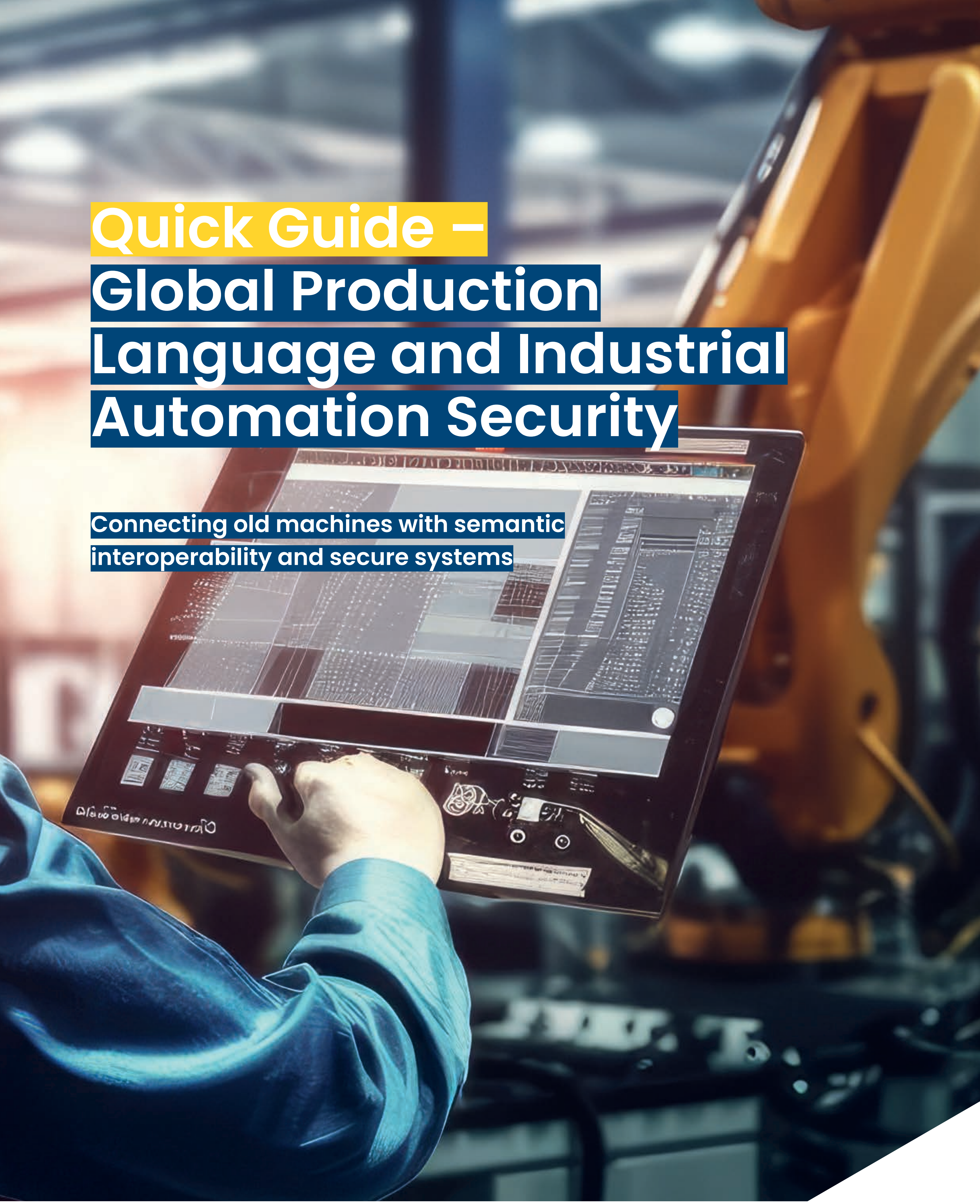

Quick Guide – Global Production Language and Industrial Automation Security

Connecting old machines with semantic interoperability and secure systems

GPQI
Dialogues for Innovation and Trade

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On behalf of
German Federal Ministry for Economic Affairs and Climate Action (BMWK)
Berlin, Germany 2023
Jakarta, Indonesia 2023

Text
Global Project Quality Infrastructure

The German Federal Ministry for Economic Affairs and Climate Action (BMWK) has commissioned the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH to implement the Global Project Quality Infrastructure (GPQI).

Implemented by

Federal Ministry for Economic Affairs and Climate Action

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Introduction

The transition to *Industrie* 4.0 is often perceived as a huge challenge, particularly for companies with low resources. Retrofitting 4.0, the process which makes existing equipment and software able to adopt *Industrie* 4.0 technology, may be the low-cost solution. In fact, most of the global lighthouse projects for *Industrie* 4.0 were created by transforming pre-existing operations (brownfield).[1]

Furthermore, adoption of *Industrie* 4.0 technologies can streamline tasks performed by humans. This opens up opportunities for upskilling and reskilling employees in readiness for better, more human-friendly tasks.

This guide highlights four crucial elements that are relevant to small and medium-sized industrial enterprises making the successful transition to *Industrie* 4.0.

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[1] World Economic Forum. 'Fourth Industrial Revolution: Beacons of Technology and Innovation in Manufacturing' WEF White Paper, January 2019

1

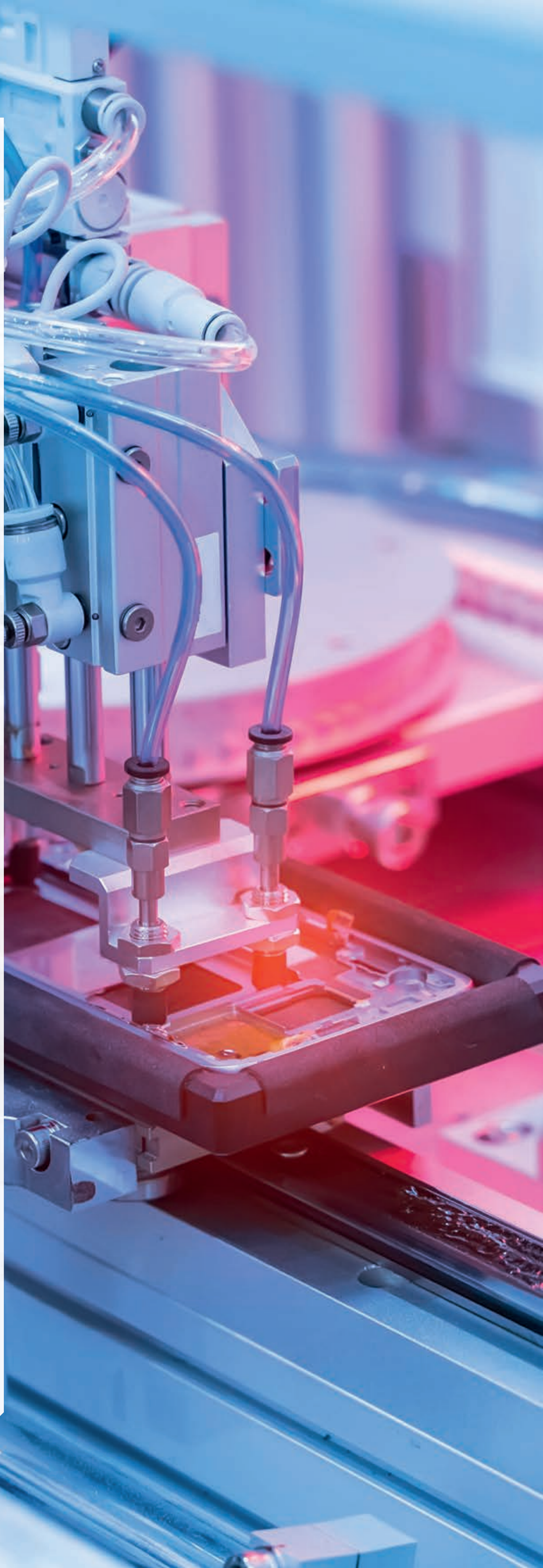
Assessing companies' readiness using the *Industrie* 4.0 readiness index

As a first step on the journey transition, companies can assess their readiness level using available indexes. This assessment supports companies by providing ideas on where to start and what to prioritise during their transition. Indonesia has developed the Indonesia Industry 4.0 Readiness Index (INDI 4.0), which establishes five pillars for measurement: management and organisation, people and culture, products and services, technology, and factory operation.

By undertaking these measurements, companies can identify applicable improvements to close the gap between their existing manufacturing systems and their target level of *Industrie* 4.0 implementation for each pillar.

For the INDI 4.0 assessment, companies are invited to fill out an online survey in the National Industrial Information System (SIINas) https://siinas.kemenperin.go.id/. Following this, a verification process will be carried out by designated experts through a site visit. The INDI 4.0 readiness scores range from level 0 to level 4 (0 = not ready to transition, 1 = early stage, 2 = medium stage, 3 = ready, 4 = already implement Industrie 4.0).

Transition to *Industrie* 4.0 is a step-by-step process. It is not necessary for companies to implement all Industrie 4.0 features and technologies at once. In other words, now is the right time for companies to start the transition.



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2

Adapting old machines and business process to the new digital reality

The starting point for companies is to define the main objectives, manufacturing pain points or critical issues they want to address in their transition to *Industrie* 4.0. This will help with deciding which features and technologies of *Industrie* 4.0 need to be adopted. Companies can achieve improvements by prioritising simple, low-cost and rapid-return technologies.

Assessing the condition of existing equipment is also required. The adaptation of old machines to ***Industrie*** 4.0 components depends on the existing technologies (i.e. system and controller) used in the machines. In some cases, installation of additional components is required.

Furthermore, digitalisation can also be embedded in business processes to transform manual tasks, which can be time-consuming for companies. One way to transform this process is via web or mobile applications, replacing the paperwork for the check sheet.

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3

Using open standards for machine communications

Industrie 4.0 previews the need to connect different types of machines and systems from different manufacturers. In order to reduce integration costs of machinery, a universal language for machine-to-x communication has been developed, so that machines from different vendors can be connected reliably with each other and integrated efficiently with upper layer systems such as Manufacturing Ecosystem Systems (MES).

4

Ensuring the security of industrial automation and control systems

Since *Industrie* 4.0 enables the interconnectedness of operations – particularly between information and operation technology – ensuring security in connectivity is crucial. Moreover, when using Open Platform Communications, industrial companies become more vulnerable to outside parties gaining access to their system. Hence, security in the storage, transfer and processing of data must be guaranteed. In this context, a set of international standards has been established to provide guidance on designing secure systems for industrial application.

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How did it all start?

During the Hanover trade fair in 2011, representatives from German industry, academia and the German Government revealed their shared vision of how emerging digital technologies would impact the future of manufacturing industries. This concept was then named *Industrie* 4.0.

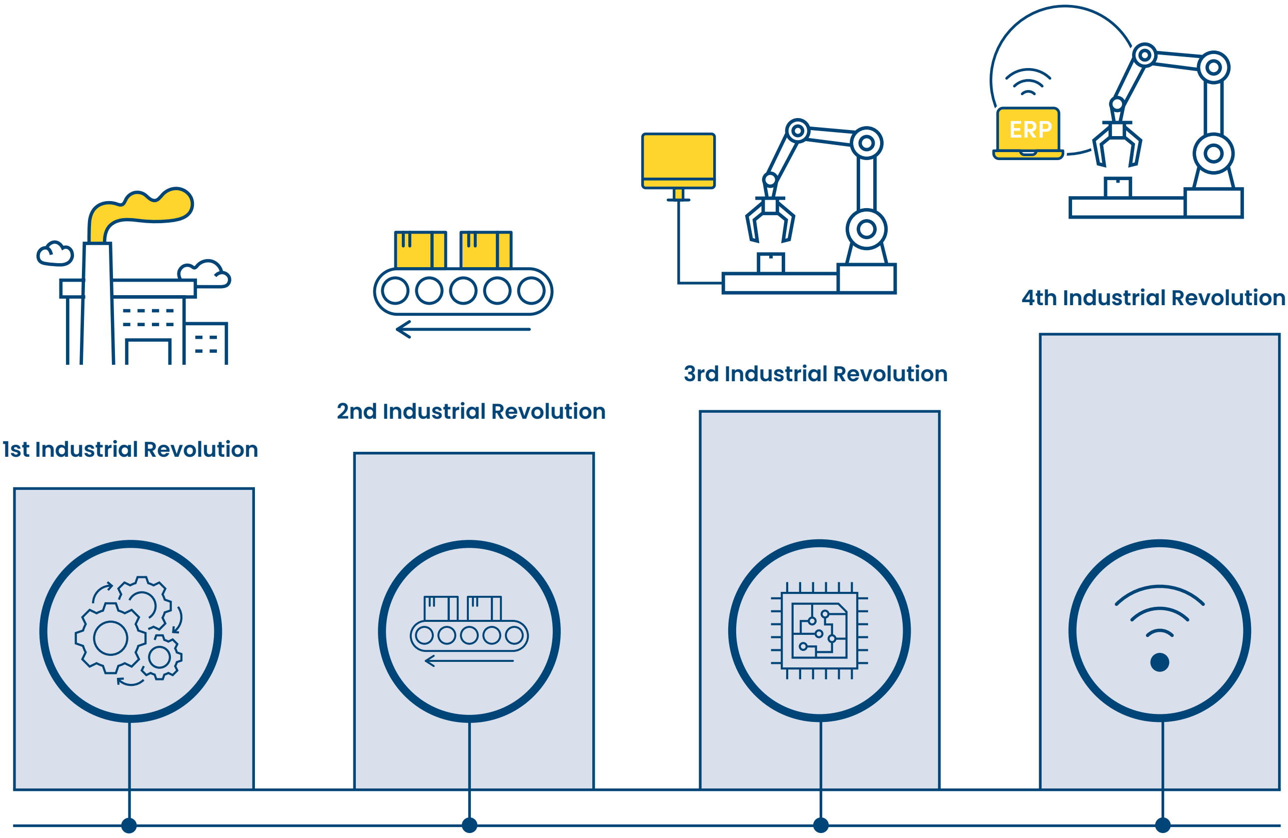
Unlike the introduction of industrial automation (Industry 3.0) in previous decades, digitalisation (*Industrie* 4.0) enables:

- automatic gathering and processing of more complex, real-time and larger volumes of data in production processes;
- automatic exchange of information and processes between machines.

To gain the benefit, companies should translate findings from the data into actions, in order to enable:

- agile reaction to increasingly frequent changes in demand;
- understanding of cause-effect relationships in production processes;
- achievement of sustainability objectives.

In both the 3rd and 4th industrial revolutions, the same question arose: how to adapt old machines and equipment to new technologies?



MECHANISATION

- ☑ increase physical capacity

Replacement of equipment, percentage of installed base:

100%

replacement of complete loom necessary[2]

INDUSTRIAL ORGANISATION

- ☑ standardise methods and processes

Replacement of equipment, percentage of installed base:

~ 10–20%

little replacement, as tooling equipment could be retained; only conveyor belt needed.

AUTOMATION

- ☑ increase productivity
- ☑ improve quality
- ☑ improve process efficiency

Replacement of equipment, percentage of installed base:

~ 80–90%

high level of replacement as tooling equipment was replaced by machines.

DIGITALISATION

- ☑ manage in real time
- ☑ understand complex causalities
- ☑ generate autonomy of machines and processes
- ☑ mass customisation to adapt to personalised customer demands

Replacement of equipment, percentage of installed base:

~ 40–50%

existing machines are connected, only partial replacement of equipment.

© source: Festo Brasil

[2] Statistisches Bundesamt; Deutsche Bundesbank; Prognos; Thomas Nipperdey; McKinsey & Company, see World Economic Forum. 'Fourth Industrial Revolution: Beacons of Technology and Innovation in Manufacturing' WEF White Paper, January 2019

Retrofitting 3.0 and 4.0 What are the differences?

The answer lies in retrofitting, a term used to describe the process of upgrading machinery and equipment. Based on its characteristics and stages, retrofitting can be divided into Retrofitting 3.0 and Retrofitting 4.0. It is necessary to note important differences between these two types of retrofitting. →

Classic industry retrofitting or Retrofitting 3.0

focuses on upgrading the physical production process and mechanical components. Classic retrofitting aims at the automation of machinery and equipment in terms of productivity, quality, energy efficiency and longevity. The payback is typically calculated in terms of cost reduction and/or increase in output.

Example: exchanging a stepper motor in a machine tool for a model with lower energy consumption.

Retrofitting 4.0

focuses on upgrading or installing electronic components (controllers, network connectivity or sensors) in machines with *Industrie* 4.0 technologies (cloud computing, Internet of Things, artificial intelligence (AI) and machine learning, etc.). Retrofitting 4.0 aims to enable the collection, transmission and processing of production data for decision-making, either by employees or by other systems and equipment. In this case, there needs to be convergence of the operational technology (OT) system handling the autonomous manufacturing equipment and the information technology (IT) system managing the broader computer system.

The rapid payback typically occurs in terms of the reduction of unscheduled downtime and process optimisation of machines due to new cause-and-effect findings and optimised machine utilisation. Long-term payback may include decreased costs for machine maintenance, increased productivity and improvement of product quality.[3]

Example: Internet of Things (IoT) is being integrated in machines, enabling thousands of sensors to work in real time and transfer data to a cloud server for analysis. The findings can be used to optimise production performance and process quality, leading to lower energy and resource consumption and lower emissions.

Case study of Global Lighthouse Industry 4.0: To achieve its productivity goals, the Siemens factory in Amberg, Germany, implemented a structured, lean, digital factory approach by deploying smart robotics, AI-powered process controls and predictive maintenance algorithms. The goal was to achieve 140% factory output at double product complexity without an increase in electricity or change in resources. This resulted in a 50% increase in labour efficiency, a 20% increase of work-in-progress, a 13% increase in overall equipment effectiveness, a 13% increase in process quality improvement and a 30% decrease in engineering effort.[4]

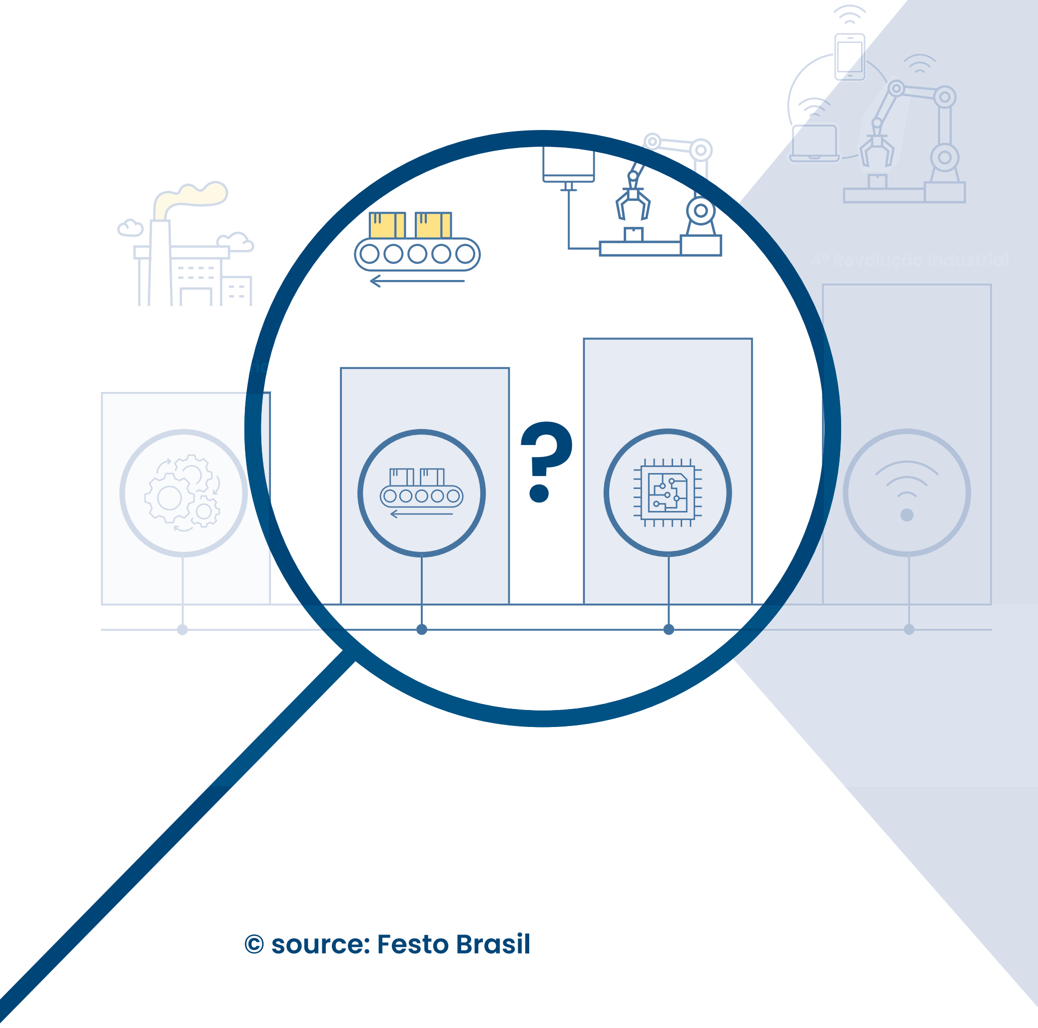
In contrast to Retrofitting 3.0, Retrofitting 4.0 has relatively high impact with comparatively little replacement of equipment.

[3] World Economic Forum. 'Fourth Industrial Revolution: Beacons of Technology and Innovation in Manufacturing' WEF White Paper, January 2019

[4] World Economic Forum. 'Global Lighthouse Network: Reimagining Operations for Growth' WEF White Paper, March 2021. https://www3.weforum.org/docs/WEF_GLN_2021_Reimagining_Operations_for_Growth.pdf

Objectives of Classic Retrofitting (Retrofitting 3.0)

- Modernise or expand existing machines, facilities and inputs
- Ensure the supply of maintenance parts
- Extend the service life
- Increase the volume produced
- Increase the quality of products
- Optimise energy efficiency
- Comply with legal requirements



Sensors and actuators for process automation

Control (Programmable Logic Controllers/ PLCs, Numerical Controls/NCs) and Networks (AS-Inter-face; PROFIBUS)

Project computerisation (Computer Aided Design/CAD)

Robotisation

Vertical integration

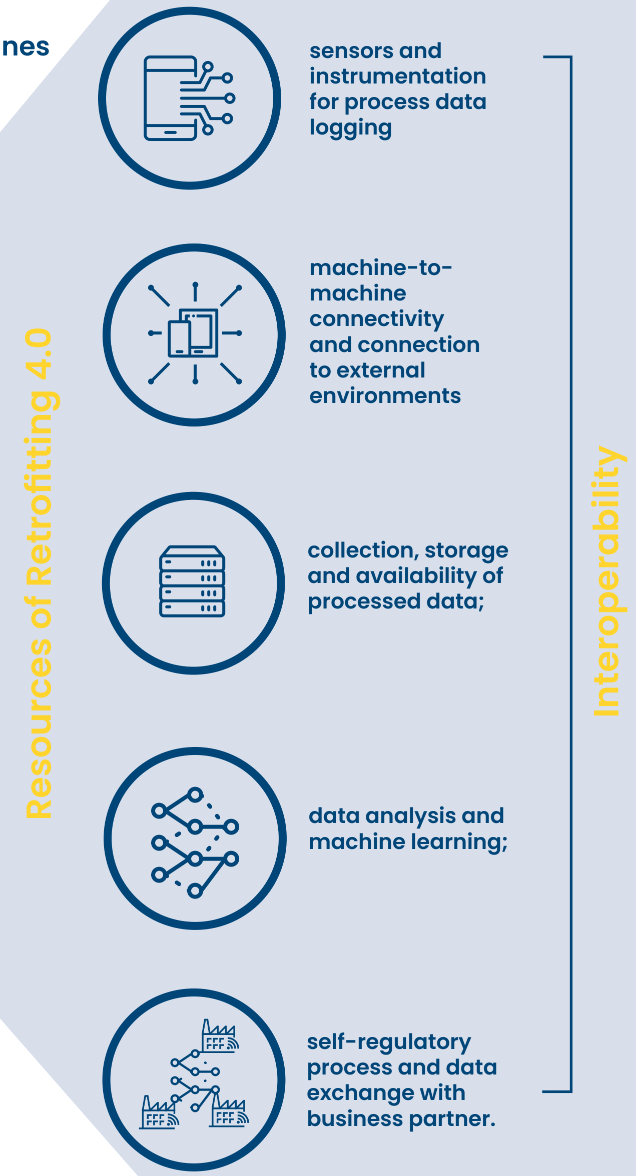
© source: Festo Brasil

Objectives of Retrofitting 4.0

Companies can choose retrofitting objectives according to their needs and manufacturing pain points by considering high market potential, available resources and budget, and utilisation of company strengths.

- Increase the availability of machines and production lines
- Create transparency about plant efficiency
- Monitor the machines' condition and performance in real time
- Improve the utilisation rate of machines by identifying hidden productivity potential
- Measure energy consumption of machines
- Improve warehouse operations and management through digitalisation
- Track workpieces in process or in stock
- Increase self-regulation of machines and production lines
- Utilise findings from machine data analytics for decision-making in the next process

Retrofitting 4.0 uses a systematic computing infrastructure and standardised communication technologies.



© source: Festo Brasil

Characteristics of Retrofitting 4.0

In carrying out Retrofitting 4.0, it is helpful to identify existing technologies in the industry and requirements for upgrade in every layer of the process based on the targeted scale of retrofitting. There are three main layers:

(1) Machine infrastructure

After considering the existing technologies, IoT sensors may be added to the industrial equipment.

(2) Controller or automation platform

In Indonesia, most of the existing equipment has outdated controllers without a communication protocol and port; this may cause incompatibility. In such cases, a middleware or additional tapping device can be used to rejuvenate equipment.

(3) Software and applications

Generally, the automated industry has one or more networked computers on which specific software and/or applications are installed. Before adding new applications, consideration must be given to the version of the Operating System (OS). For example, some applications may not be compatible to run within the most updated OS. On the other hand, updating the OS is crucial in order to ensure that the antivirus software grants access to the internet connection.

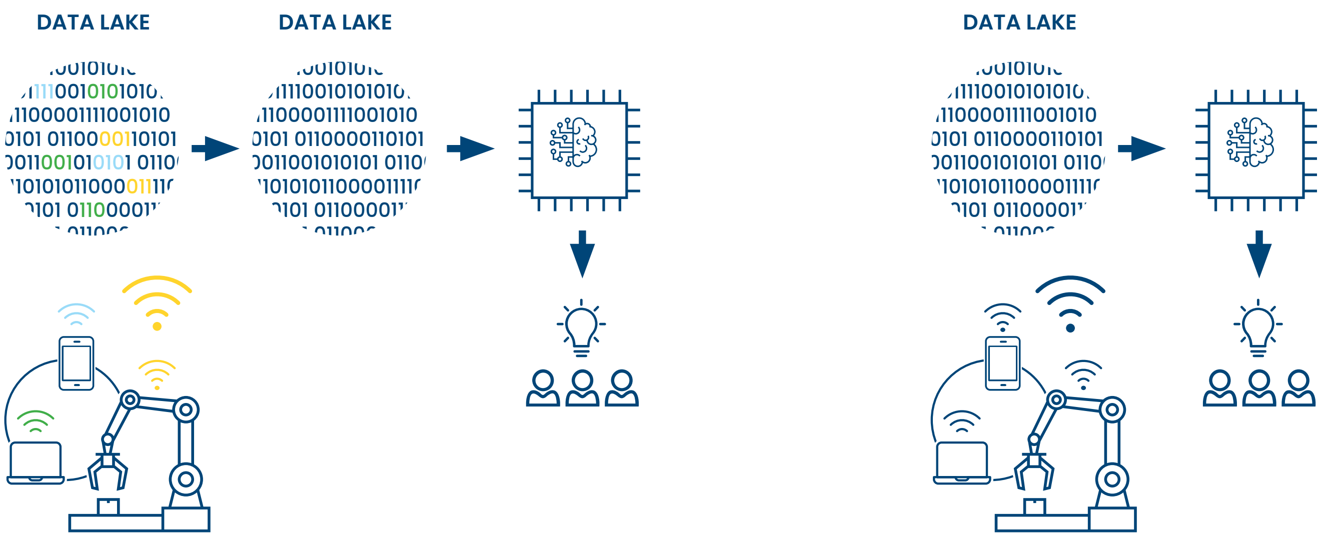
In this case, a confirmation from the Original Equipment Manufacturer (OEM) or machine builder is required to ensure that the OS update does not result in incompatibility of applications, or that OEMs have alternative applications for use. If this is not possible, a dedicated Internet Protocol (IP) network – separate from the main network – should be created.

A fundamental characteristic of Retrofitting 4.0 is that its added value depends on the interoperability between the equipment and systems used. The simpler, broader and more hands-free the flow of information, the greater the potential for financial return.

In practice, to ensure interoperability of machines, it may be necessary to send a request for access to the OEMs or machine builders to unlock machine communication settings. This may also imply additional security aspects.

Example 1: Data structure for artificial intelligence (AI) applications

Today, a large part of the project budget for implementing artificial intelligence in industrial processes is allocated for processing the data collected – the so-called data lake. However, different equipment and systems make data available in various formats, measures, frequencies, etc., without using a standardised format for data exchange.



One example: using artificial intelligence to analyse cause-and-effect relationships.

The economic viability of this type of solution will be improved if the data obtained from the equipment and systems already follows a standard structure. In addition to enabling a total cost reduction during the project, the use of a standard data structure allows additional equipment to be integrated later into the same mechanism at low additional cost. Many equipment manufacturers have already recognised the enormous benefit of having a common communication language for their machines. Since 2018, therefore, mechanisms have been created to align communication standards for each type of equipment.

Need for standardised interfaces

- Replacement of a manufacturer's proprietary interfaces to allow automatic integration of machines (plug-and-produce)
- Support for different protocols
- Cost savings by reducing integration efforts
- Semantic description of machines and equipment
- Communication on an open and interoperable platform
- Global acceptance
- Security by design both for Information Technology (IT) and Operation Technology (OT)

OPC UA or Open Platform Communication Unified Architecture (IEC 62541) is used as the preferred series of standards published by the International Electrotechnical Commission (IEC). Additional contents of the OPC UA are still in development (see Annex for detailed contents).

Benefits of standardisation in data exchange

For machine builders:

- specification of what data is exchanged and how;
- lower or zero internal development costs;
- less coordination effort between partners (manufacturer, integrator, user);
- focus on machine functionality, while being future-ready in terms of security.

For machine users:

- simpler combination of machines and components from different manufacturers;
- lower integration and configuration costs;
- greater technical consistency and scalability of solutions, while always considering potential threats due to security by design.

As one of the world's largest industry associations, the Machinery and Equipment Manufacturers Association (VDMA) is leading efforts to create a global consensus among manufacturers of different types of equipment on standards for the secure and reliable exchange of data.

Because of its robustness, security and independence from specific platforms and suppliers, **OPC UA** is the preferred communication standard. In addition, OPC UA enables the development of standardised information models – so-called **OPC UA** Companion Specifications – such as the OPC UA for Machinery or OPC UA for Machine Tools. These will guarantee homogeneous communication of information between equipment and with systems (e.g. IoT Platforms running in the Cloud or MES).

Once **OPC UA** is established, both machine manufacturers and users will benefit from ease of integration and data retrieval. Interoperability will ensure long-term investment security as new technologies and solutions can be easily integrated.

Having open communication also poses an exposure to cyberattack. In mitigating this, the **OPC UA (IEC 62541)** is equipped with security mechanisms in its layers. In the communication layer, a secure channel is established between the client and the server by using encryptions, signatures and digital certificates. In the application layer, there are mechanisms for user authentication and for verifying permissions of command.

Example 2

Profiroll Technologies GmbH is a manufacturer of machine tools and leader in cold rolling machines. Profiroll not only supplies the machine tools but also develops the processes from a single source.

For Profiroll, digitalisation is a way to increase efficiency in manufacturing. In doing so, Profiroll puts forward a standardisation by implementing the OPC UA for Machine Tools on its shop floor, in line with the umati initiative (universal machine technology interface). umati promotes adaptation of the standard for connecting both greenfield and brownfield machines in a uniform way. umati provides best practice solutions for the way machine tools share information defined in Companion Specifications over OPC UA. By applying the umati sample servers with standardised information as the machine interface, the data can easily be extracted from machines in a standardised manner, and other more advanced functions need only to be developed as additions.

As a medium-sized company, Profiroll implemented its digital transformation strategy in steps by collecting and analysing standardised data to increase efficiency. Furthermore, in the process, senior management clearly committed to the goals, process and costs of digitalisation and established a creative atmosphere. In this way, the company developed a natural momentum for transition which far exceeded expectations. Digital transformation opens up opportunities for data collection and analysis at reduced cost, which can help determine the changes required for more efficient management. However, it is always important to consider the issue of cybersecurity, which can otherwise lead to loss of data, transparency for competitors or serious damage.

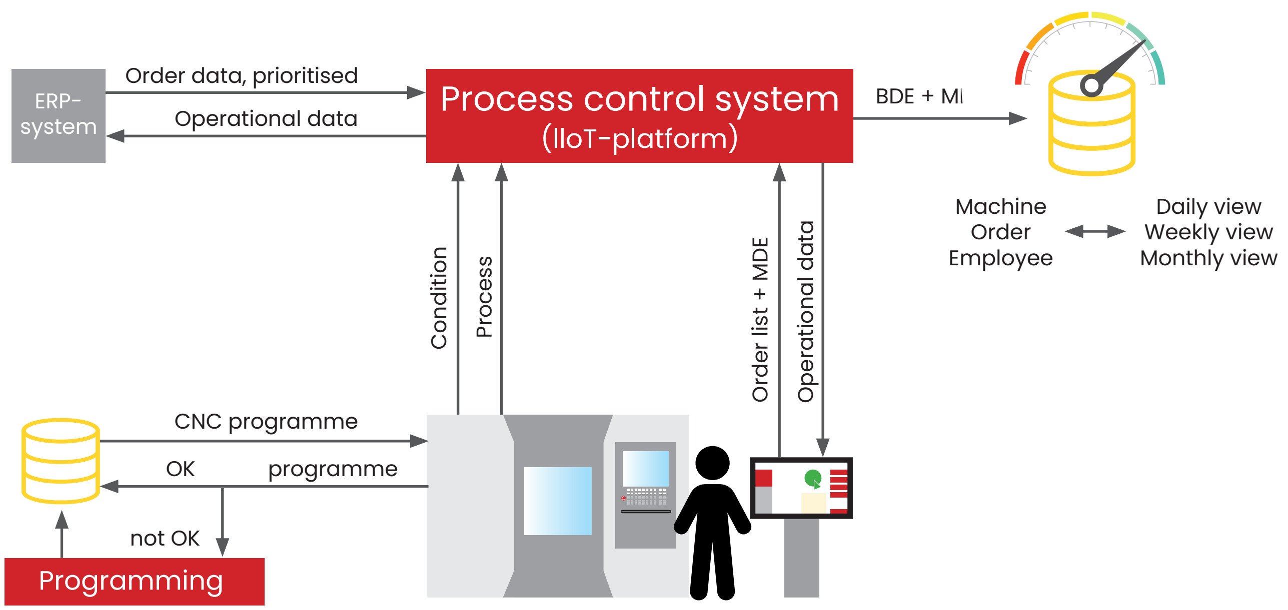
umati
universal
machine technology
interface

umati (universal machine technology interface) is a global community of machine-building industries and their customers, which has set itself the objective of promoting and implementing the OPC UA Companion Specifications. umati facilitates communication between machines and plants or their integration into customer and user-specific IT ecosystems – easily, seamlessly and securely. As such, the initiative aims to unlock newpotential for production of the future – worldwide. **umati.org**

Digitalisation goals of Profiroll:

Availability of early warning system and sensors	Efficiency	Quality
Central systems for 30 machines	**Production control** - paperless - live updates/real time - set-up summary	• Worker information system • Computer Numerical Control (CNC) program versioning • Integration of Quality Management (QM) measurement of workstations, including digital QM files
Grinders	**Production/analysis of key figures** - reporting - machine/operating data acquisition - plausibility check	

Profiroll's implementation of digitalisation:



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Source: VDMA

Need for standardised cybersecurity systems

Once *Industrie* 4.0 is implemented, the consequences of a cyberattack are more severe than attacks on traditional IT systems, owing to the fact that much more data is now available.

These consequences include not only loss of privacy, but also loss of life and health, harm to the environment, loss of product integrity, financial losses and potentially even more widespread damage.[5] This is because there is interconnectivity between IT and OT equipment.

To prevent this, security systems encompassing IT and OT must be established, and the use of a standardised approach can significantly reduce the likelihood of a successful cyberattack.

IEC-62443 is a series of standards that specifies principles and requirements to secure Industrial Automation and Control Systems (IACS). The standards provide comprehensive guidance throughout the entire life cycle and for all aspects of the industrial process. This includes not only technology (hardware and software) but also people and processes. The **IEC-62443** series has proven to be broadly applicable in a wide range of different industries.[6]

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[5] International Society of Automation. Quick Start Guide: An Overview of ISA/IEC 62443 Standards Security of Industrial Automation and Control Systems. ISA, 2020.

[6] International Society of Automation, 'The International Electrotechnical Commission Designates ISA/IEC 62443 as a Horizontal Standard,' ISA, November 17, 2021,

Conclusion

If you are going to implement a Retrofitting 4.0 project:

- assess your companies' readiness using digital maturity tools and the readiness index;
- define your objectives by prioritising low-cost and rapid-return technologies;
- be mindful of the requirements for machine upgrades in every layer of the process: machine infrastructure, controller or automation platform, software and applications.
- advise your integrator or project team on the benefits of using the Global Production Language based on OPC UA and IEC-62443 standards as your solution: easy integration of machines, return of investment, reduced risk of cyberattack.

These are the recommended standards to follow for the next step in your retrofitting projects:

- **IEC 61987** Industrial-process measurement and control – data structures and elements in process equipment catalogues
- **IEC 63365** Industrial-process measurement, control and automation – digital nameplate
- **IEC 61406** Identification Link
- **IEC 63278** The Asset Administration Shell – providing technology with additional semantics in terms of an asset's life cycle.

Annex:

List of parts in the IEC 62541 Unified Architecture (OPC UA) series

Publication number	Title	Publication number	Title
IEC 62541-1	Overview and concepts	IEC 62541-14	PubSub
IEC 62541-2	Security Model	IEC 62541-15	Safety
IEC 62541-3	Address Space Model	IEC 62541-16	State Machines
IEC 62541-4	Services	IEC 62541-17	Alias Names
IEC 62541-5	Information Model	IEC 62541-18	Role-Based Security
IEC 62541-6	Mappings	IEC 62541-19	Dictionary Reference
IEC 62541-7	Profiles	IEC 62541-20	File Transfer
IEC 62541-8	Data Access	IEC 62541-21	Device Onboarding
IEC 62541-9	Alarms and conditions	IEC 62541-22	Base Network Model
IEC 62541-10	Programs	IEC 62541-23	Common Reference Types
IEC 62541-11	Historical Access	IEC 62541-24	Scheduler
IEC 62541-12	Discovery and global services	IEC 62541-100	OPC UA for devices (Device Interface (DI))
IEC 62541-13	Aggregates		

This Quick Guide was based on Quick Guide on Global Production Language, developed within the framework of the German-Brazilian Working Group on Quality Infrastructure of the Global Project Quality Infrastructure (GPQI) implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The document was adapted and enhanced to ensure it meets the Indonesian context – in particular, the key target audience of Indonesian SMEs.

The adaptation was achieved through discussion and inputs from members of the expert group for Industrie 4.0, established within the Indonesian-German Bilateral Dialogue on Quality Infrastructure. The Brazil Quick Guide is available in Portuguese here: bit.ly/3mdYfna

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