteria:

IIoT Technology

The key aspect of IIoT architecture is that the connection is "one to any," meaning that data may be exchanged with many different stations and used for many different purposes. There is no specific focus on a specific point-to-point application or use case, as is typical for non-IIoT-based interfaces.

-25%

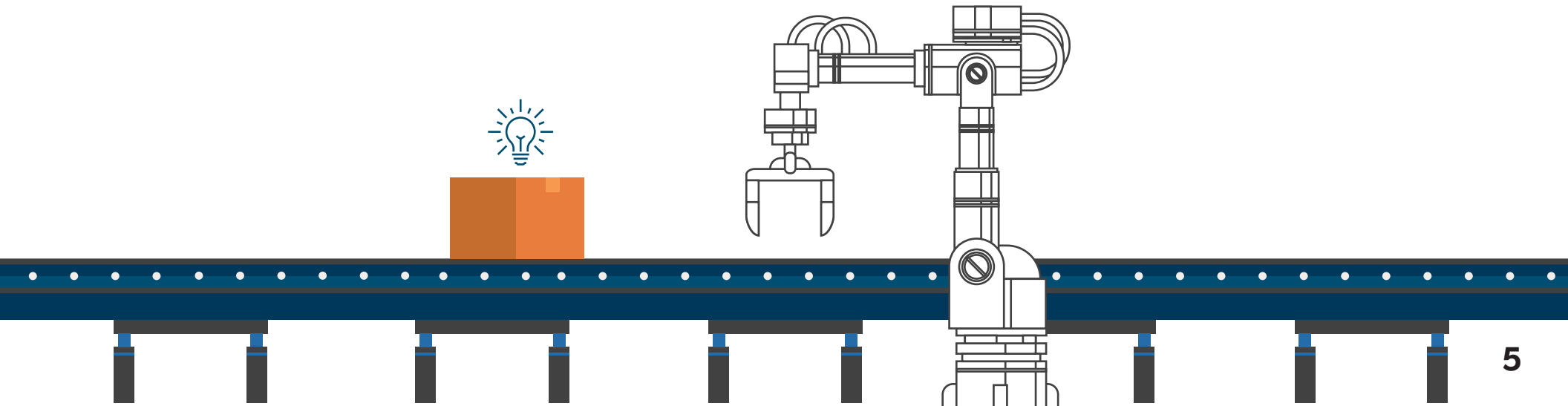
AIQ points should be **reduced by 25%** if the station interface is not based on true IIoT technology.

Common Defined Language

If there is variation in how information is expressed, continuous additional interpretation and translation of the data meaning is needed. This introduces potential issues with data management across the operation, including establishing baseline language for all possible interpretations.

-25%

AIQ points should be **reduced by 25%** if the data format requires significant translation due to variances.



Exact Association

Data exchanged should relate to an exact trigger; for example, a material consumed came from a specific identified carrier.

-20%

AIQ points should be **reduced by 20%** if the association of specific source material unique ID, or the consumption point component reference designator, cannot be guaranteed.

Timeliness

Data exchange should be event-driven, with information being made available to Smart applications immediately.

-25%

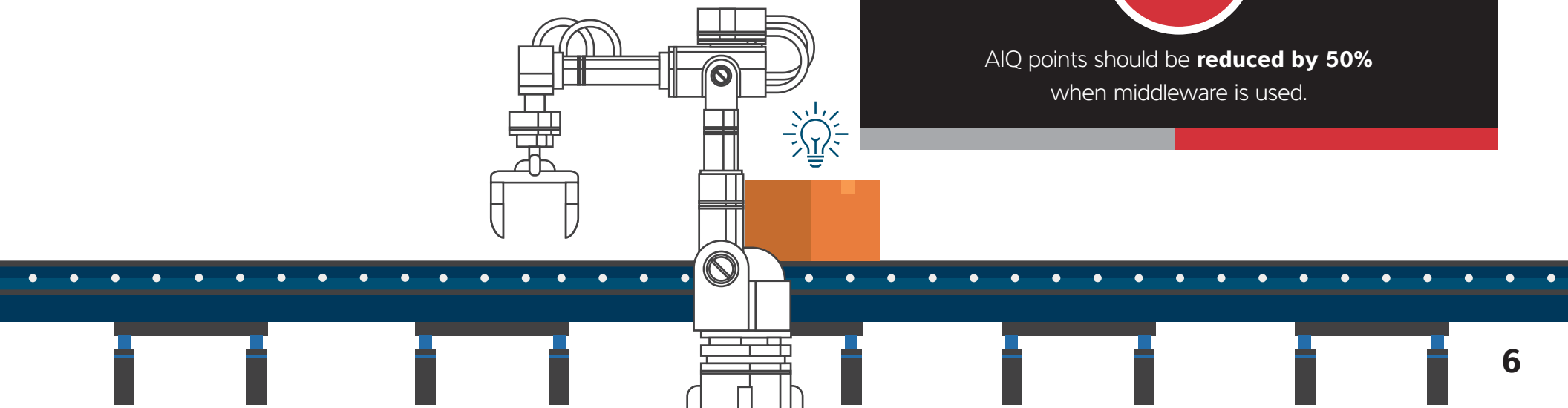
AIQ points should be **reduced by 25%** when information about an event is delayed for a period, especially if the interface is based on a polling narrative.

Middleware

Where a third party is required to help acquire or translate data, the result is middleware. Its use introduces significant ongoing risk, and potentially unlimited ongoing support, should anything change regarding the data transfer.

-50%

AIQ points should be **reduced by 50%** when middleware is used.



Level of Detail

The minimum level of detail required differs between equipment, but it is essential that common data meets a minimum requirement. The best reference to assess this is the IPC Connected Factory Exchange Standard (IPC-2591), v1.3 or later, which lists the minimum requirements of data exchange.

-20%

If any requirement from this list is not met, AIQ points should be **reduced by 20%** progressively for each item that is missing.

Automated Data Acquisition Total: _____

Bi-Directional Capability

There are many use cases where information is received by a station in addition to the station sending data out to others.

-25%

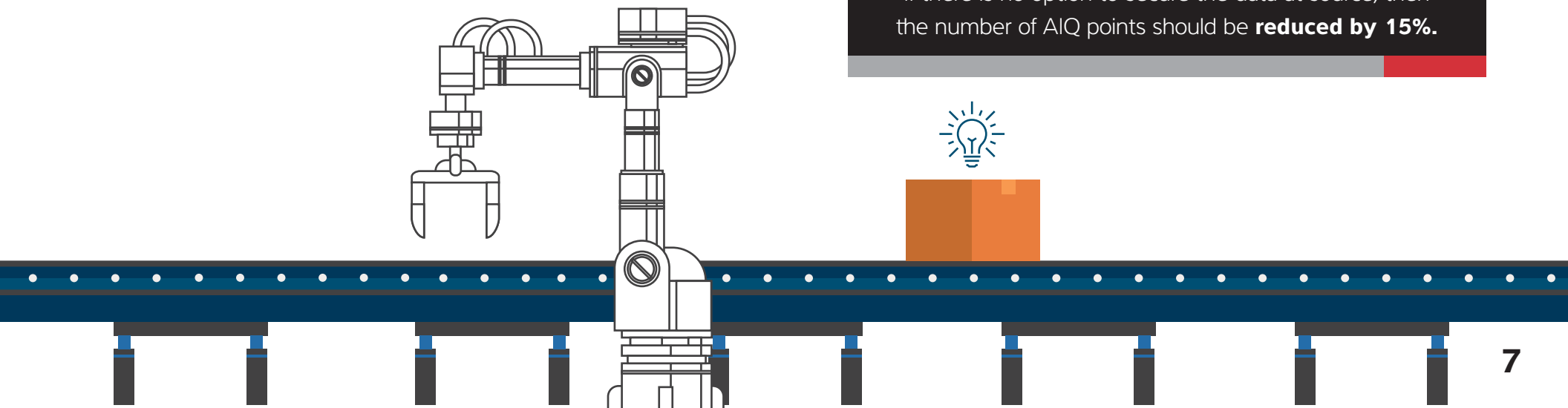
AIQ points should be **reduced by 25%** if the station does not support the bi-directional flow of data.

Security

Manufacturing data in sensitive applications, such as that regulated by ITAR, for example, should be encrypted at the source to retain data security.

-15%

If there is no option to secure the data at source, then the number of AIQ points should be **reduced by 15%.**



Manual Data Acquisition

For paperless manual stations, reduce initial AIQ points depending on achievement of the following criteria:

Level of Detail

As with automated data collection, the requirements for the minimum level of detail differs according to what actions are performed. For manual processes, the best reference is to use the CFX standard section that lists the minimum requirements according to process type.

-20%

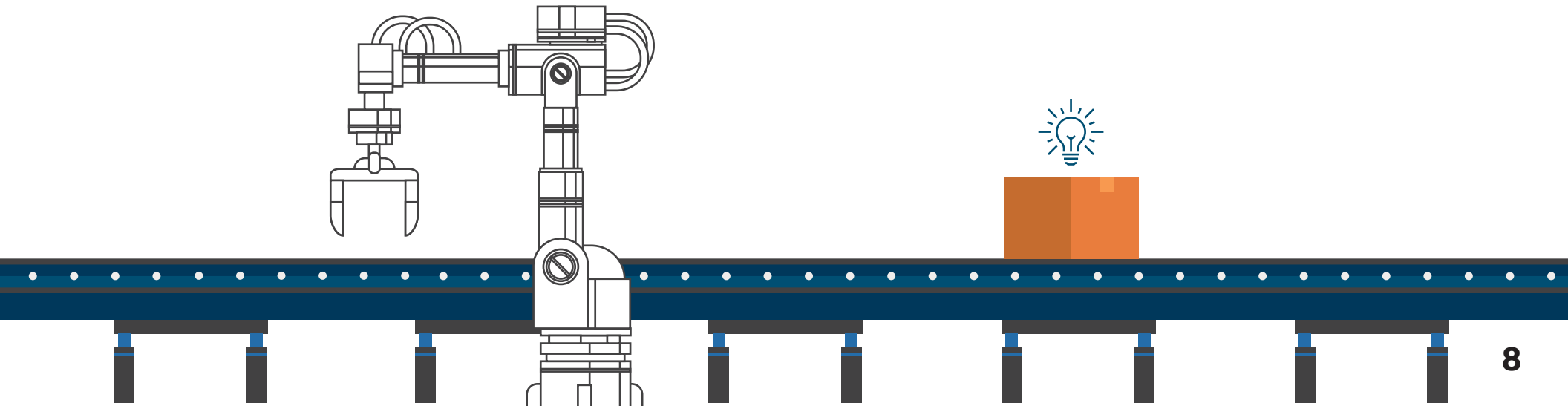
If any area of data collection isn't supported, AIQ points should be **reduced progressively by 20%** for each that's missing.

Input Qualification (List)

Wherever possible, free-form data input must be avoided. Choosing an input from a contextualized list of possible choices ensures no interpretation of data is needed, and input is accurate and complete.

-50%

AIQ points should be **reduced by 50%** where free-form data is used to record key data.



Input Qualification (Range)

Where it's necessary to enter values, like measurement taken, the entered value should be compared to the limits expected for the measurement. It's good practice to not share the limits with the operator, but to prompt for confirmation if a value is entered that's out of range.

-15%

Where input qualification of values entered is not performed in this way, the number of AIQ points should be **reduced by 15%.**

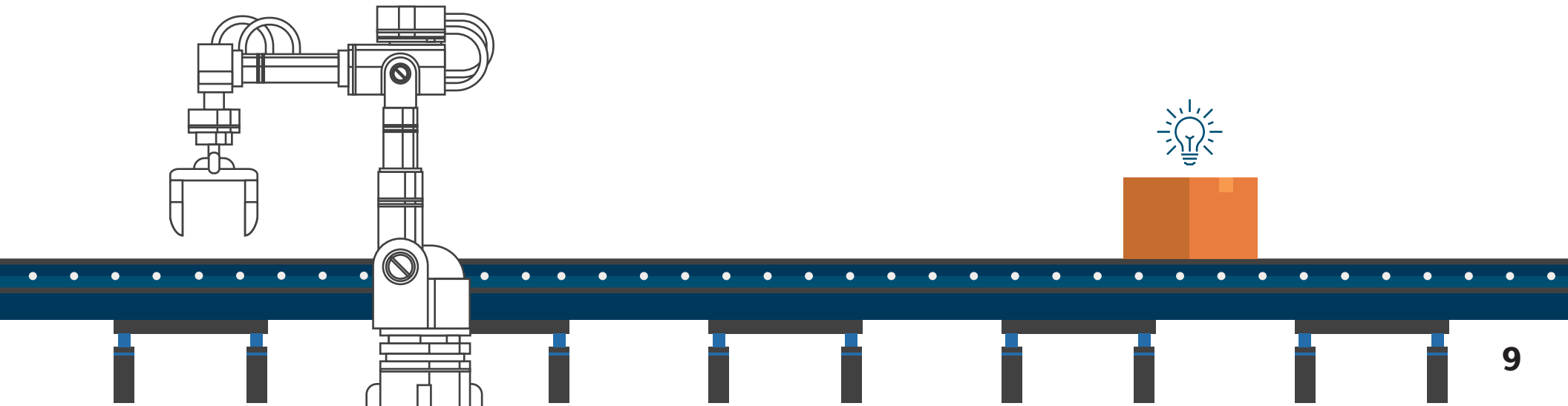
Timeline

Data capture at manual stations should be event-driven, as in automated data capture.

-50%

AIQ points should be **reduced by 50%** where information about an event is delayed for a period.

Manual Data Acquisition Total: _____



Stage 2: Data-Driven Manufacturing Values

The next stage is to determine whether the data from each station is being used effectively in key Smart manufacturing applications. In the next stage of assessment, we will measure the effectiveness of the accumulated "Smart data" as it is used in real-time for automated decision-making and analyses that contribute to the factory's overall performance.

Each of the applications may be relevant to some or all the identified production stations. In each case, an assessment should be done for the stations directly involved in the activities listed. Individual station scores are, therefore, likely to be affected by more than one application.

There are seven key Smart application areas to assess. The AIQ assessment method for each of these applications is to take the currently accumulated AIQ points for each station as the starting value. Various aspects of how the data is used in these applications will determine how to adjust the number of points for each station.

If there is no use of data in a particular application, basic requirements are not fulfilled and all the reductions apply with no increase in points due to advanced data usage. **The greater the degree to which each area is data-driven, the higher the score of each station in the factory will be.** At the end, the total points from all seven application areas are added to get the final AIQ result for the factory operation.

Let's walk through each of the seven areas in order to perform the calculations:

Manufacturing Process Execution

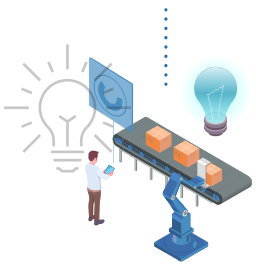
Active Quality Management

Lean Materials Management

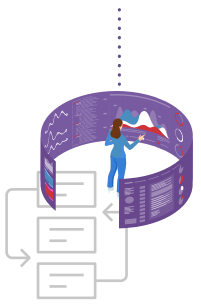
Adaptive Planning

Digital Manufacturing Engineering

Manufacturing Intelligence



Enterprise Analytics



Manufacturing Process Execution

Basic Functions

Process Status

Understanding the status of every production station, whether automated or manual, is vital in identifying needed actions and strategizing increased asset utilization. As the production station is running, supervisory systems determine minimum cycle time, productivity etc. Calculations of various basic performance metrics are determined or qualified by the basic process status.

-50%

AIQ points should be **reduced by 50%** if Smart data is not used to show continuous visibility of the status of the station.

Processing Event Information

As each production unit is being processed, information about the operation is used to create full traceability information and refine productivity calculations. Should the station stop or pause, the exact explanation from its point of view must be communicated.

-50%

AIQ points should be **reduced by 50%** if Smart data is not being used to provide analysis of the operation determining accurate productivity levels, identifying causes of lost opportunity, etc.

Production Unit Qualification

As products arrive at the production station, the exact ID of the production unit should be confirmed. Quality issues can happen when the incorrect production unit is processed. Without reading individual production unit IDs, data collected during processing cannot be specifically applied.

-40%

AIQ points should be **reduced by 40%** if the automated qualification of the specific production unit is not being done prior to entry to the production process.

Operational Result Capture

Data captured at the end of the operation at each station determines eligibility for progress to the next station or diversion to an inspection or repair station, for example.

-40%

AIQ points should be **reduced by 40%** if Smart data is not being used to control automated routing of passed or failed production units.

Advanced Functions

Machine Learning / Closed Loops

The principle of the analysis of data derived from production stations is used to discover sources of variation related to key process metrics and subsequent decision-making. In the case of a single machine, it's called Machine Learning. Closed loops follow a similar process involving two or more stations, with inspection data used to suggest corrections for prior and future stations to reduce the likelihood of significant variation causing a defect.

2x

AIQ should be **multiplied by 2** where such machine learning and closed-loop software technologies are being utilized.

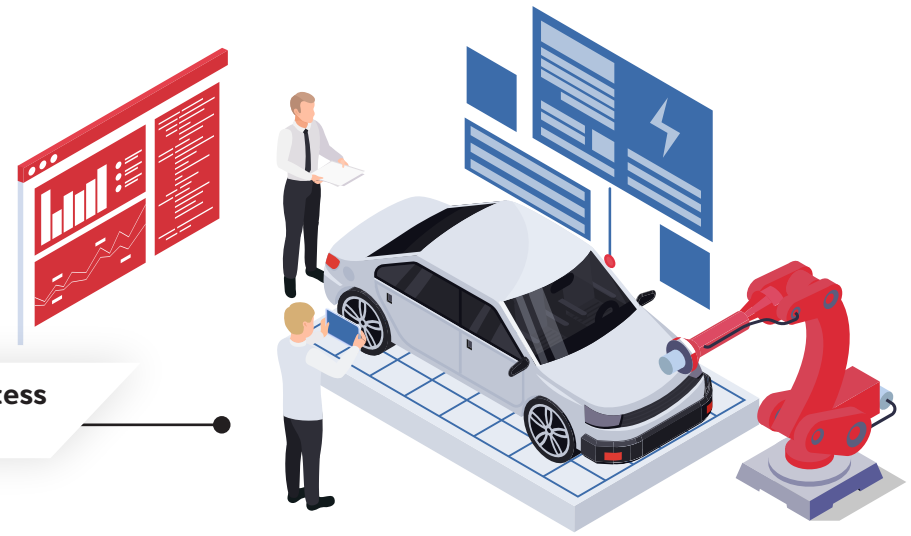
Poka-Yoke Control

Automatically stopping a production station is essential when a repeating quality concern has been detected. Active quality solutions detect these automatically based on Smart data, highlighting issues and safely preventing the station from continuing to produce poor quality.

1.5x

The remaining number of AIQ points should be **multiplied by 1.5** if the automated station can be automatically and safely stopped, or the manual station is automatically instructed to stop.

Manufacturing Process Execution Total: _____



Active Quality Management

Active Quality Analysis & Control

As machine vendors utilize data exchange between machines as part of closed-loop solutions, the same concept should be applied to wider line operating conditions. Active Quality Analysis utilizes data from all sources to perform analysis that ensures quality metrics are contained within control limits. SPC or 6-Sigma methodologies provide early warning mechanisms that identify increased risk of defects in advance.

+50%

AIQ points should be **increased by 50%** where the station is capable of contributing quality-related data, and the data is actively used for analysis.

Use of Traceability Data

As quality improves, most defects fall into the one-off category. Analysis of traceability data can find the most likely root cause of a defect but can also identify other products made under similar conditions that may have similar weaknesses, reducing the risk of early field failures.

+50%

TAIQ points should be **increased by 50%** where traceability data derived from a station is being utilized in this way.

Electronic CAPA / FRACAS

Where variation or specific root causes have been found, it is important to document the corrective action taken and define preventative actions to eliminate recurrence. Implementing this through physical and electronic action, with alarms raised and production processes stopped where acute risk is identified, creates a superior level of quality management.

+100%

AIQ points should be **increased by 100%** where data from production stations is utilized in this way.

Automated Compliance & Conformance Reports

In each industry sector, different requirements exist for reporting adherence to specific rules and regulations in approved formats. For quality systems that use Smart data, any required report format should be created using built-in templates and automatically populated using data from production stations.

+20%

AIQ points should be **increased by 20%** where the station has data utilized for this activity.

Active Quality Management Total: _____

Lean Materials Management

Basic Functions

Unique Material Identification

Materials are identified by ERP by part number and are then assigned a good received note (GRN) number at arrival. Each carrier, however, once booked into the site, starts its own unique journey. In any Smart factory, identification on an individual carrier and material basis is essential to accurately manage storage, selection, consumption, and spoilage, ensuring accurate inventory levels. Where management of materials is not controlled using identifiers that are unique to the carriers or materials, the benefit from advanced material management is negligible.

-30%

In such cases, the number of AIQ points for any station that utilizes materials should be **reduced by 30%.**

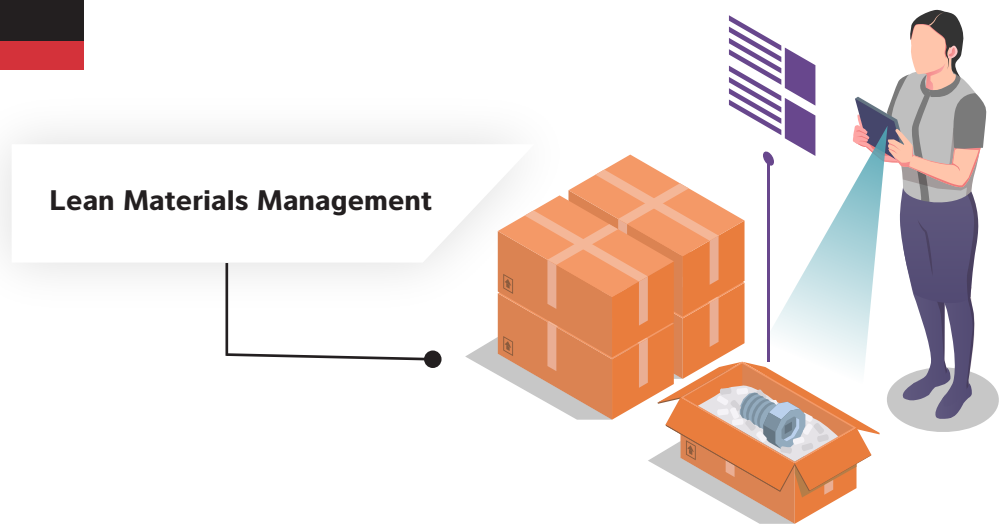
Advanced Functions

Advanced Storage Strategy

The organization of materials based on part numbers quickly becomes wasteful, with space allocation and re-positioning becoming increasingly difficult. Managing locations using a random method, where materials can be stored in logically defined locations, can effectively double the warehouse space capacity and halve operational costs.

+25%

The number of AIQ points for all stations that utilize materials stored in this way using an automated solution should be **increased by 25%.**



Logistics "Pull" System

Lean Material Management, using materials as the trigger to supply materials to production stations, represents a significant reduction of material-associated costs, such as inventory investment, space, and logistics.

+150%

Where the Lean "pull" system is introduced as an automated function, replacing ERP "push" system, the number of AIQ points for stations consuming materials and providing data used to create triggers should be **increased by 150%.**

Advanced Material Management

Certain materials require specialized storage and processing, such as temperature control, anti-static, anti-moisture, with associated drying and baking processes etc., to remain usable.

+25%

Where such rules for material management are automated, the number of AIQ points for stations that utilize such materials should be **increased by 25%.**

ERP Back-Flush Elimination

With the availability of continuous information related to material usage and spoilage, the feedback to ERP should be immediate. In non-Smart systems, ERP designates material quantities as simple completion count, often referred to as the "back-flush" method. This means consumption data is not available until the work order has been completed.

+15%

Where the "back-flush" method has been replaced with the use of live information, the number of AIQ points for each associated station should be **increased by 15%.**

Automated Inventory Count

Data can be used to automatically decrease the count of materials consumed or spoiled as part of the assembly process. Smart supply-chain automation utilizes this information to maintain the accurate count of materials associated with each carrier, replacing the need for manual counting and periodic stock checks.

+20%

AIQ points should be **increased by 20%** where data from each station is used to maintain inventory levels in such an automated way.

Lean Materials Management Total: _____

Adaptive Planning

Visualization

The status and progress of current production, visualized as a timeline, with extrapolation to completion of current commitments, is a basic element of adaptive planning.

+15%

AIQ points points should be **increased by 15%** where this is provided automatically.

Dependencies

Where the visualization includes the calculation of the availability of dependent items, such as the availability of materials, sub-assemblies from prior processes, tools, etc...

+10%

Then the number of AIQ points should be **increased by 10%** for each of the three types of dependent items.

"What If" Scenarios

As any planning decision involves the prioritization of some factors over others, it is important to be able to judge the effect of any planning decision before making a commitment.

+5%

Where a "What if" feature is included as part of the adaptive planning solution, the number of AIQ points should be **increased by 5%.**

Adaptive Planning Total: _____

Digital Manufacturing Engineering

Basic Functions

Design Data

Virtually every product in production has been designed using Computer Aided Design (CAD) tools. But multiple documents and data listings derived indirectly from design are used to create manufacturing work instructions and machine programming data. This leads to mistakes and inconsistencies that require time and iterations to perfect. The use of digital twin data, made from 3D-CAD and electronic design data for products incorporating PCBs ensures the full potential of design data is available for manufacturing, without risk of duplication of effort and mistakes.

-30%

When production stations are set up, have operation documentation, or are programmed using indirect design data supplied on paper, in lists, emails, PDF files, etc., the number of AIQ points should be **reduced by 30%.**

BOM Processing

The Bill of Materials (BOM) flow starts from the design process and is altered and processed by global and local purchasing teams following internal policies. The aim is to guarantee good quality, cost-effective materials, often obtained simultaneously from multiple sources. The frequent omission of clear, unique identification of components, and the plethora of identification methods used means that BOM data is a frequent source of errors. An advanced BOM management function within the MES solution eliminates these issues, with automated confirmation of every component and material.

-30%

Where a specific advanced BOM management tool is not utilized, the number of AIQ points for each affected production station should be **reduced by 30%.**

Assignment to Configuration

Where engineering solutions create digital twins of potentially complex products without pre-assignment to specific configurations, flexibility is introduced such that the planning operation is free to select the best configuration available for the desired rate, as customer demand changes.

+30%

AIQ points should be **increased by 30%** where stations are operated without set pre-assignment of product allocation.

Paperless Work Instructions

To ensure quality assembly as part of the Industry 4.0 flexible factory, knowledge of basic steps, updates, changes, variants, and product tailoring must be accurate. This cannot be guaranteed when using paper, which can be lost, misplaced, or out-of-date.

-50%

AIQ points should be **reduced by 50%** where paper is used at any station for operation or work instructions.

Advanced Functions

Engineering to Order

There are many use cases where products need to deviate from intended flow or follow a bespoke path depending on work that is necessary, for example, for an MRO (Maintenance, Repair & Operations) work order. The same principle applies where a few or less units are to be built, with configurations created on the fly aided by templates.

+25%

AIQ points should be **increased by 25%** where production stations are designated as part of an Engineering to Order environment.

Configure to Order

Multiple variants of products are often made in a factory. Operations must adapt to different variants depending on changing customer demand, with each variant processed as an individual product. In the Smart factory, a single, dynamic bill of materials is used to greatly reduce engineering time and complexity, reducing the risk of issues when switching from one variant to another in agile mixed production.

+12%

Where such variants exist, and specific production stations are used in this way, the number of AIQ points should be **increased by 12%.**

Automate to Order

Automate to order allows bespoke tailoring of parameters for each individual piece or quantity, with subsequent work instructions automatically updated with determined values. This ensures control and efficiency in even the most extreme environments.

+25%

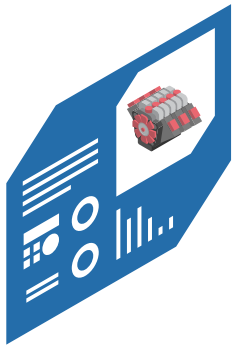
AIQ points should be **increased by 25%** where production stations are set up to perform this kind of work.

Use of Augmented Reality

The use of Augmented Reality allows operators to move from station to station, performing their activities "hands free," with the same paperless work instructions and references, but without need for MES IT hardware, reducing investment in hardware and IT infrastructure and promoting flexibility.

4x

Where augmented reality "stations" are used, the number of AIQ points should be **multiplied by 4.**



Digital Manufacturing Engineering

Digital Manufacturing Engineering Total: _____

Manufacturing Intelligence

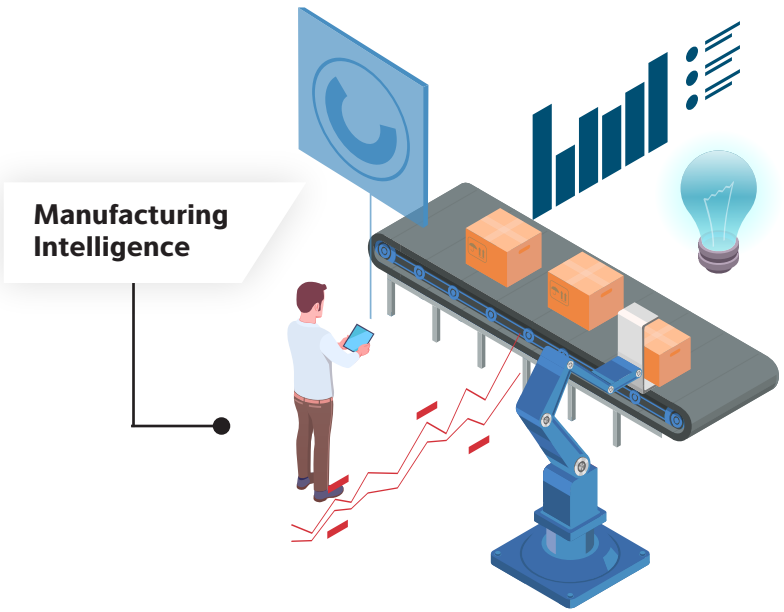
Basic Functions

Dashboards

Each production station should be included in all relevant KPIs, continuously displayed at or near the station. For every potential issue and trend that adversely affects the station, the dashboard must be able to clearly show trends and empirical information.

+25%

AIQ points should be **increased by 25%** where such information is complete and correctly displayed.



Manufacturing Intelligence Total: _____

Advanced Functions

Reports, Alarms & Alerts

Most reports have no effect or bearing on the Smart production factory, as their content is historical with no opportunity for recovery. An exception to this is where the rules-based engine has detected a trend, such that an action has been determined to prevent further consequences.

+40%

In cases where the production station is included for this kind of functionality, AIQ points should be **increased by 40%.**

Ontology

The way solutions understand the meaning and relationships of data and how they work together to create actions, alerts, and analytics is called the ontology within the solution. In many cases however, results are based on fixed rules. In such cases, a small, often unnoticed change can invalidate results, creating waste and lost opportunity. A good indication of robust ontology is where the solution allows a change to be added ad-hoc with zero code or system changes, and all analytics continuing to work.

+40%

AIQ points for each affected production station should be **increased by 40%** where a robust ontology can be demonstrated consistently.

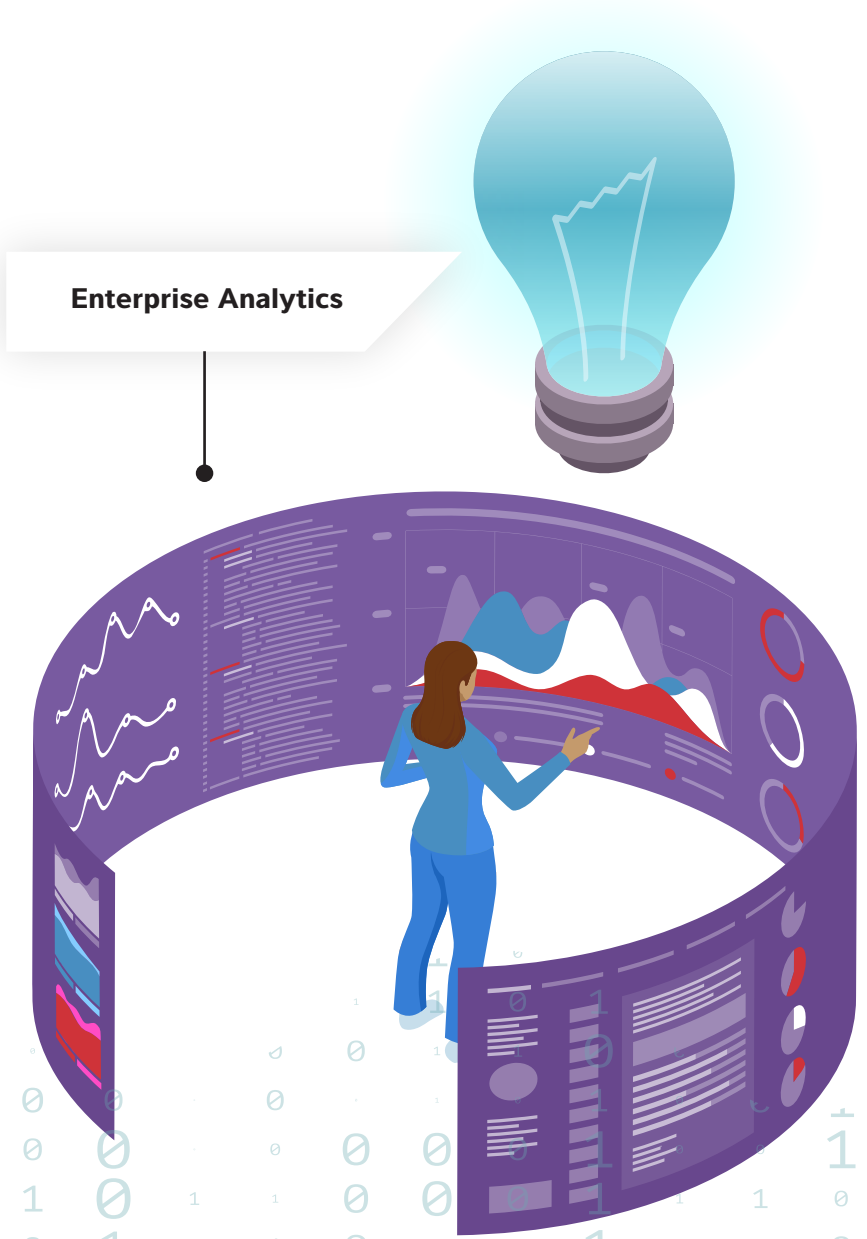
Enterprise Analytics

Contextualized Data

Enterprise business systems, many of which feature Business Intelligence (BI) tools, benefit from summarized and standardized data that combine information across multiple sites. BI tools can be used effectively with manufacturing data, eliminating the need for software customization and adaptation.

-25%

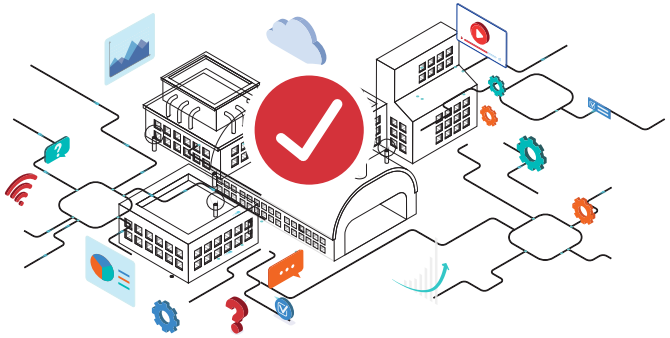
Where non-contextualized data is utilized by enterprise analytics, the number of AIQ points for each included station contributing should be **decreased by 25%.**



Enterprise Analytics Total: _____

Manufacturing Process Execution
+
Active Quality Management
+
Lean Materials Management
+
Adaptive Planning
+
Digital Manufacturing Engineering
+
Manufacturing Intelligence
+
Enterprise Analytics

FactoryLogix®



Adding it All Together

At the end of the second stage of Smart Factory AIQ determination, we add together the final AIQ points for each station, having been adjusted progressively through consideration of each Smart application. In isolation, the final result is not important, unless comparing factories within the same organization or comparing results with friends.

The real importance is how the data highlights which areas are contributing to the advantages of being Smart, and which are holding the business back. Action can then be taken to ensure a balanced approach towards Smart manufacturing, and that the right tools are chosen in order to make it happen.

Grand Total: _____

Empower Your Smart Factory with a Solution that Optimizes AIQ

Aegis' FactoryLogix is an IIoT-driven MES that has been designed to lead world-class Smart manufacturing initiatives, providing every opportunity to achieve the maximum number of AIQ points. It provides tangible, realistic, and cost-effective Industry 4.0 advantages that help organizations prepare for the next stage of advancement in innovation. **Visit aiscorp.com to see how.**

Want to learn more about achieving a high AIQ?

Read the Whitepaper

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