
MES & Industry
INTERNATIONAL SUMMIT 4.0
Connect for a smarter future
ALFÂNDEGA DO PORTO
PORTUGAL
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2023
Jan Snoeij
MOM Institute
Industry 4.0 Vision vs Reality
Maturity Assessment

Industry 4.0 Vision vs Reality

Agenda

- Introduction
- Trends and Observations in Manufacturing
- Manufacturing in the Age of AI
- Smart Manufacturing & Industry 4.0 and 5.0
  - Examples: Challenges and Successes
- Are You Ready?
- Manufacturing Capability Maturity
  - Assessment
- Conclusions and Wrap-Up

Observations

During the COVID-19 Pandemic

Companies are either

- Scaling up production, e.g. pharma, medical devices, food & beverage, sanitizers, …
- Changing their product portfolio
  - Swinckels: beer → sanitizers
  - Dior, Louis Vuitton: perfumes → sanitizers
  - Aerospace, automotive companies: ventilators
  - Bloom Energy: fuel cell generator → ventilators
  - Burberry: trench coats → masks and gowns

    Also utilizes its Supply Chain network to fast track the delivery of 100.000 surgical masks!

Observations

Ukraine War

Example: Company producing cathodes for aluminum industry

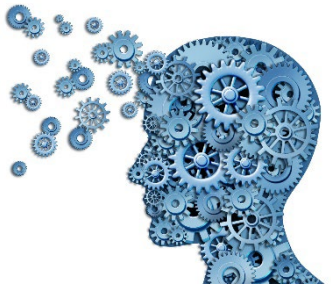
- One of the biggest competitors is in Russia. Because of the embargo customers are now buying from this company.
- Raw materials were also delivered from Russia and Ukraine. Supply Chain is now unreliable.
- Quality of raw material is more varying and unpredictable at receipt. Flexibility in recipe management and production is required.
- High gas and electricity consumption. Rising prices are driving improved energy management. Energy delivery is not reliable.

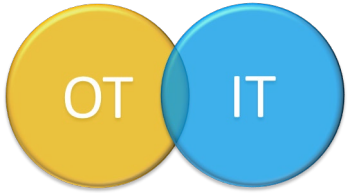
- ➢ Production definition management and flexibility
- ➢ Supply Chain logistics
- ➢ Energy management

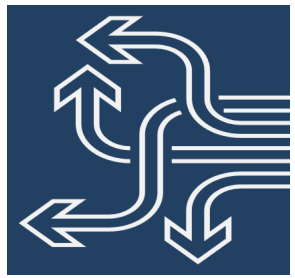
Operational Challenges

Some Examples

- Lack of Visibility and Transparency
- Lack of Agility
- Lack of Interoperability
- Root Cause Analysis
- Knowledge Attrition
- IT/OT Convergence
- Rapid Product and Process Change
- …

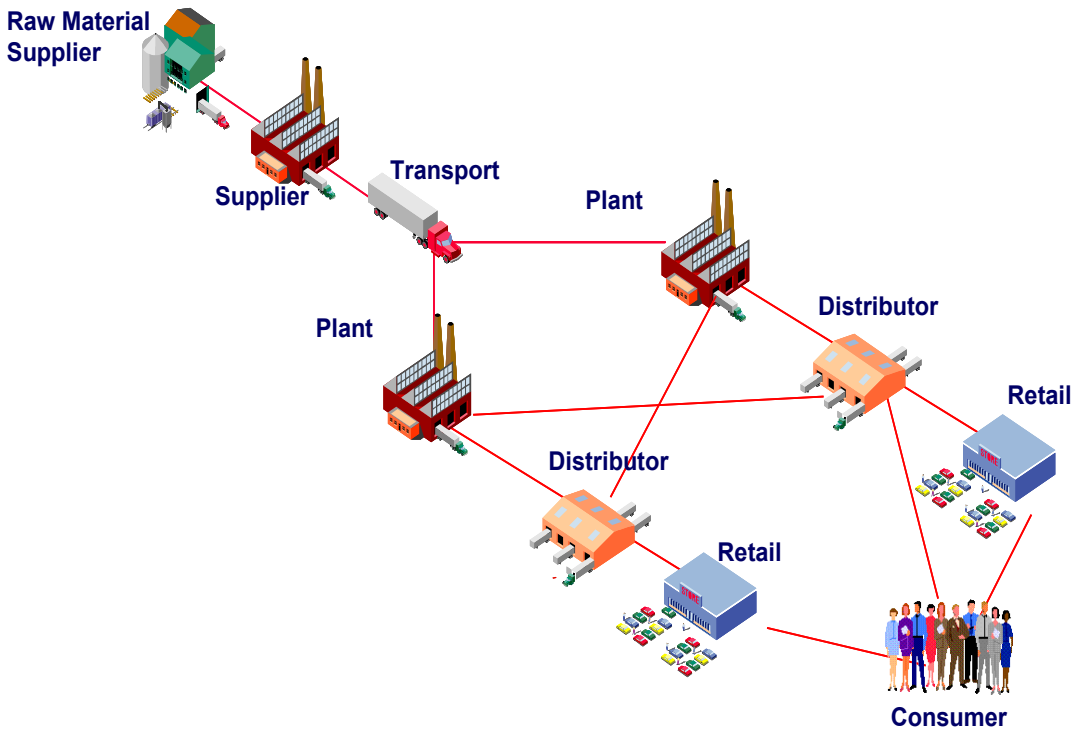




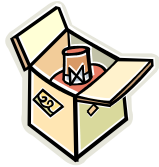


Manufacturer's Needs Have Evolved

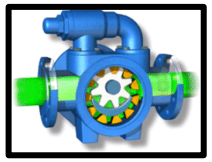
Transforming Raw Materials into Valuable Products



- Yes, we will always be manufacturers
- Utilizing **all our resources** for efficiency, effectiveness, compliance and AGILITY!


Material (& Energy) resources


Equipment resources


Physical assets


Personnel resources

- Improve continuously

It Is About Process Capabilities

Transforming Raw Materials into Valuable Products

Best-in-Class	Average	Laggards
Standardize processes across the enterprise for optimizing manufacturing operations		
64%	37%	30%
Standardize measurements of KPIs across enterprise		
68%	58%	51%
Standardize processes for response to adverse events		
64%	51%	19%

- Best-in-Class companies standardize
  - In three ways

- Traditionally ERP is a corporate tool.
- MES was often owned by engineering (OT domain).
- Nowadays, it is owned by the business
  - ➢ Enterprise application

Source: Aberdeen

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Manufacturing in the Age of AI

Progress and Expectations

- Julie Fraser from Tech-Clarity analyzed information from 300+ mainly discrete manufacturing companies.
- Progress and expectations with respect to speeding the loop from data to effective action.

Source: Tech-Clarity (2023)

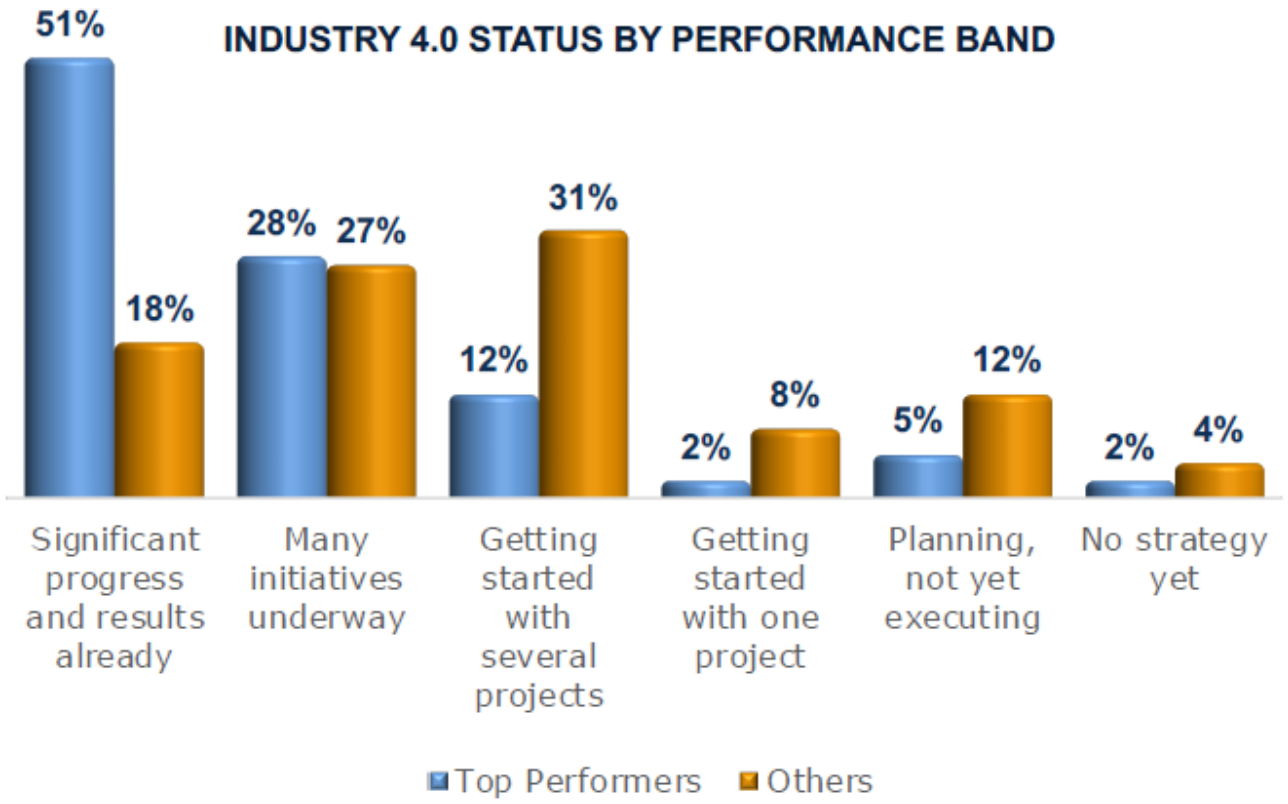
Manufacturing in the Age of AI

Progress and Expectations

Source: Tech-Clarity (2023)

Improvement is Possible: Top Performers

Manufacturing in the Age of AI



Progress on Industry 4.0

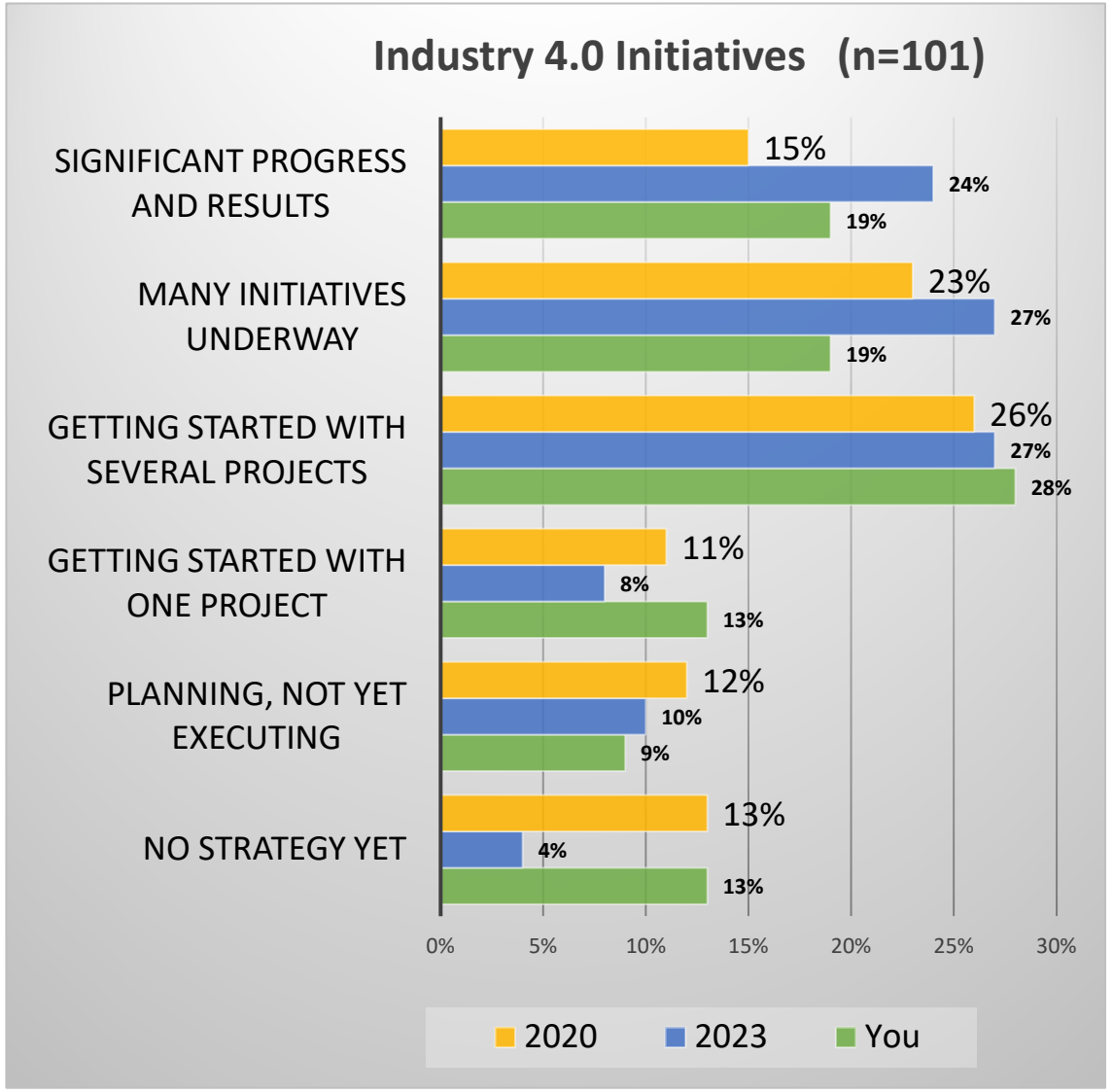
Manufacturing in the Age of AI

Industry 4.0 Vision

- The future of manufacturing is more flexible, agile, and responsive based on AI and intelligent automation.
- While the concept encompasses the entire enterprise and supply chain, the manufacturing area often poses the most significant challenges and opportunities for gaining substantial benefits.

Note

- When manufacturers embark on an Industry 4.0 initiative, they typically know it will be a multi-year journey



Source: Tech-Clarity (2023)

Gain Business Capabilities

Manufacturing in the Age of AI

POLL 1

Question

What excellent capabilities (score 5 on a scale from 1 – 5) does your company have as a result of your Industry 4.0 initiatives?

Select all that apply.

- Share best practices
- Agree on a single source of truth
- Manage systems consistently and effectively
- Collaborate among teams
- Provide data fast enough to impact performance
- Transform data into actionable insights
- Put IT and OT data into a common context for analysis
- Integrate IT and OT systems and data
- No manual handoffs
- None of the above

Gain Business Capabilities

Manufacturing in the Age of AI

Source: Tech-Clarity (2023)

Improvement is Possible: Top Performers

Your Response (Poll 1)

RESULT

The technicians will show the result of the Poll 1 now!

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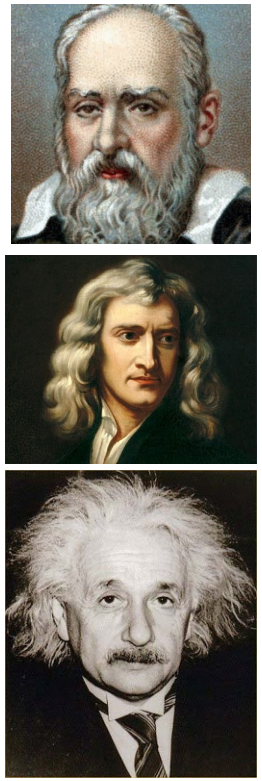
Smart Manufacturing Means Different Things

To different people

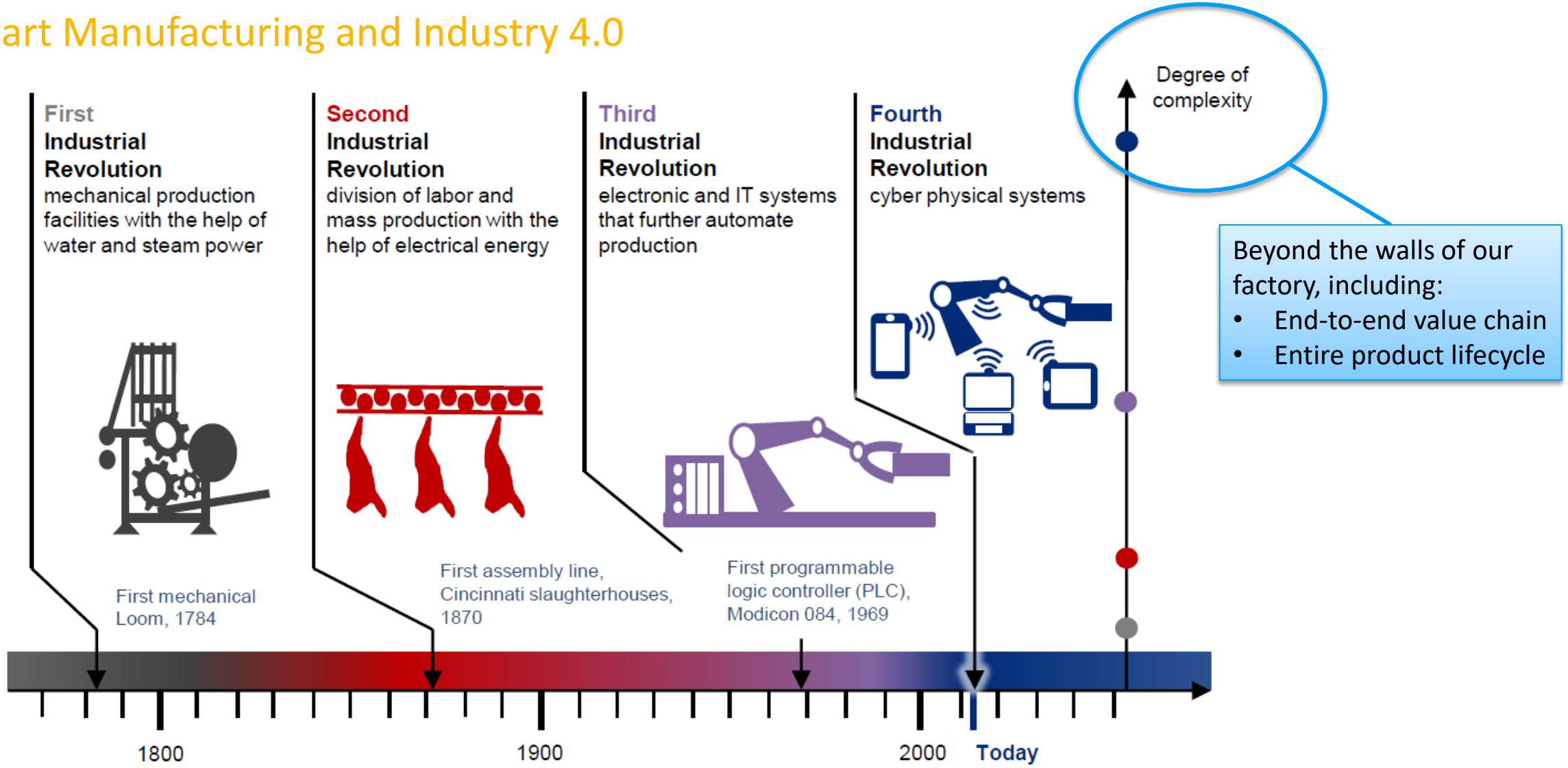
Smart People



- To some Smart Manufacturing is applying the technology of smartphones, smart houses, and smart cars to manufacturing assets (equipment)
- For some it is applying new info technologies in supply chains
- For some it is applying new info technologies in product development
- For some it is applying new info technologies in business to shop floor integration
- For some it is the development of smart products

Industrial Revolutions

Smart Manufacturing and Industry 4.0



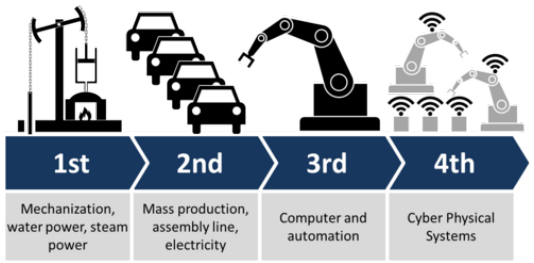
The Fourth Industrial Revolution

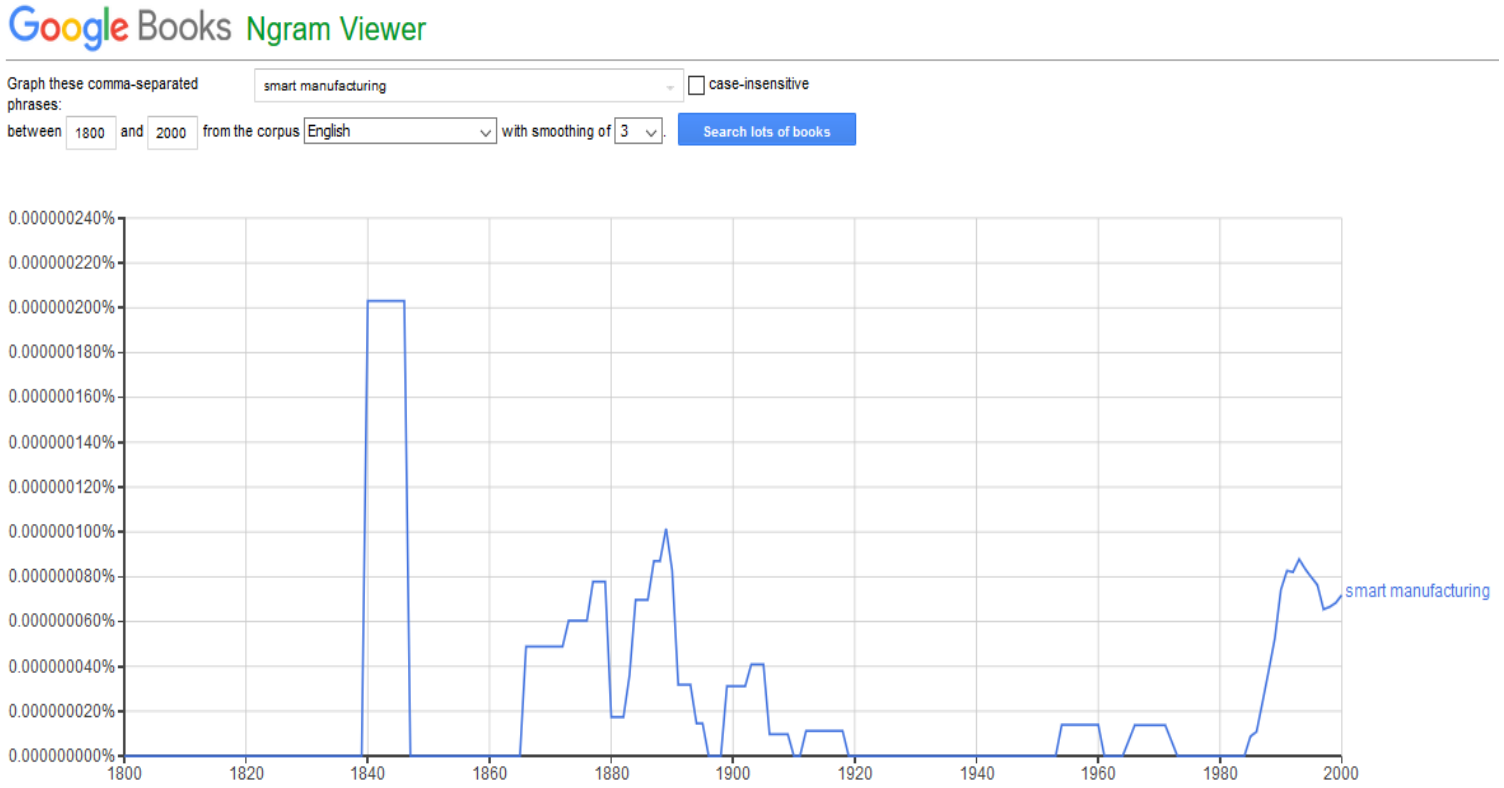
Brad Keywell, Co-founder and CEO, Uptake:

- It is about empowering people, not the rise of the machines.
- Machines, rather than something to be feared, are the tools that will help us solve the world's biggest problems.
- Automation, machine learning, mobile computing and artificial intelligence are no longer futuristic concepts, they are our reality.
- The change (and chance) brought by the Fourth Industrial Revolution is inevitable, not optional.

Smart Manufacturing is Not New

- Smart Manufacturing" was even more popular, in 1845 and 1890's





Smart Manufacturing is not New

1983: Collaboration with robots

1986: Digitalizing manufacturing

But Now …

- A shift is ongoing from just mass production to mass customization of products.
- More and more products will be sold as an (annual) ***service*** versus the traditional buy-it-once sale.
- The dynamics of the demand is increasing faster and more extreme than ever before.

Industry 5.0

Digital and Green Transition

- Places the well-being of the worker at the center
- Uses technology to provide prosperity beyond jobs and growth
- While respecting the production limits of the planet

European Commission

Industry 5.0

Inflation of Terms or …

Industry 5.0 Summary

- Reduced Cost
- Empowered Workers
- Competitive Industry by attracting Best Talents
- Training for Evolving Skills
- Competitive Edge in new markets
- Improved Safety and Well-Being

European Commission

This should be part of any Industry 3.0 or 4.0 initiative!

Many I4.0 Technologies and Methodologies

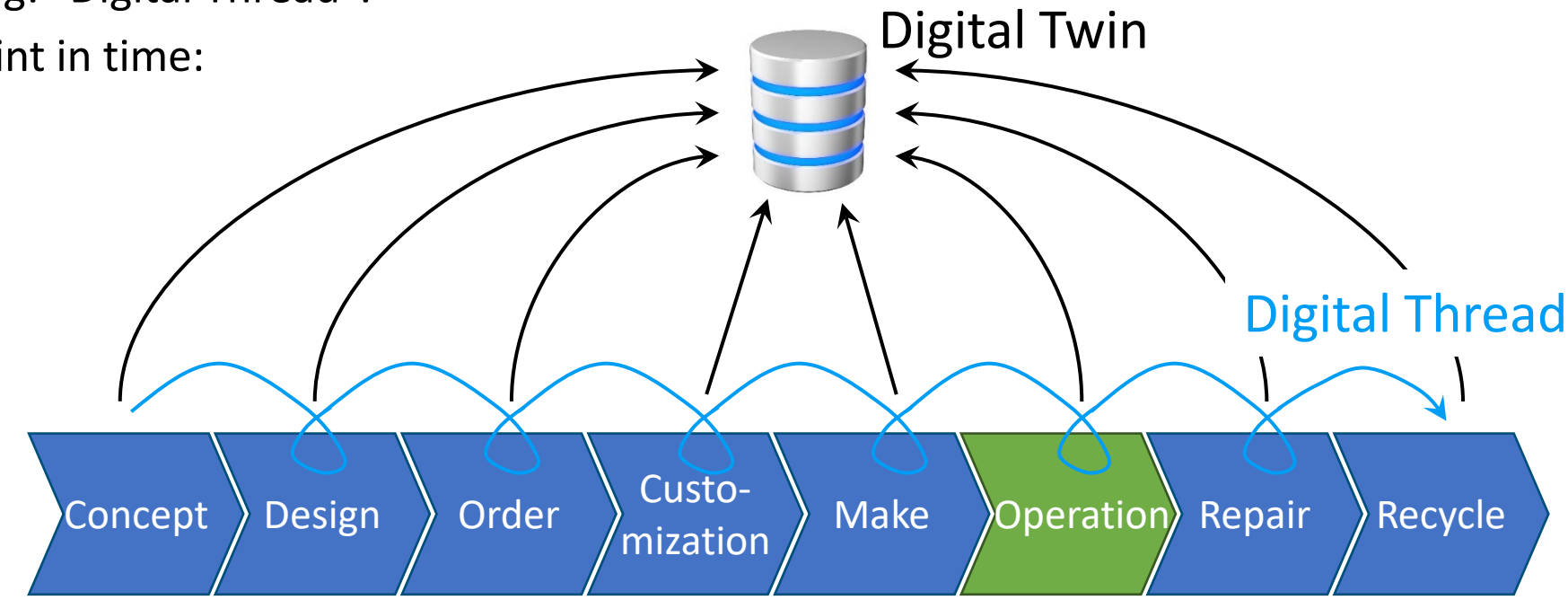
Some Examples

- Cyber-Physical Systems (CPS)
- (Industrial) Internet of Things (IoT and IIoT)
- Digital Twin and Digital Thread
- Smart Factory and Smart Ecosystem
- Big Data Analytics
- Artificial Intelligence (AI)
- Standards
  - RAMI4.0
  - OPC UA and MQTT

Digital Twin and Digital Thread

Basic Concepts for Industry 4.0

- Essential to Industry 4.0: Information exchange over the entire lifecycle of a product.
- Information exchange should be linked, seamlessly transferred from system to system, such that it does not need manual re-entering: "Digital Thread".
- Storing that data, at any point in time: "Digital Twin".



Source picture: Jonas Berge

Tools in a Metals Company

Example

- Steel alloys production
- After blast furnace, steel factory and continuous casting, hot and cold rolling takes place.
  - Make the steel plates (slabs) thinner, create specific surface properties, etc.
- Rotating rolls are specific tools, usually used in pairs
- Produced to fine specification for its purpose
- Entire history of the pair of rotating rolls is captured and used for cleaning, repair, overhaul, etc.
- Includes actual produced products property data
- This example thread covers order, customize, make, operation, repair and recycle.
- In the past, this thread was not digital. Today, it can be.

Benefits

Digital Thread

- The digital thread enables:
  - Better products
    - Avoiding mistakes, especially in (manual) translations from engineering specs
  - Produced in less time
    - Faster New Product Development and Introduction
    - Better communication of engineering changes,
    - Increased responsiveness to required changes (inside & outside)
  - Detecting issues before they become expensive and time-consuming (by simulation)
  - Continuous design and model refinement through captured data
- The digital thread allows multiple groups and organizations to work as one virtual team!

Challenges

Digital Thread

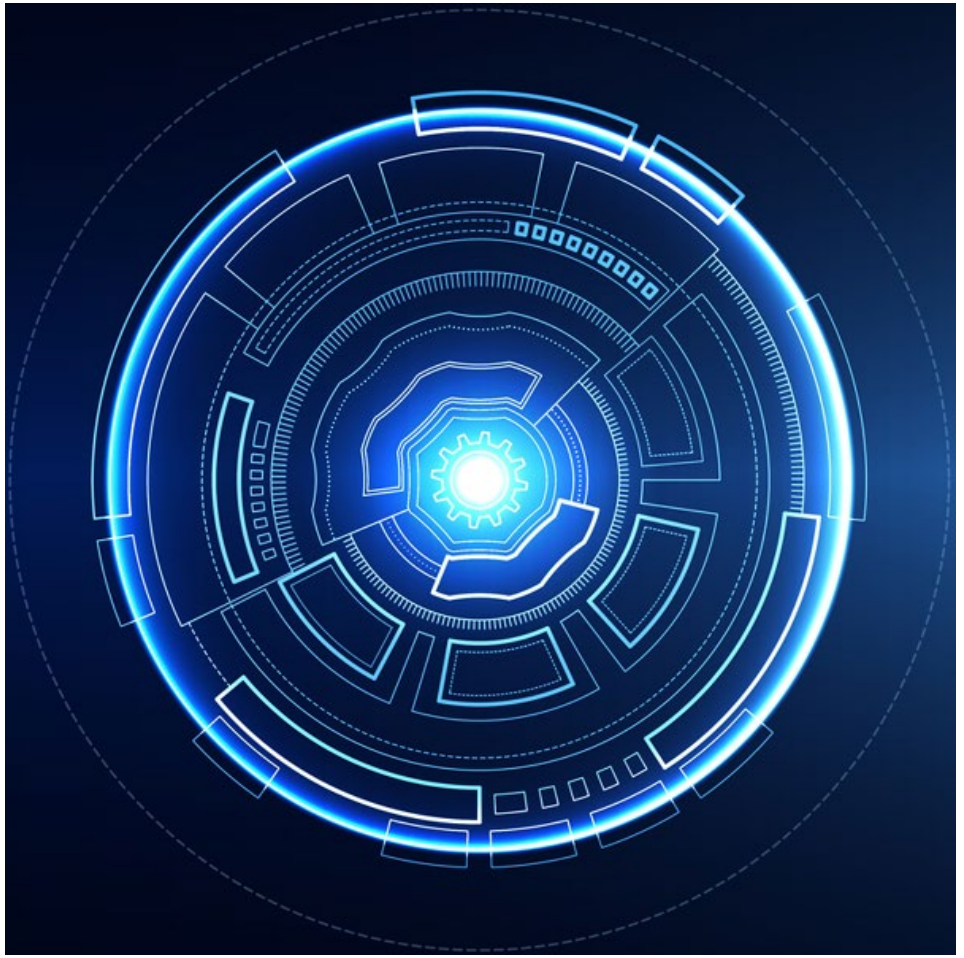
- Digital strategy and vision
- Information security concerns
  - Sharing information across the borders of your company
- Organizational structure and culture
- Skills gap
  - Next to the right tools and processes, the right expertise is required
- Upfront investments

- Are you really ready for Industry 4.0 and the digital thread and twin?

Failure at Digital Transformation

People are NOT the problem!

- Two-thirds of businesses recognize their company must digitize asap in order to stay competitive.
- GE, Ford and other major players poured $1.3 trillion into transformation initiatives, 70% of which ($900 billion) was wasted on failed programs.
- The biggest reason: failure to effectively communicate their goals, strategy, purpose and outlook with their employees.
- It's the organization's failure to communicate effectively with its people that sets them up for digital transformation trouble from the start."



Source: Keith Kitani, CEO of GuideSpark (2019)

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Six Communication Tips

1. Focus on the why.
2. Create personalized communication journeys.
3. Create targeted multimedia experiences that reach different groups.
4. Communicate in context.
5. Use data to measure and iterate.
6. Become a ***change-ready*** organization.

Source: Keith Kitani, CEO of GuideSpark (2019)

Smart Manufacturing and Industry 4.0

Some Great Examples

- Big Data
  - An African gold mine found more data to capture
  - Detected unsuspected fluctuations of oxygen during leaching
  - Increase yield 3.7% ($20M annually)
- Advanced analytics
  - Automaker uses data from online configurator identifying popular options
  - Reduced the number of options -> +30% gross margin
- Human-machine interfaces
  - Logistics company, picking using augmented reality
  - Error rates down with 40%
- Digital-to-Physical transfer
  - Car builders using 3D printing parts for new cars
  - Rapid prototyping to minimize time-to-market

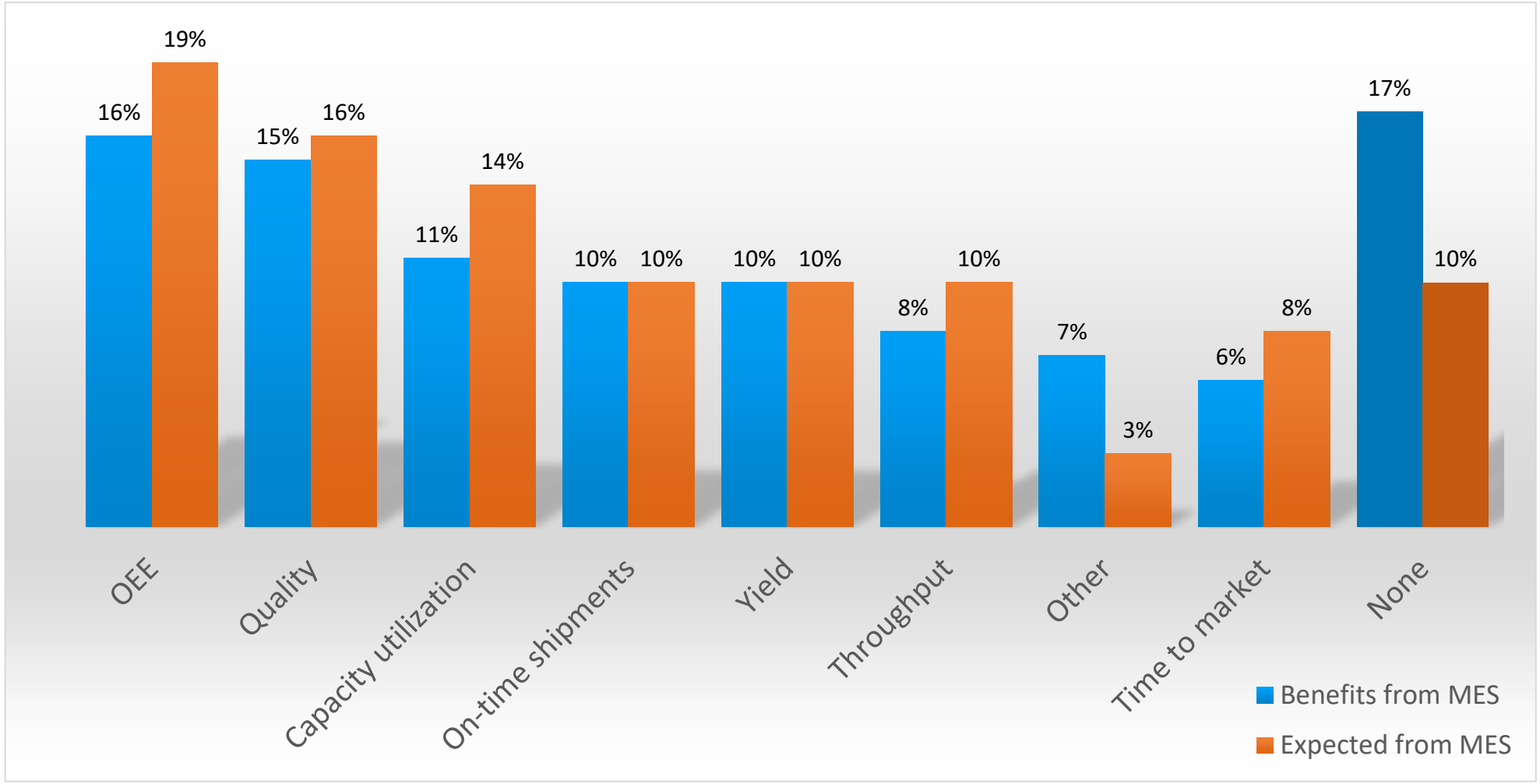
Source: McKinsey

Significant Improvements MES

Your Response to Question 2 and 3

n = 94 / 90)

RESULT

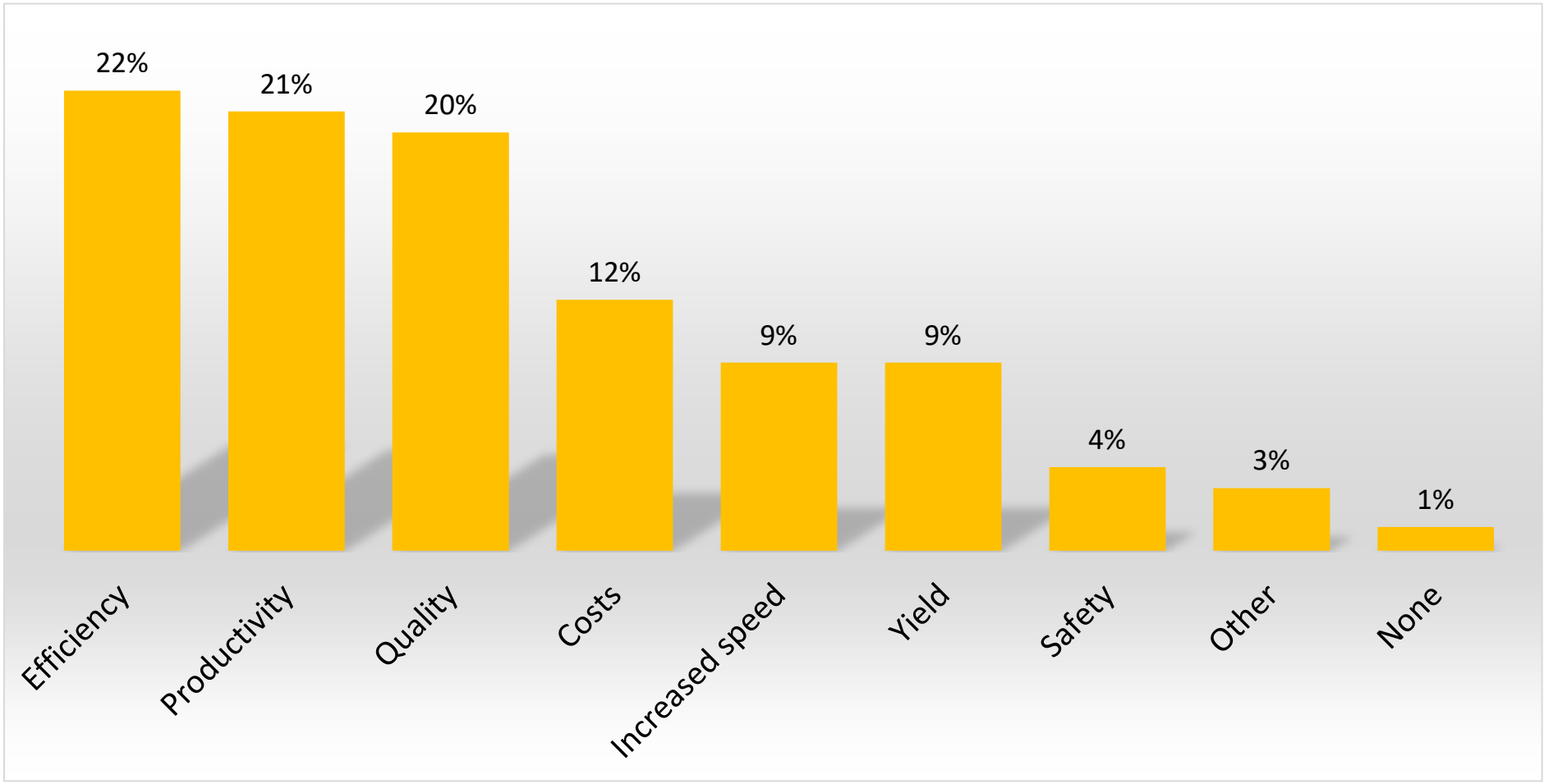


Anticipated Benefits Advanced Analytics

Your Response

n = 88)

RESULT



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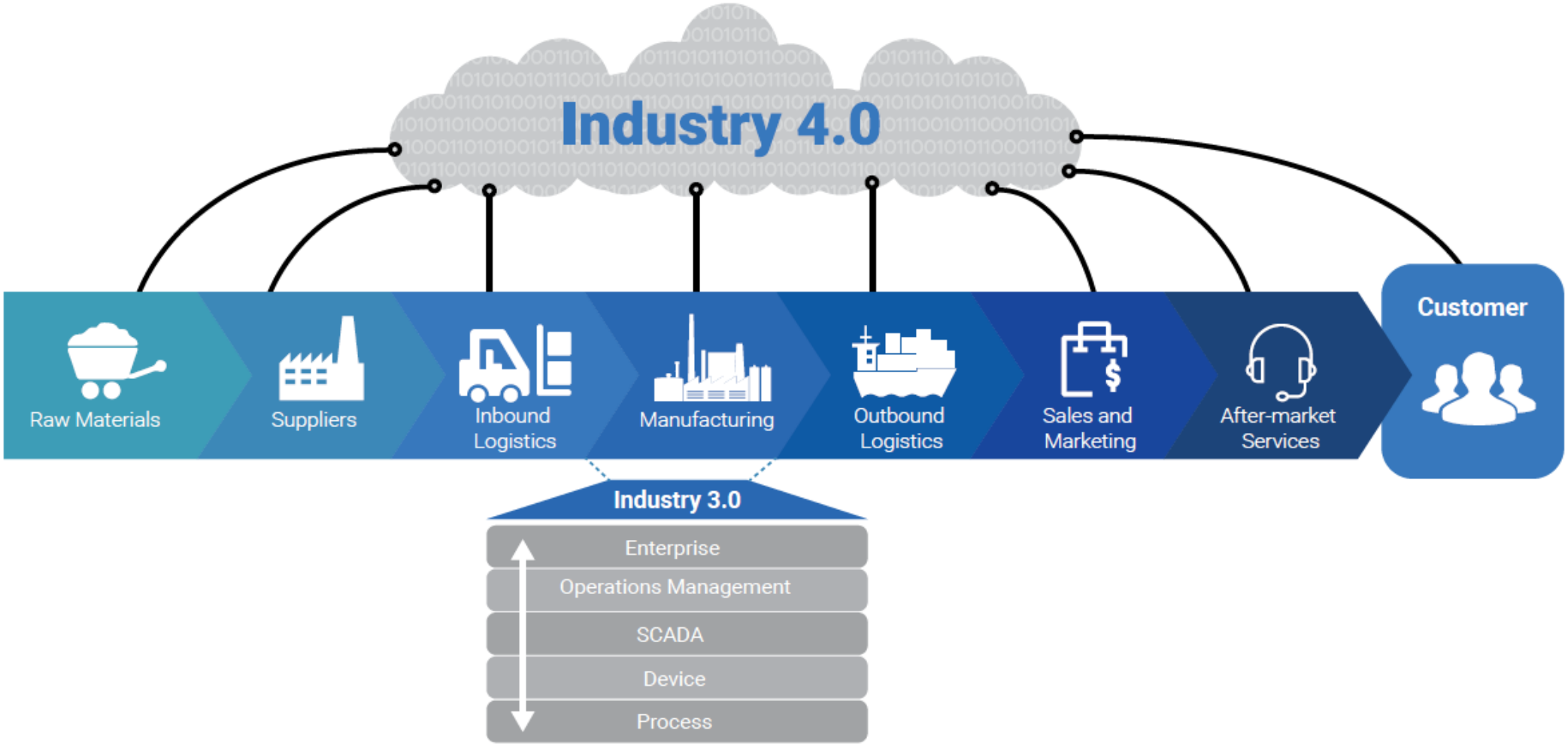
Questions and Challenges

- Should we be investing in Industry 4.0?
- One of first steps: investment in MES/ MOM?
- Is organization capable of adopting Industry 4.0?
- Will this initiative result in value for the organization?
- Will the organization sustain this initiative in long-run?

Singapore Smart Industry Readiness Index (SIRI)



Source: Singapore Economic Development Board

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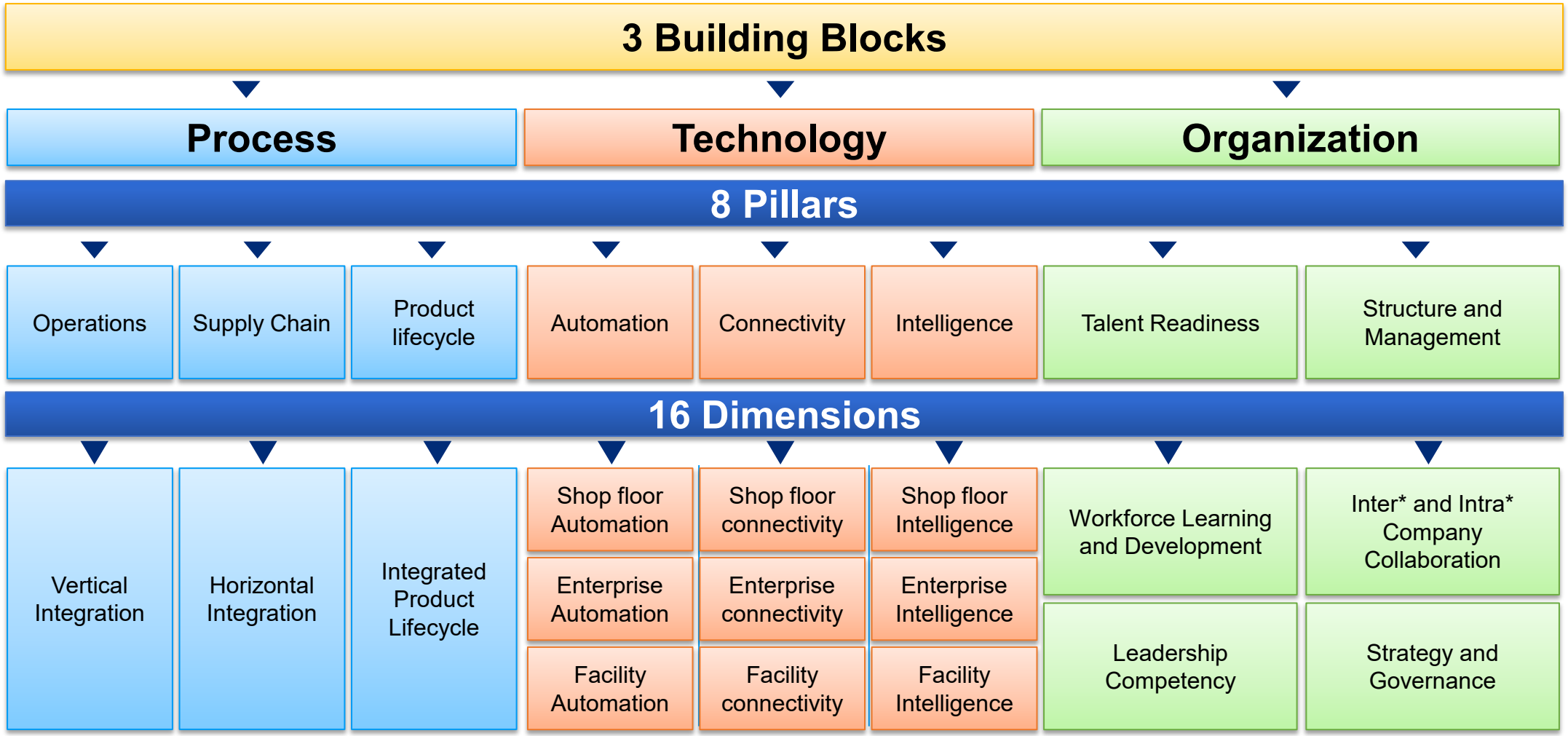
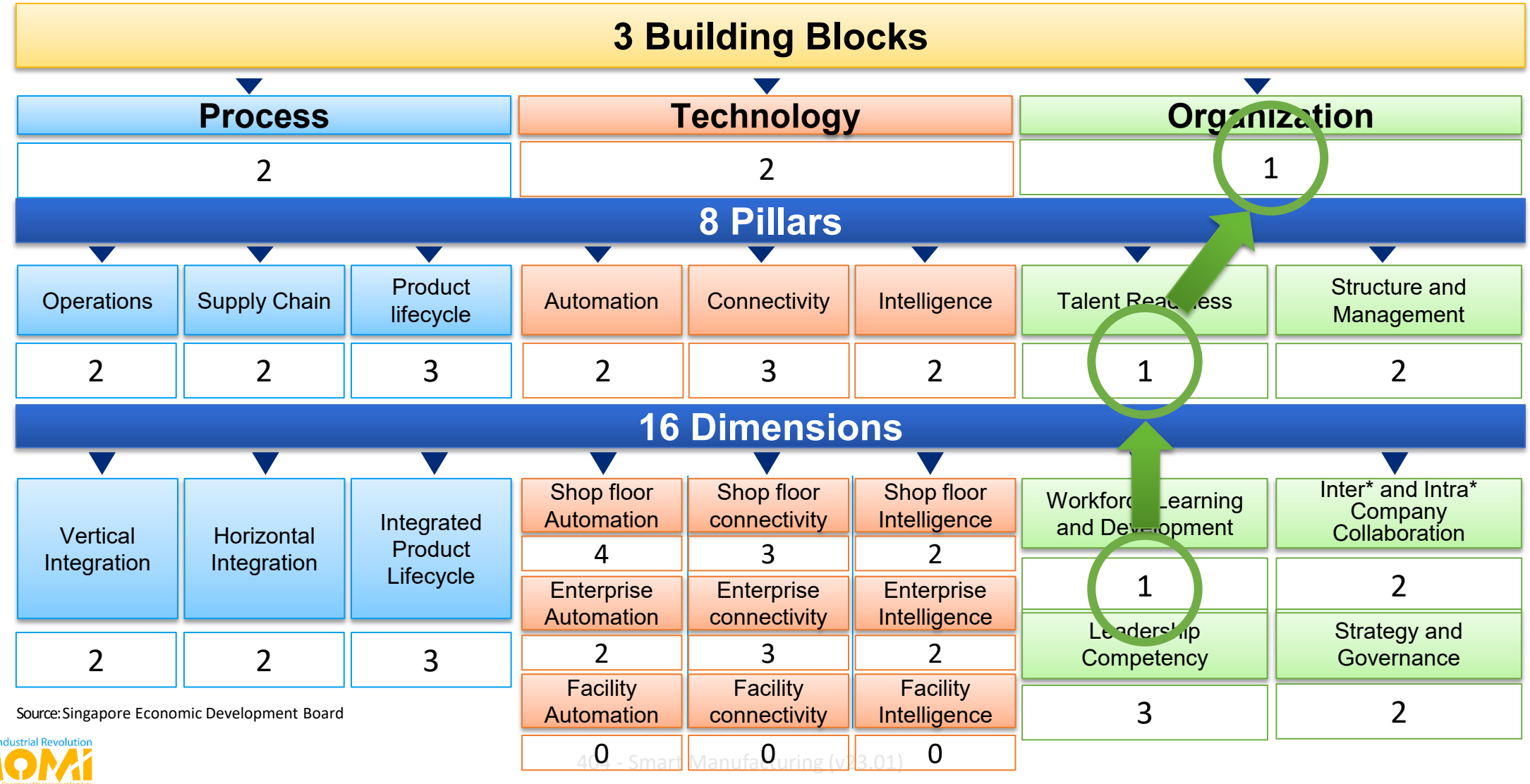


Source: Singapore Economic Development Board

Singapore Smart Industry Readiness Index (SIRI)

Example: Search for the "Weakest Link"



Source: Singapore Economic Development Board

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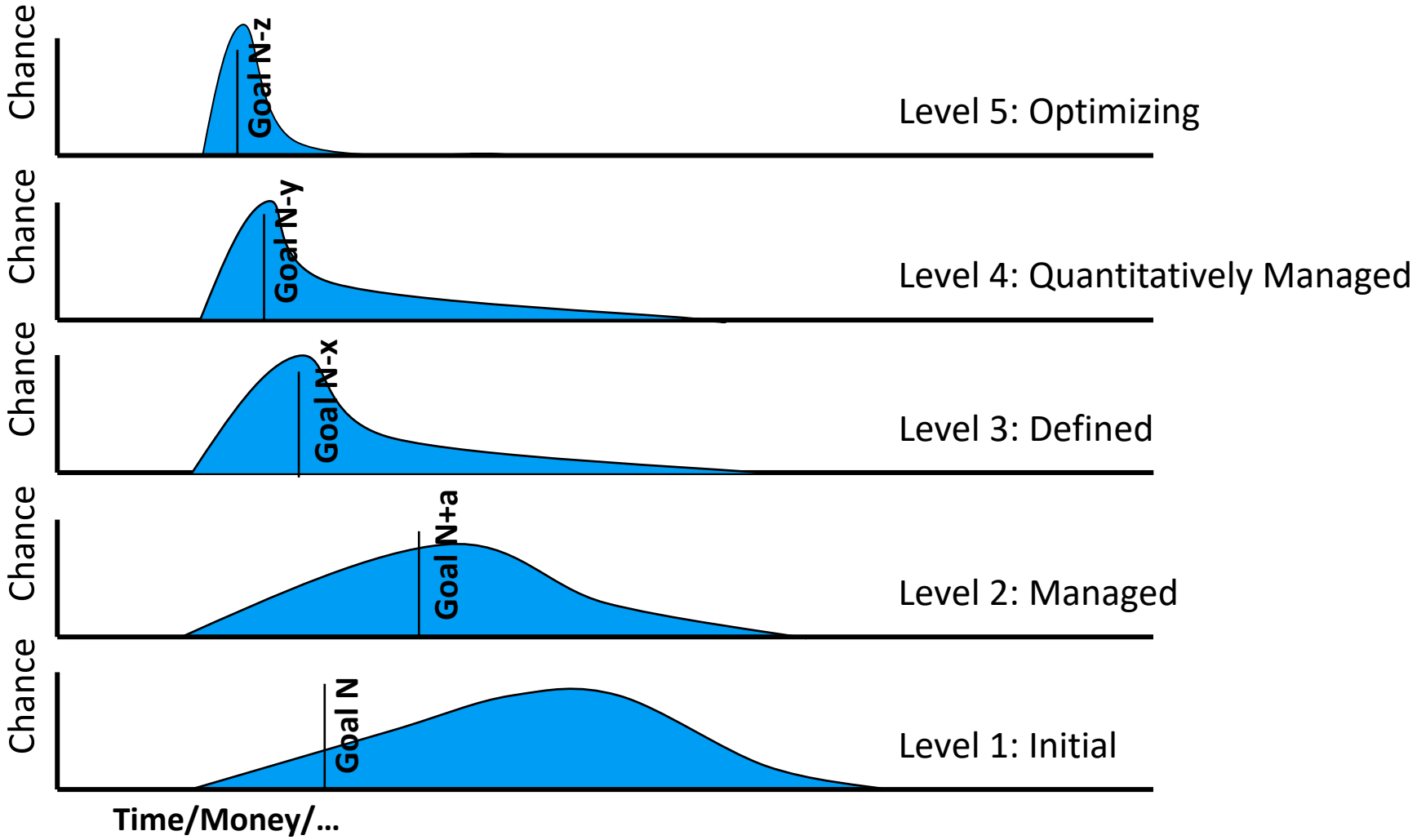
Maturity Level and Changing Predictability



Benefits

Maturity Models

Maturity Models create a **shared vision** of purpose of process improvement within the organization.

Maturity Models help establish a **common language**.

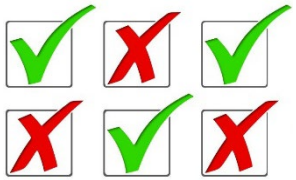
Maturity Models define a set of **priorities** for attacking problems.

Maturity Models support **objective measurement** via reliable appraisals.

Embedded Risk?

Maturity Models

"All models are wrong; **some models are useful**."



Maturity Models **do not address all of the issues** that are important for success.

Maturity Models are actually a management framework, with **many details left out** (they give goals, not methods).
Example: “You must have peer reviews.” But how should the reviews be run?

Maturity Models **do not help in times of crisis**.

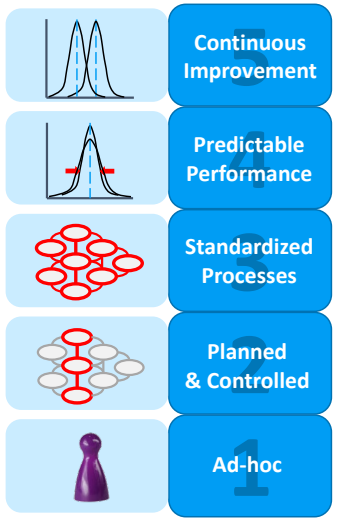
Manufacturing Maturity Model

MESA International

The Manufacturing Transformation Strategy's direction is derived from analysis of the following four Manufacturing Business Domains:

1. Business and Operations Processes (*Processes*)
2. Organization and Governance (*Structure*)
3. Personnel Skill Sets (*People*)
4. Manufacturing System Technology (*IT*)

+



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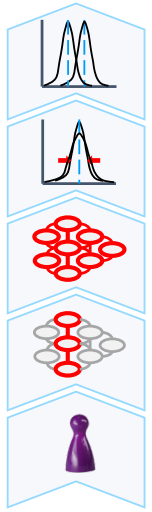
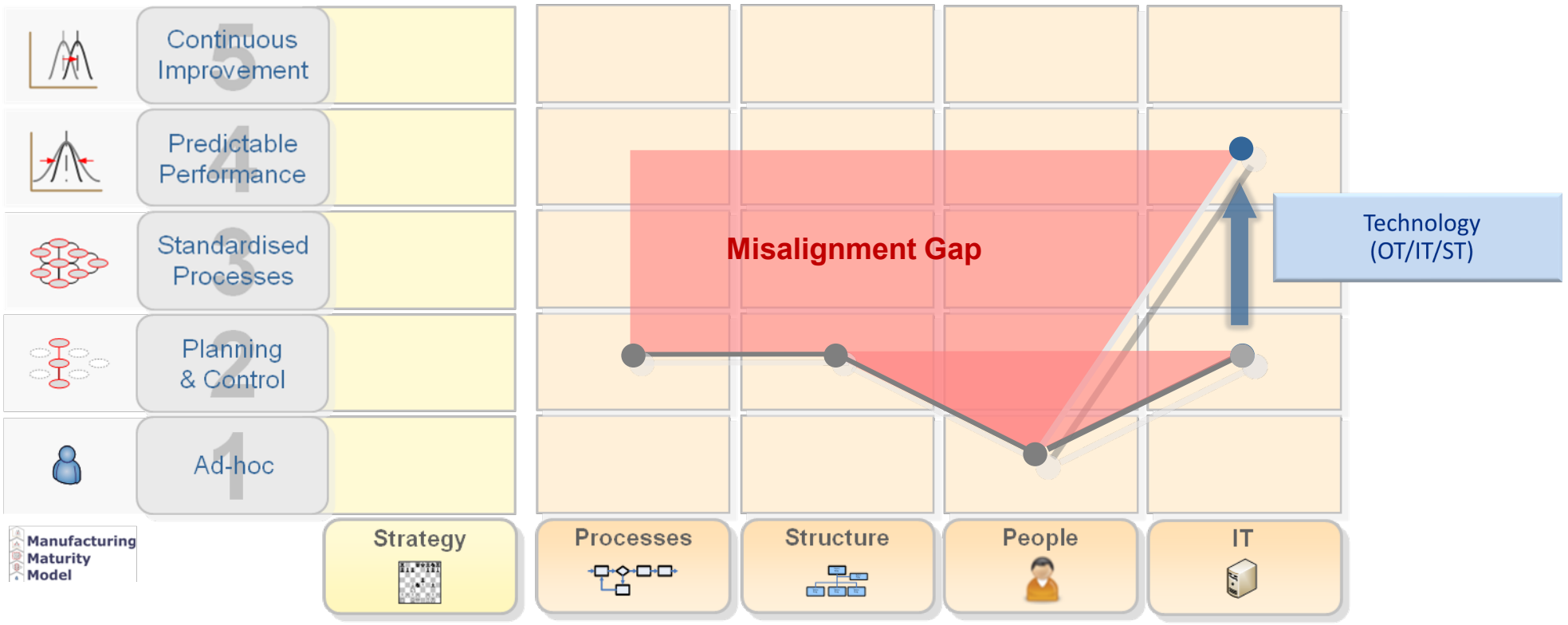


Manufacturing Maturity Model

Source: MESA White Paper 38

Before and After Technology

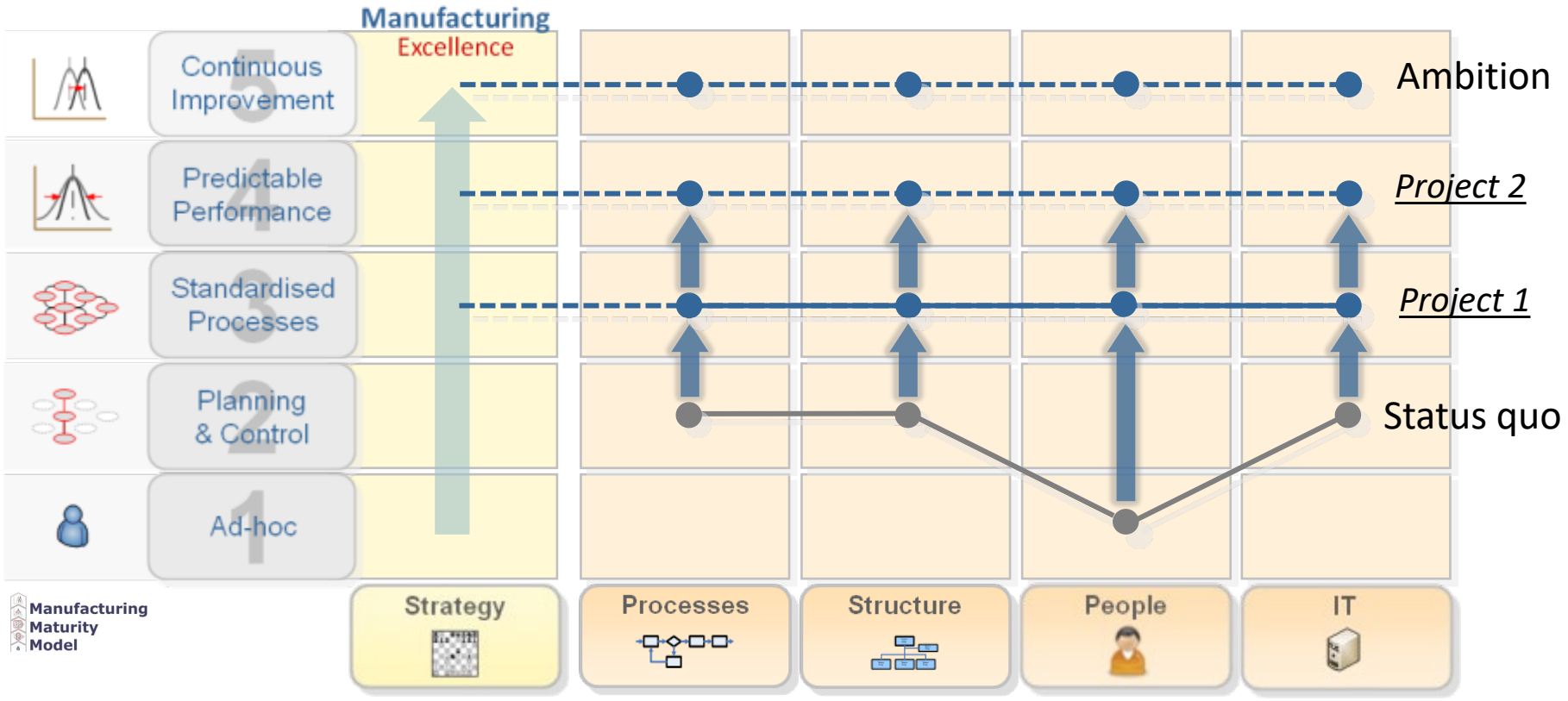
Mind the Gap?



Source: MESA White Paper 38

Manufacturing Maturity Model

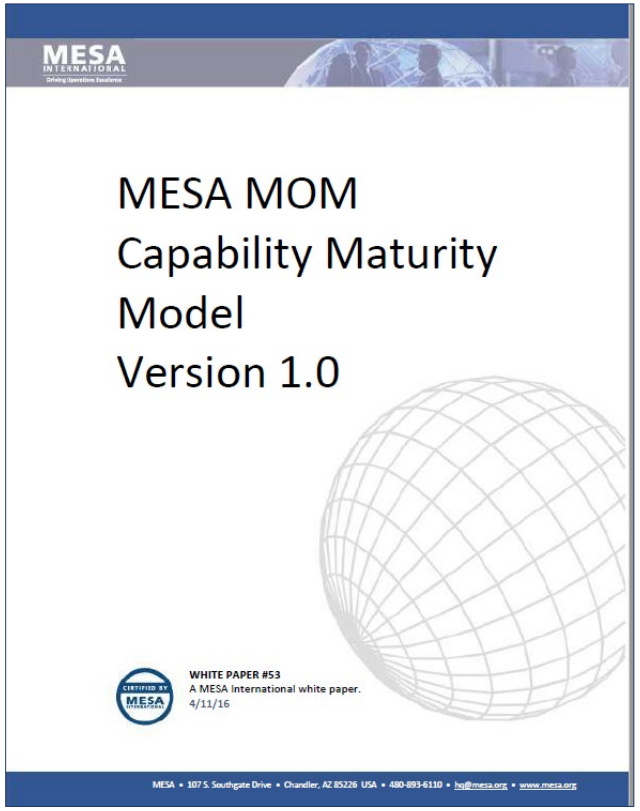
Step by Step Approach



Source: MESA White Paper 38

Manufacturing Capability Maturity

An assessment approach



Source: MESA White Paper 53

- Assessment based on ISA-95 part 3: *Activity Models of Manufacturing Operations Management*.
- A set of characteristics for each major activity defined in ISA-95, used to define the maturity level of an organization.
- Aspects of maturity
  - ***Roles & Responsibilities, Succession Plans and backups, Policies & Procedures, Technology & Tools, Training, Information Integration and KPIs***
- Delivers not only current maturity level, but provides guidelines for structured step-by-step improvement, a plan!

MESA Capability Maturity Model

Explicit Application to Manufacturing

There are no defined procedures for Production and the processes are not repeatable during times of stress.

Individuals using their own local knowledge, experience, tools and methods do Production.

There are no formally defined procedures for obtaining and validating the job lists and work masters.

Production schedules are regularly not met and there is considerable unexpected variability in production times for similar jobs.

There are no documented-assigned responsibilities for performing Production; lines of succession for responsibilities are not defined.

Source: MESA White Paper 53

MESA Capability Maturity Model

Explicit Application to Manufacturing

Production processes vary across organizational groups, with different processes and procedures used in different groups.

The ability to perform Production processes is based on knowledge informally maintained and passed on within the organizational group.

Senior production personnel, operating as expeditors, routinely handle exceptions or abnormal situations.

Responsibilities to perform Production are defined by individual groups but no formal lines of succession for responsibilities are defined

There are defined procedures for obtaining and validating the information listed above, but no consistency across groups.

Source: MESA White Paper 53

MESA Capability Maturity Model

Explicit Application to Manufacturing (Production)

Responsibilities to perform the activities are defined for all organizational groups and formal lines of succession are defined

Production processes are defined across all organizational groups, and the organization follows written and controlled policies.

Production policies are communicated to all groups and training is available on policies.

Production workflow procedures are communicated to all groups and training is available on procedures.

Senior production personnel, operating as expeditors, are rarely used; they primarily handle major production problems.

Source: MESA White Paper 53

MESA Capability Maturity Model

Explicit Application to Manufacturing

Process metrics and management control systems are in place and ensure that all processes are followed.

Exceptions to the Production procedures and policies are well defined and documented

All Level 3 conditions hold

Senior production personnel, operating as expeditors, are rarely used and there are defined procedures for exceptions. Normal processes are updated regularly to handle exceptions that repetitively occur.

Source: MESA White Paper 53

MESA Capability Maturity Model

Explicit Application to Manufacturing

All Level 4 conditions hold

Continuous improvement processes are in place and followed. Metrics that measure variances are used to make improvements and implement corrective action plans.

Problems detected in the processes and tools used in Production are used to make improvements and implement corrective actions.

Source: MESA White Paper 53

Manufacturing Capability Maturity

High-Level Assessment

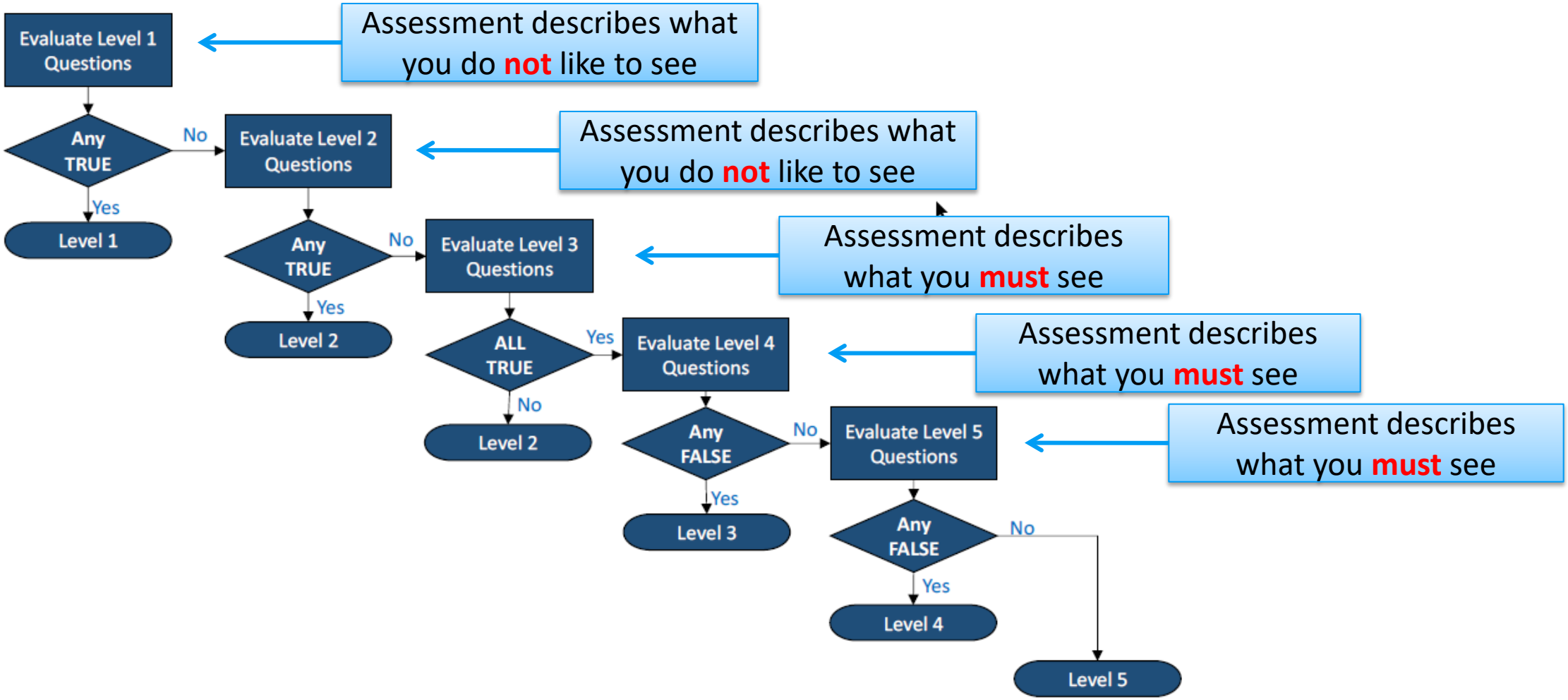
POLL 2

- Scope: Production, Maintenance, Quality and Inventory activities

- Based on a summary of characteristics of the 5 levels, please indicate the level of your company* between 1 and 5 (or NA)
  - Start your assessment at the bottom with level 1 and work up and stop where relevant items are missing in your current practice
  - Then enter your level in the Summit App.

Manufacturing Capability Maturity

Structure of the Assessment



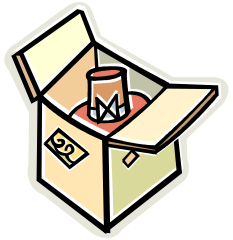
Capability Maturity Evaluation

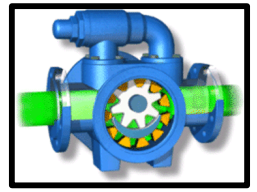
Level variation

Resources handled

In the case of resource management, analysis, tracking and data collection, there may be different maturity levels for handling:

- Personnel resources
- Material resources
- Equipment resources
- Physical asset resources





Policies & procedures, people and tools

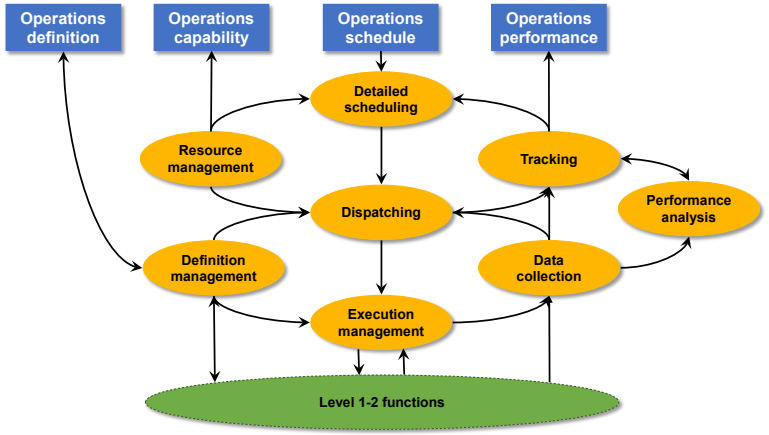
Organizations may have **different maturity levels in each of these areas**. For example, an organization may have a high maturity in policies and procedures, and a low maturity in people because there is no formal training of the policies and procedures.

Source: MESA White Paper 53

Production	Characteristics	Interpretation
5: Optimizing	• All level 4 in place • Focus on incremental and innovative process improvements • Analyse and improve process variability • KPI's routinely reviewed and updated	• Changes are frequent and implemented in a controlled way • KPI's are routinely reported, connected to analysis info and evaluated • Master data, planning data, specifications and collected data are available in systems and used for optimization and root cause finding • Analytics are understood: collecting / context / quality / value
4: Quantitatively managed	• All level 3 in place • Processes defined, repeatable, monitored and managed • Processes are updated regularly • Systems supporting, connected, monitored	• Capacity limits and specification limits are managed • Waste and schedule deviations are in view • Data quality of master data and collected data is monitored • Master data, planning data, specifications, orders and collected data are available in systems and exchanged in controlled way
3: Defined	• Processes defined and uniform • Tools / systems used routinely • Systems connected with support • Unexpected process deviations are limited	• Operator roles are defined and active, operators are trained and monitored • Systems are used to support working processes for happy flow and for exceptions • Systems are connected and supported • Preconditions for workorders are checked before start • Operator sees how he and his shift are doing
2: Managed	• Process repeatable but fail under stress • Some processes documented • Some systems used, but not trained or connected	• There is a schedule and factory can produce volume • Systems are supporting the production execution, but they are not in the lead and not connected • Data collections are done manually: no integration of shopfloor and planning
1: Initial	• Uncontrolled and reactive • Heroic individual efforts • No systems or documentation	• Personal dependencies • Differences between shifts • No uniform view on plan or material on the shopfloor • High variability in efforts, "craftsmanship"

Scope: Activity Sets

Manufacturing Capability Maturity Assessment



Source: MESA White Paper 53

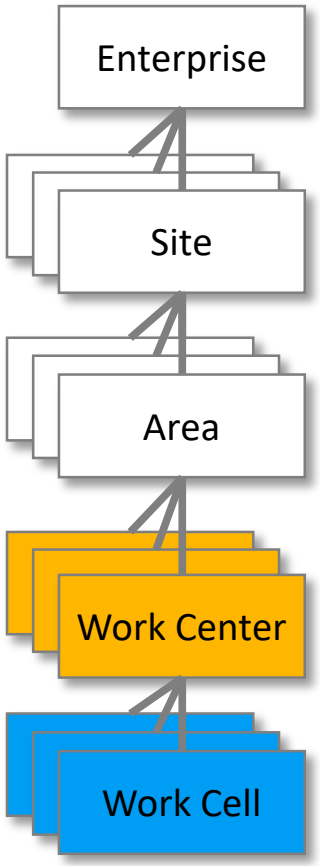
ISA-95 identifies the categories and activity sets used in maturity evaluations. There are four categories:

- **Production operations management** focuses on the activities directly involved in the production of products or services.
- **Maintenance operations management** focuses on the activities of ensuring the operation of all equipment used in production or services.
- **Quality operations management** focuses on quality test management and laboratory operations, including testing operations supporting receiving, final inspection and other non- production-related testing.
- **Inventory operations management** focuses on material movement and storage operations, including movement and storage operations supporting receiving, shipping and other non-production-related material movement and storage.

Each category is defined by a set of activities. Each of the activity sets have at least one associated maturity level.

Organizational scope

Capability Maturity Evaluation



Source: MESA White Paper 53

- The scope of a maturity assessment can be a:
  - Site, department or area
  - Division
  - Team or shift
  - or any combination of these

    identified as the “organization” in the model.
- Individual teams or shifts may have a high maturity, but the overall area, site or company maturity is defined as the **lowest** maturity of any individual subgroups.

Required: Objective Evidence

Can be obtained in multiple ways

1. **Interview** personnel about their jobs and see if what they tell you matches the defined process.
   - Open-ended questions to elicit responses, because it allows personnel to add additional information and descriptions.
   - Challenge and probe or follow up with questions on uncertainty.
2. **Observe** the operations as performed.
   - Ask personnel to demonstrate their jobs and work practices.
   - Observing actual operations can also be less disruptive to operations than interviews. Do not rely only on documentation and records.
   - Interviewing personnel and observing actual operations is an important part of obtaining objective evidence of the maturity level.

Required: Objective Evidence

Can be obtained in multiple ways

3. Review the documents and records used in operations.

- It is important to check that the documents are adequately controlled and are available to those who need them.

4. Examine actual operations records and collected data.

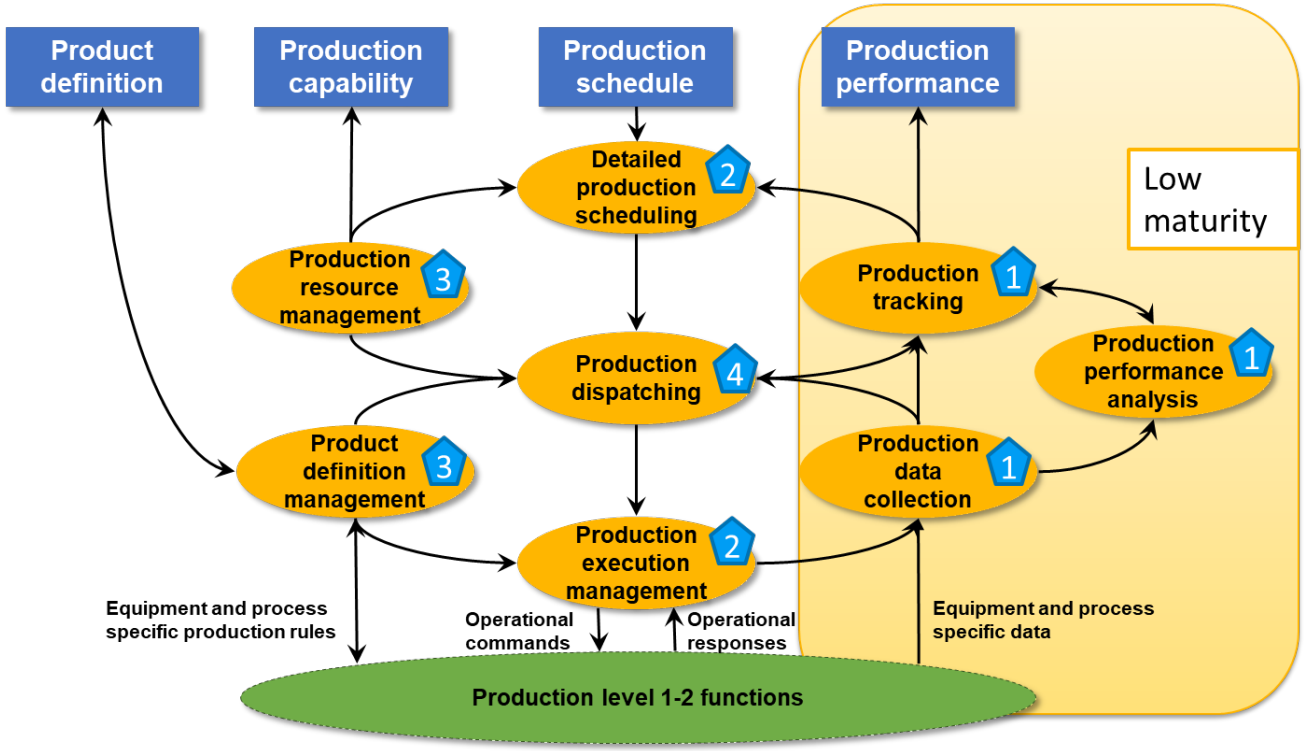
- It is often impossible to interview every person, look at all documents and observe all activities.
- Look for representative documents in each of the activity areas.

The best way to achieve objective evidence is to have well-prepared questions related to the activity evaluated.

Visualization Results

Example

Production Operations Management



Manufacturing Transformation

- Strategy
- Plan
- Roadmap

➢ Continuous Improvement initiatives

Manufacturing Capability Maturity

Production

RESULT

The technicians will show the result of the Poll 2 now!

Manufacturing Capability Maturity

High-Level Assessment Exercise: Results

- Assessment at more detailed level
  - Activities on the shopfloor
  - Production, Maintenance, Quality and Inventory
- Normally, you ask/check:
  - Is there consensus in the assessing team?
  - About what do we disagree? What needs further investigation?
  - What is needed to get to a higher level? How to address the weakest elements/characteristics?
  - Does this deliver benefits?
- Create a Continuous Improvement Plan

Industry 4.0 Vision vs Reality

Agenda

- Introduction
- Trends and Observations in Manufacturing
- Manufacturing in the Age of AI
- Smart Manufacturing & Industry 4.0 and 5.0
  - Examples: Challenges and Successes
- Are You Ready?
- Manufacturing Capability Maturity
  - Assessment
- Conclusions and Wrap-Up

Industry 4.0 Vision vs Reality

Vision

- Innovation
  - Improve performance
  - More value in the perspective of the final customer
  - Perfect order delivery in a dynamic world
- Asks for
  - Visibility and transparency
    - Throughout the end-to-end supply chain (SCM)
    - Throughout the entire product lifecycle (PLM)
- Requires consistent and timely information
  - Capturing and sharing data/information
  - By excellent seamless integration of systems and technologies
  - Collaboration within our factory and with our partners

Industry 4.0 Vision vs Reality

IT/OT Convergence

- New Opportunities will be enabled by the increased levels of cooperation between IT and the groups managing the Operational Technology (OT), incl. monitoring or controlling the physical devices and processes in the enterprise.
- IT/OT convergence is a prerequisite to create a connected factory (IIoT) in which ***all our resources*** are linked to create an optimal performance.
- It is about integrating:
  - Information Technology
  - Operations Technology
  - Smart Technology)

Industry 4.0 Vision vs Reality

Reality

Characteristics of best-in-class

- Standardization
- Digitalization and Integration
- Manufacturing Capability (not just technology)
- Elevated manufacturing maturity (level 3 up)
  - Ensure improved ways of working are adopted
  - Special attention for Roles & Responsibilities, Succession Plans & Backups, Policies & Procedures, Technology & Tools, Training (people's skillsets), Information Integration, Key Performance Indicators
- Holistic approach, aligned with your strategy
  - Integrated systems are enablers

Industry 4.0 Vision vs Reality

Manufacturing Maturity Capability

- Crises are showing us, everything is quite fragile.
- Advanced smart technologies and concepts will help us to become less dependent on equipment, people and materials and make us more agile
- Assessments like
  - Singapore Smart industry Readiness Index
  - Manufacturing Capability Maturity

  help to identify our strong/weak 'spots' and to create a plan!
- It is about people: communicate and collaborate!

Want to Know More?

Ask Now or Later …

Thank You

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