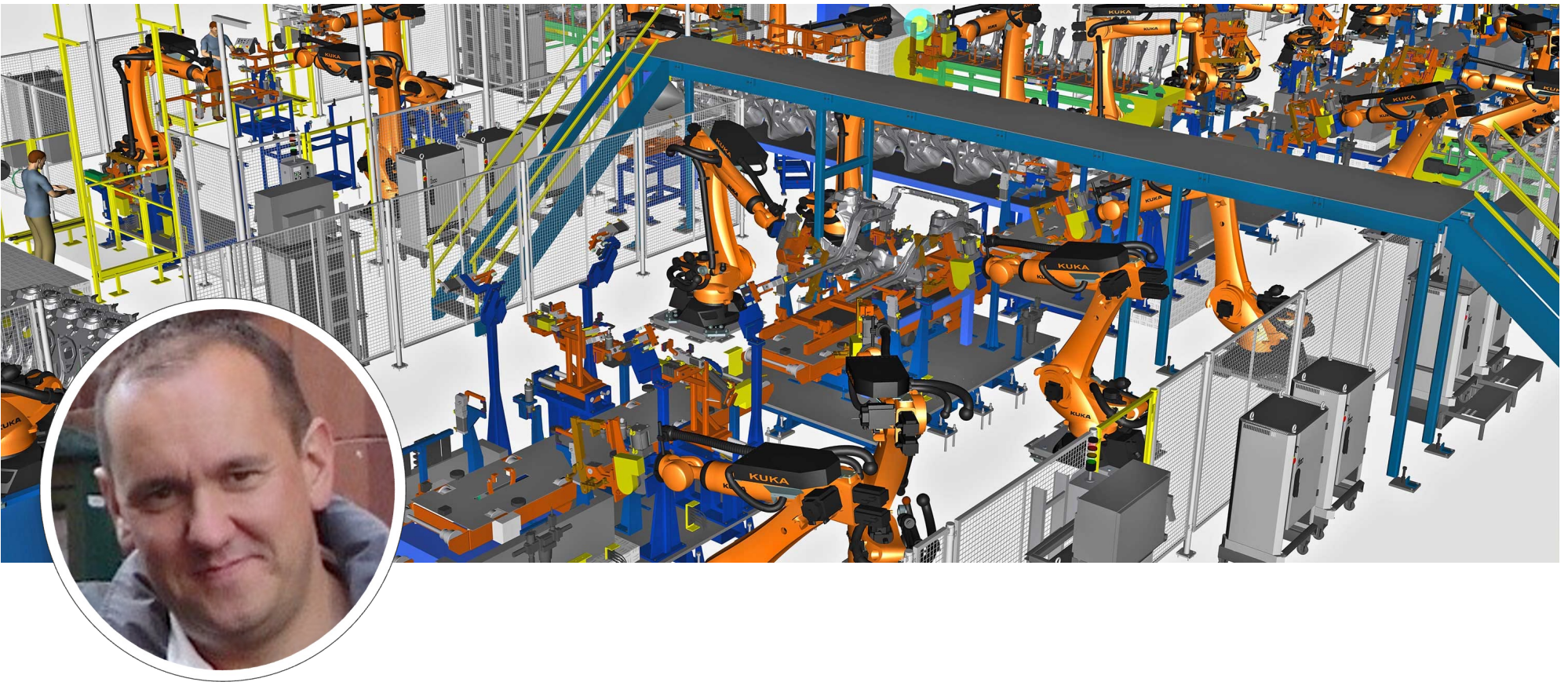




Graham Howe

Principal Research Fellow and Head of MADE Cymru

University of Wales Trinity St David in Swansea.

Part-time PhD Student at Strathclyde University.

Working with Manufacturing organisations to help deliver productivity improvements. Teaching Lean, Six Sigma and Industry 4.0 technologies and their focused industrial deployment.

graham.howe@uwtsd.ac.uk

Sometimes teaching, sometimes researching, always learning.



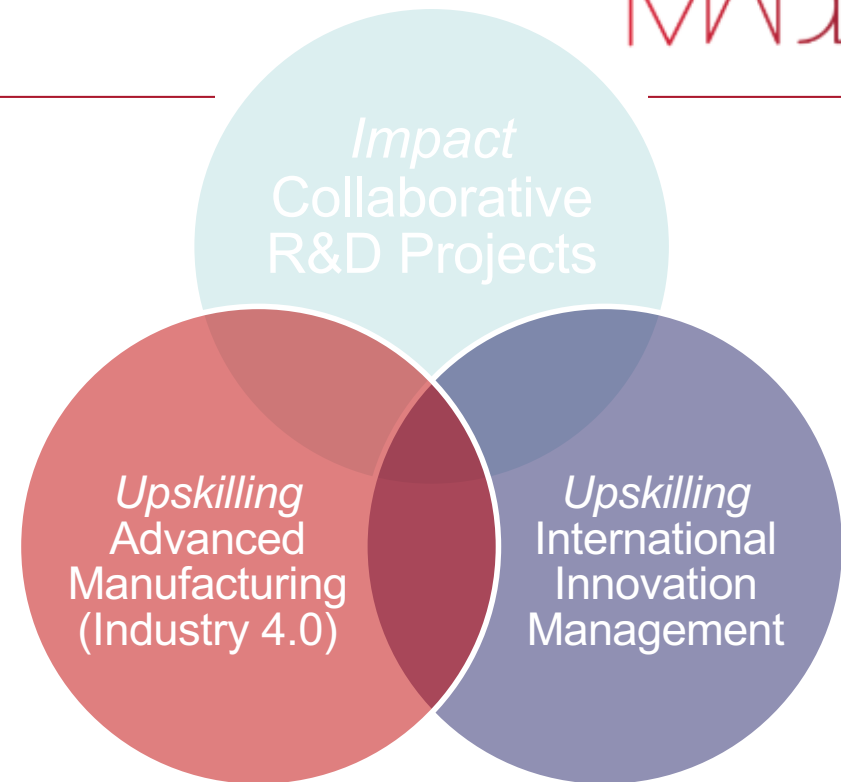
What are you looking for from the programme?
What are you bringing to the cohort?

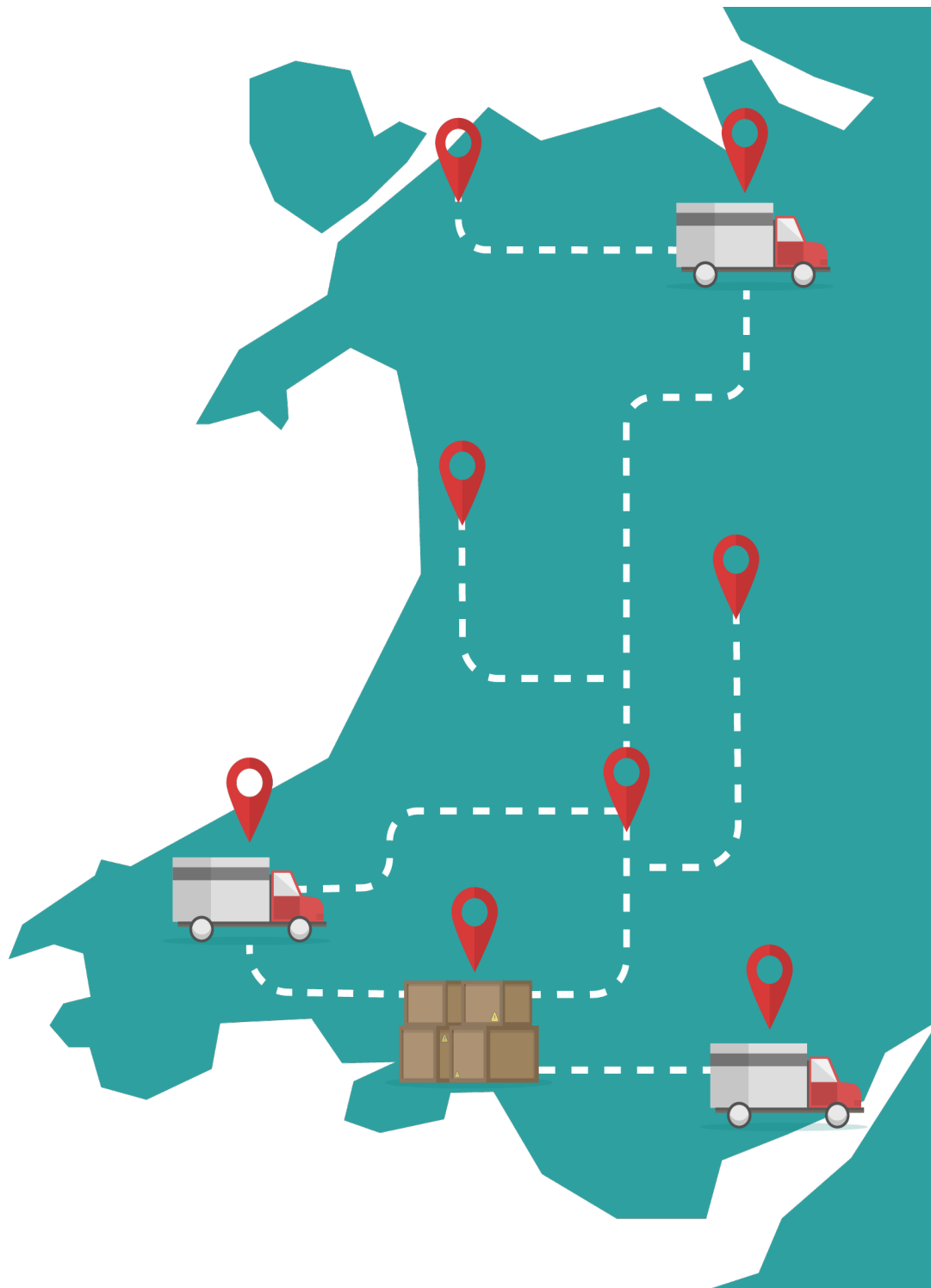
Impact through Collaborative R&D

- Advanced Design Engineering (Additive Manufacturing technologies)

Upskilling

- Upskilling for Advanced Manufacturing (Industry 4.0)
 - Level 7 MSc programme and short course options
 - Level 5 (HND level) short course options
- International Innovation Management
 - Level 7 MSc programme and short course options.

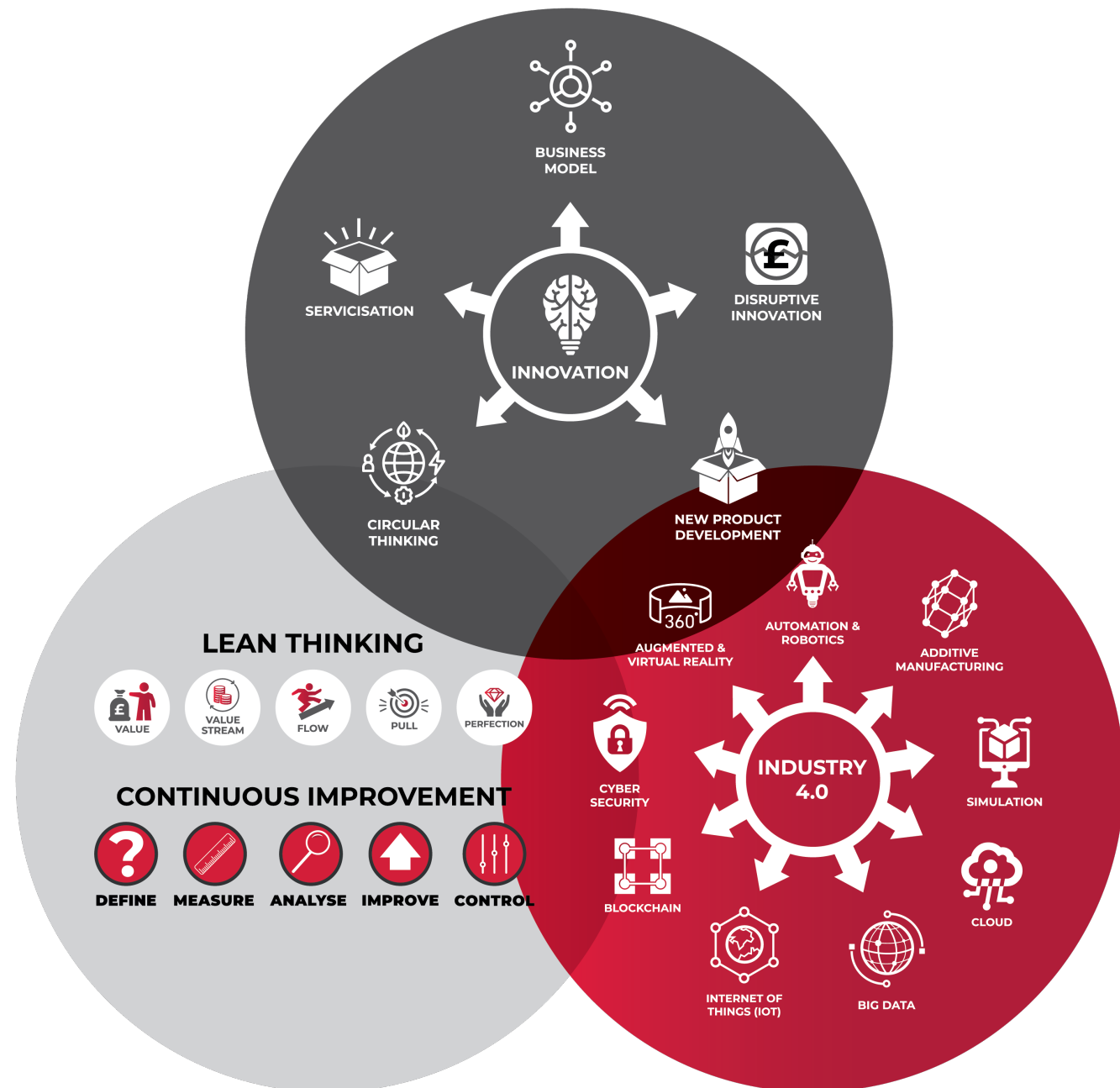




1. **Upskilling for Advanced Manufacturing (Industry 4)**
 2. **Continuous Improvement**
 3. **Innovation Management**
- Flexible way to learn while you work.
 - Friday afternoon online / blended learning delivery (1 or 2 lectures).
 - 3 more Entry points (October 2022, February 2023 and June 2023.)
 - Hop-on / Hop-off Learning opportunities.
 - Bite sized Learning at Level 5 & Level 7
 - Fully funded (for limited period).

Operational Excellence

- Lean Principles to help us reduce operational complexity and improve productivity.
- Combine with Industry 4.0 technology.



***“Technology
can only bring
benefits, if,
and only if, it
diminishes a
limitation.”***

Eli Goldratt (1995)







**It's not just
a course -
It's a
network.**

A network pan-Wales with different sectors and sizes.

***Thank you for the opportunity to
share MADE Cymru with you.***

Let's start the conversation and collaborate...



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

The Plan!

Lecture sessions

- Friday afternoons 1pm – 3pm we meet here on Teams.
- The programme runs from February through to September 2023.

Tutorials

- You will need to book these with David Jones – generally 30 minutes every few weeks, scheduled on a Friday morning if possible.

Moodle access!!

- Six Sigma Green Belt (ACMA5005)
- Group Project (ACMA5009)



Level 5 – Continuous Improvement with Industry 4.0



Vital! – Ensuring you have access to Moodle



Your Module

Your Course

Your Voice

One Rep per Module

Two or Three Staff Student Meetings (Online) per year
Nominate or volunteer (with their agreement!) someone
who could represent the views of the cohort.

Student ID & Enrolment

Please ensure you have completed your application and enrolment as per the instructions emailed to you from Registry/Admissions.

Upload to MyTSD – there's a “Documents Required Prior to Enrolment” tab on the Menu where they can upload a JPEG (PNGs cannot be uploaded)

Email your hwb@uwtsd.ac.uk with your Student Number and Photograph.

Useful Links

UWTSD Student Union

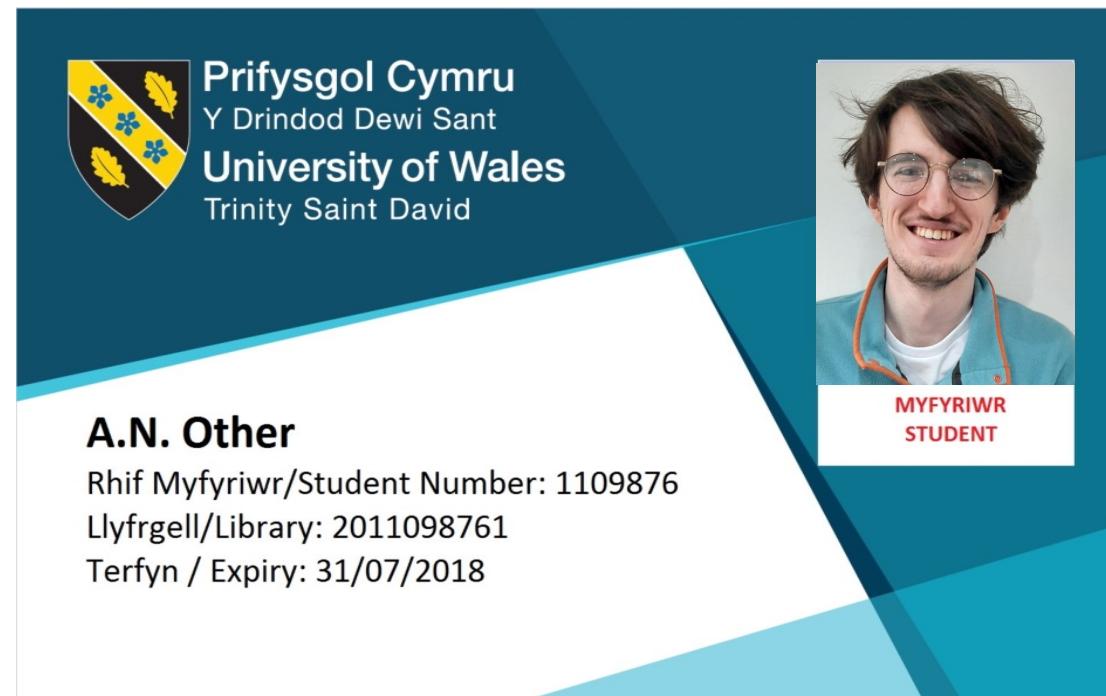
www.uwtsd.ac.uk/students-union/

The National Union of Students

www.nus.org.uk/

Totum Discount Card (NUS Card)

www.totum.com/



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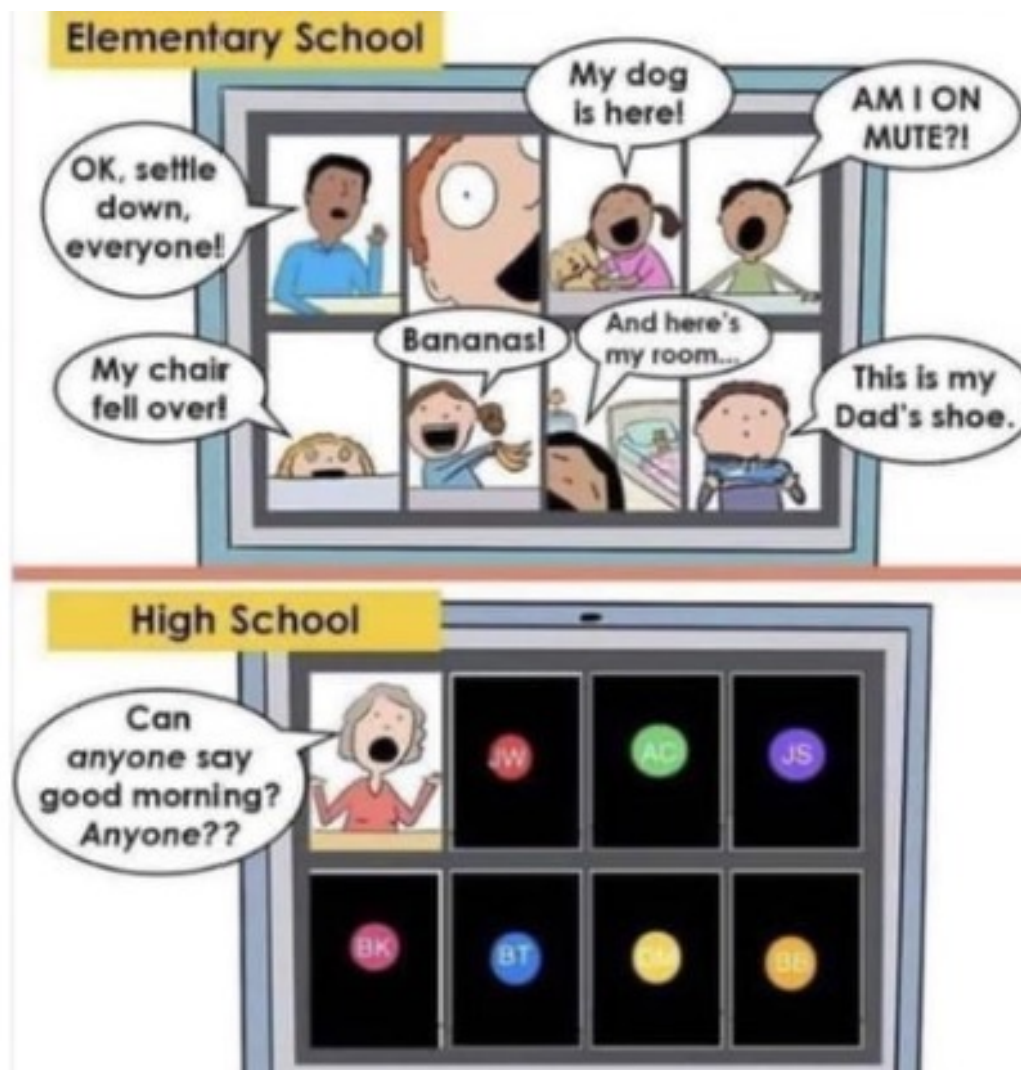
Go to **totum.com**
to get your card now



Level 5 – Continuous Improvement with Industry 4.0

Teams Sessions

- Please switch your cameras on! Engage with us and your colleagues.
- Nothing worse for us than talking to a screen of Icons / Initials.
- You will need to use your Student Email to login into Teams sessions.



Characterise the Process

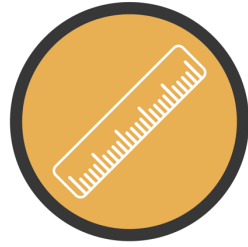
Optimise the Process



DEFINE

Define the problem
Listen to the customer (VoC)

Raise project charter



MEASURE

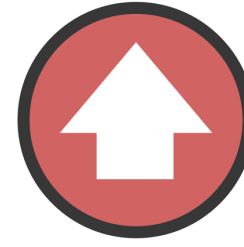
Identify measures.
Check your measuring systems.

Collect data
Listen to your process (VoP)



ANALYSE

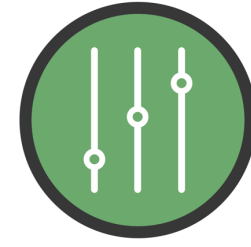
Identify the factors which are the main contributors.



IMPROVE

Determine the optimal values for the factors.

Appropriate Industry 4.0 technologies?



CONTROL

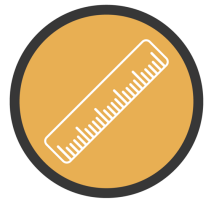
Determine the long-term controls so improvements identified and are embedded in the organisation

February 2023

August 2023



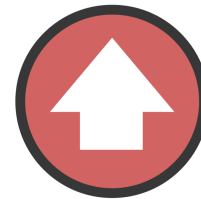
DEFINE



MEASURE



ANALYSE



IMPROVE



CONTROL

March 2023

September 2023

Group Project and Tutorials

Assessments

Online Tests

- Six Sigma Green Belt Test #1
- Six Sigma Green Belt Test #2

One hour online, multi-choice, about 45 questions

Group Project

- Pick a project within your sphere of influence/knowledge
- Go narrow and deep – Project Charter is important
- Backs up your learning with practical application

Level 5 – Continuous Improvement with Industry 4.0



DATA



PRESENTED
VISUALLY



SORTED



EXPLAINED
WITH A STORY

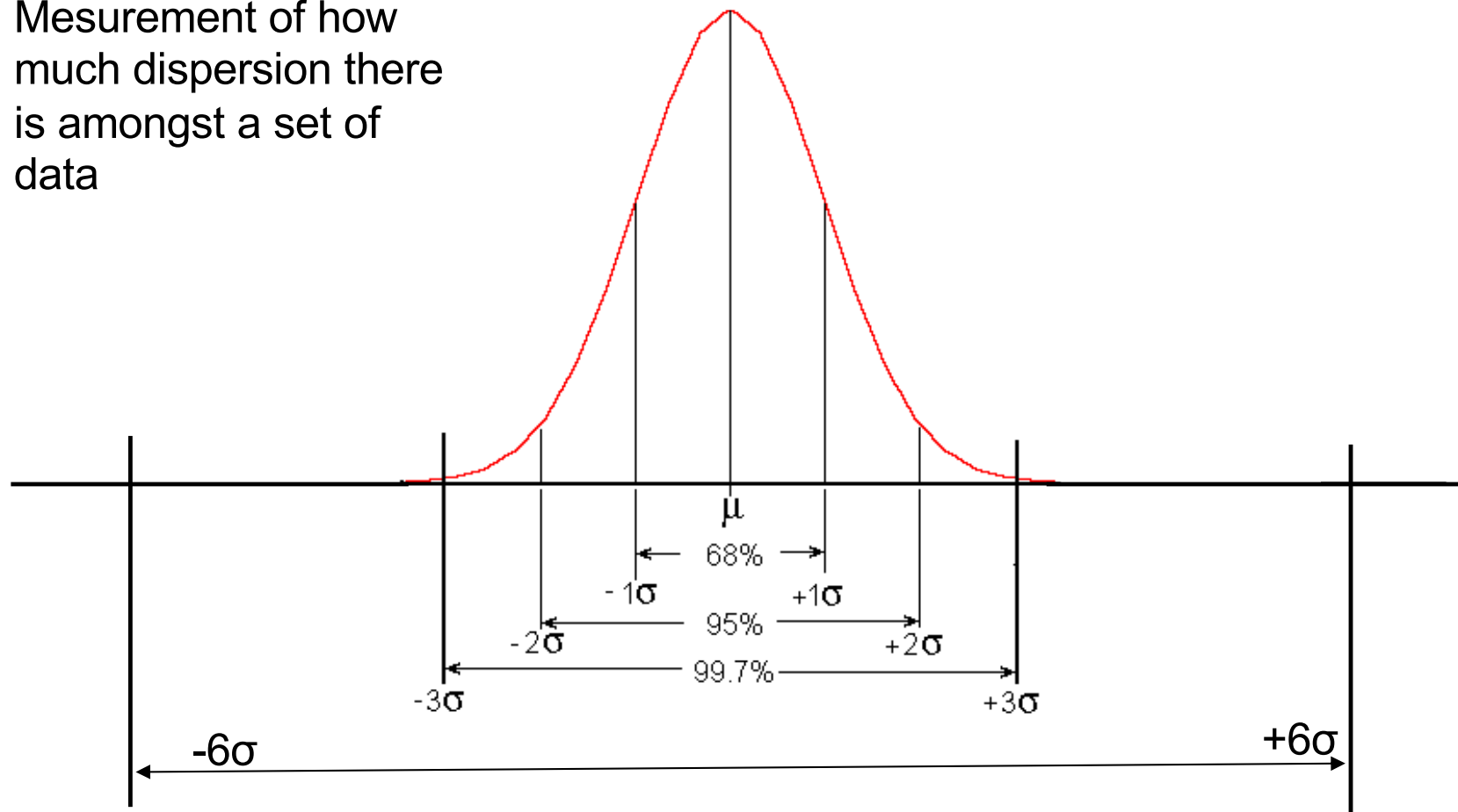


ARRANGED



Level 5 – Continuous Improvement with Industry 4.0

σ = standard deviation
Measurement of how
much dispersion there
is amongst a set of
data

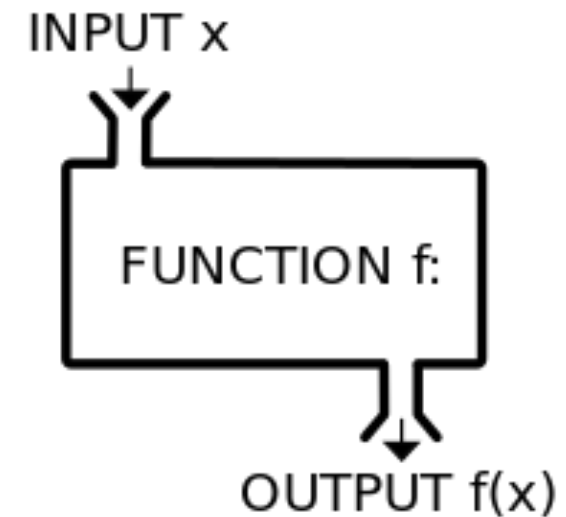


99.99966% (3.4 defects / 1,000,000 opportunities)

$$Y = (f) X$$

$$Y = (f) X$$

Outcome **Y** = (Function **f**) Output **X**



The 'Y' and 'X' Relationship

A fundamental formula used in 6-Sigma training is that “Y” is a function of “X”

$$Y = (f) X$$

In mathematical terminology, “Y” is the dependent variable while “X” is the independent variable. Expressed in another way, “Y” is an output resulting from several inputs or “Xs”

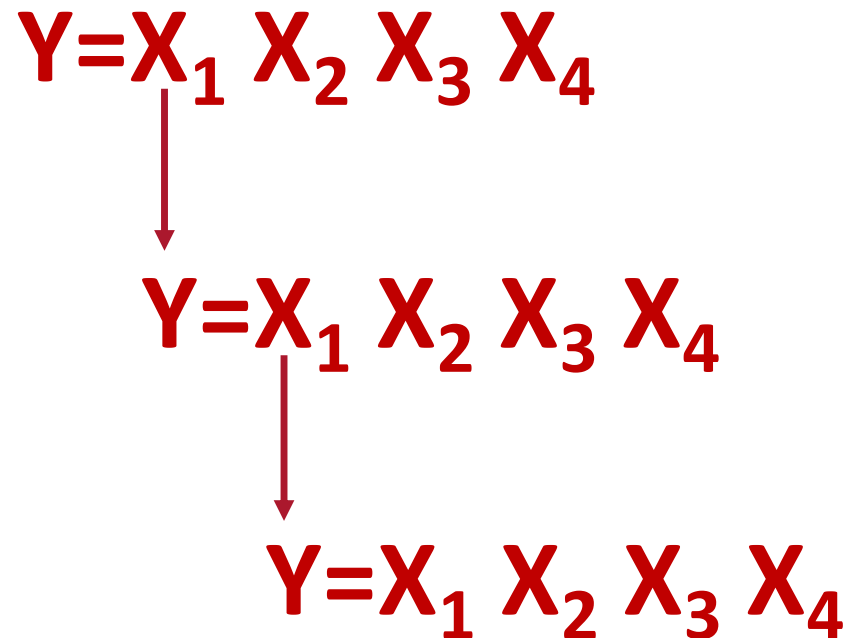
The typical diagram used to communicate this concept in Consumer Driven 6-Sigma training is as follows;

$$Y = X_1 X_2 X_3 X_4$$

The 'Y' and 'X' Relationship

Building on this concept, it can be said that every “X” is correlated to a “Y” at some deeper level in the process.

We can show this as a cascade;



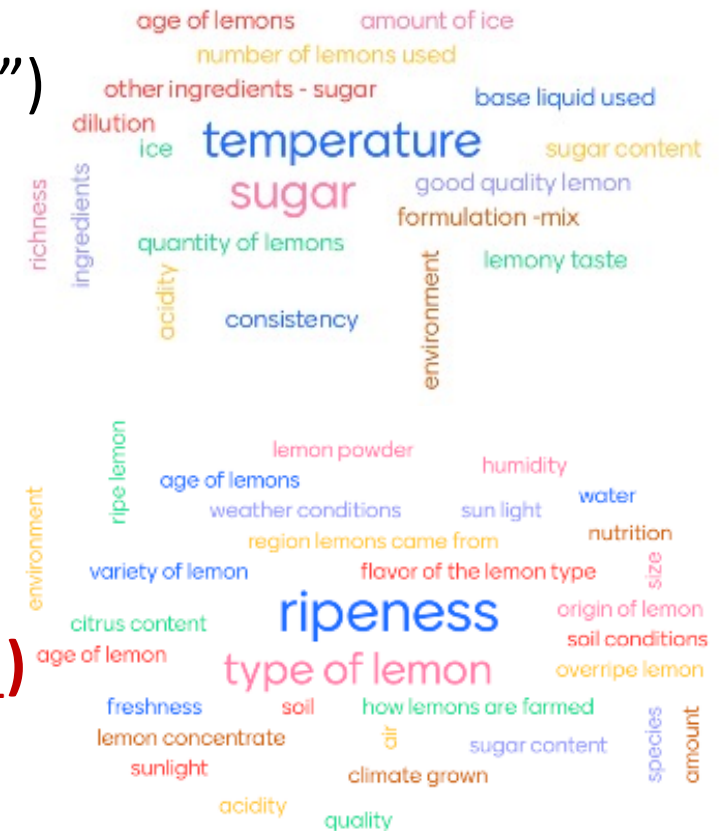
The 'Y' and 'X' Relationship example

The taste of a glass of iced lemonade (the “Y”) is influenced by several factors including;

- Type of lemon ingredient X_1
- Amount of sugar added X_2
- Type of water used X_3
- Amount of ice added X_4

Examining the “*Lemon Ingredient*” factor (X_1) which now becomes our Y , the “X” variables might include:

- Fresh squeezed lemon (potential X_1)
- Liquid concentrate (potential X_2)
- Frozen concentrate (potential X_3)



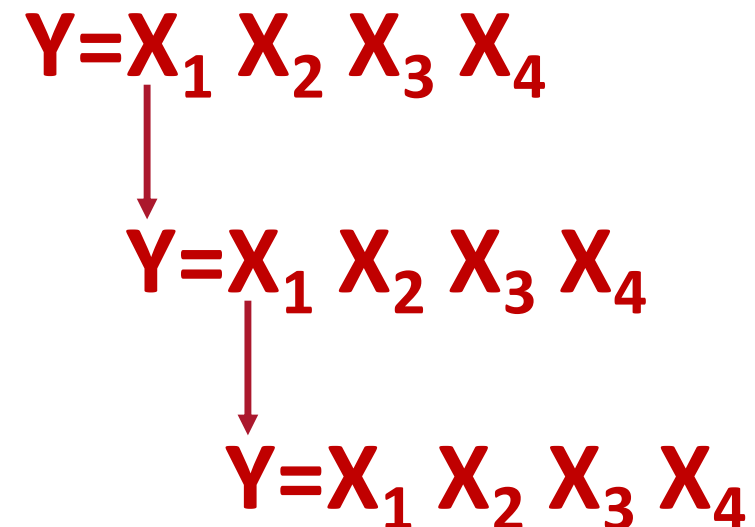
$$Y = X_1 X_2 X_3 X_4$$

$$Y = X_1 X_2 X_3 X_4$$

The 'Y' and 'X' Relationship example

Examining the “*Fresh Squeezed Lemons*” factor (X_1) which now becomes our Y , the “X” variables might include:

- Where the lemons were grown (potential X_1)
- How the lemons were transported (potential X_2)
- Age when squeezed (potential X_3)
- How lemons were squeezed (potential X_4)

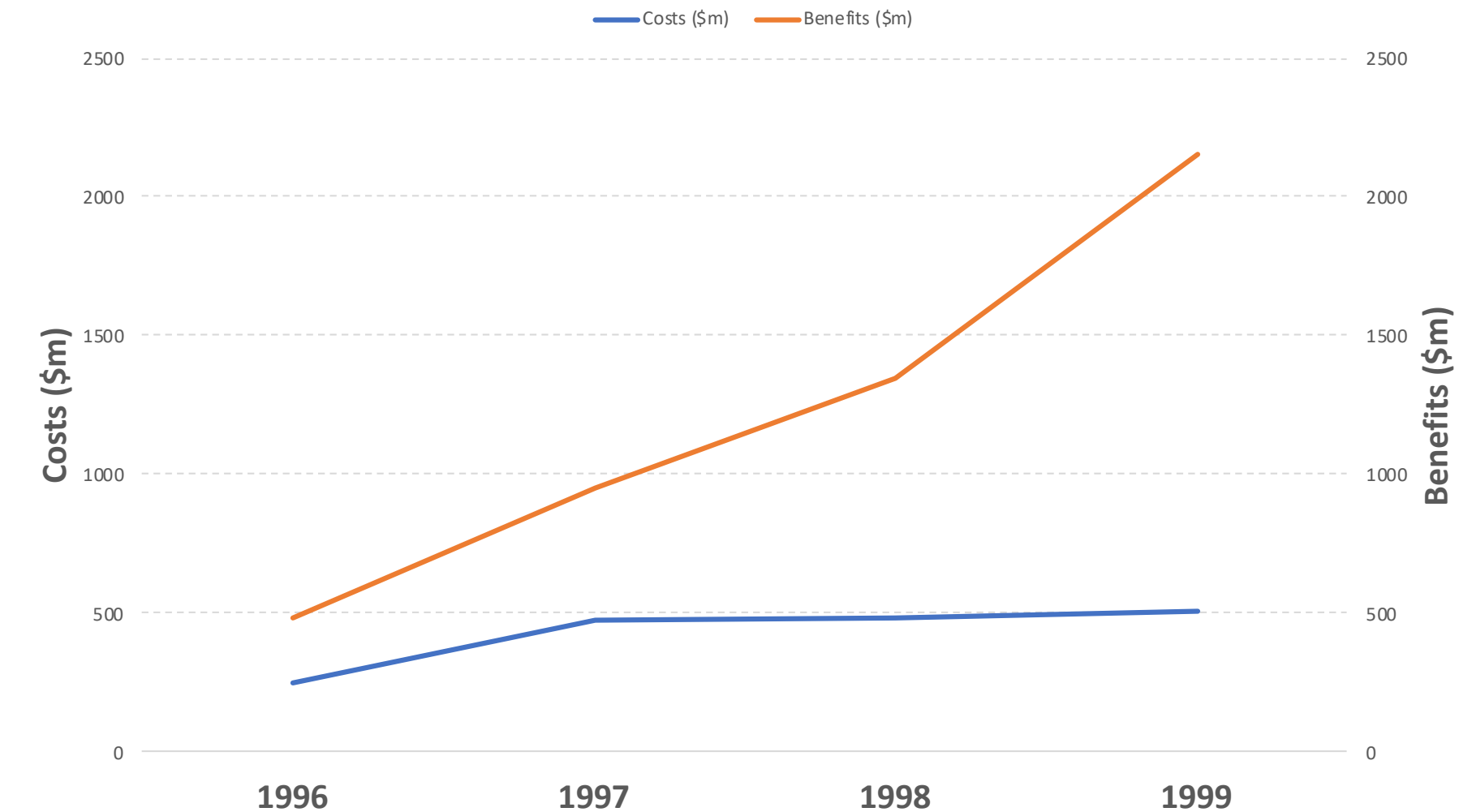




DMAIC CYCLE

5 Phases of Continuous Improvement

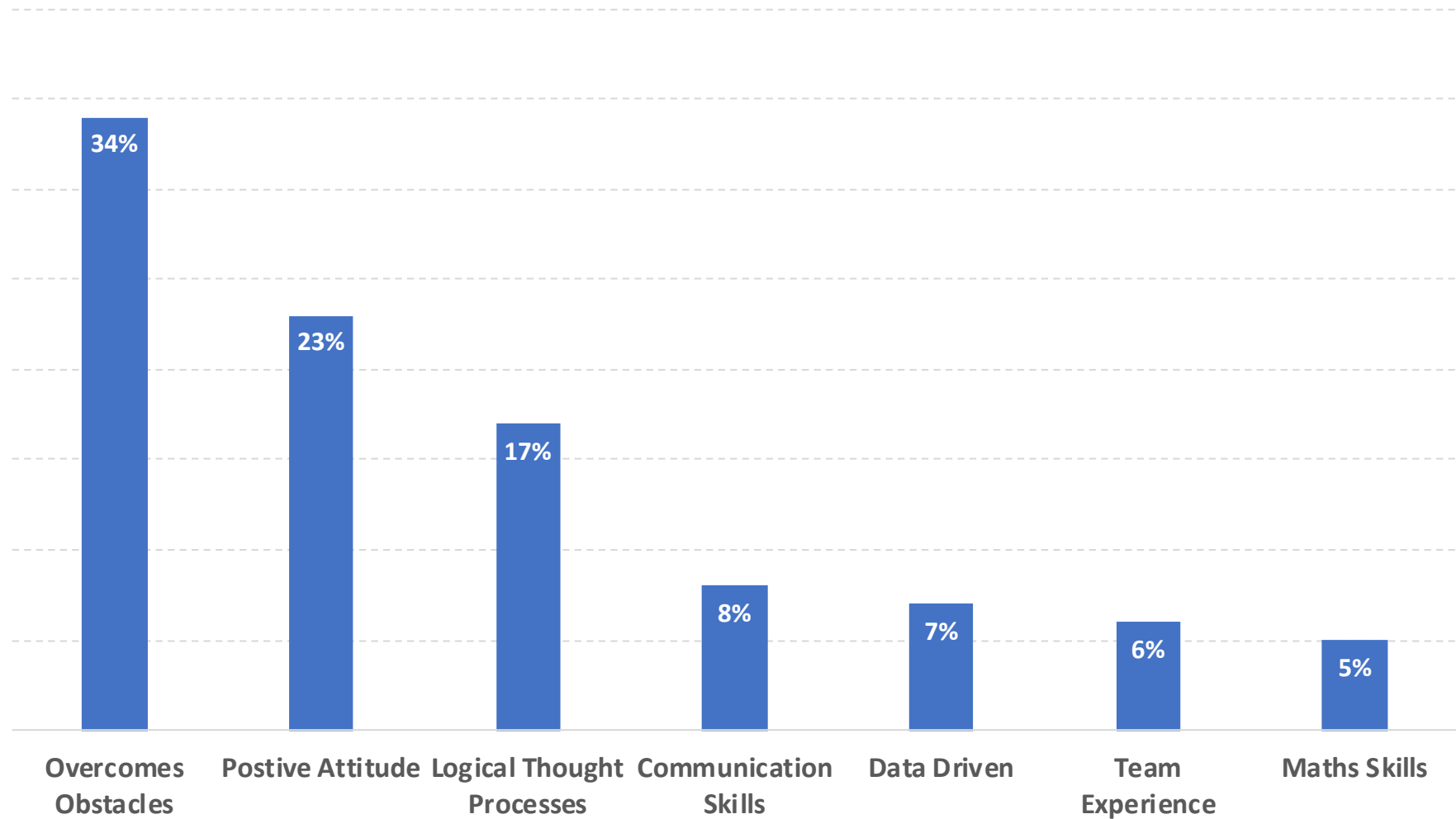
GE's Reported cost of Six Sigma versus Benefits



Keller (2005) Relative Success Factors

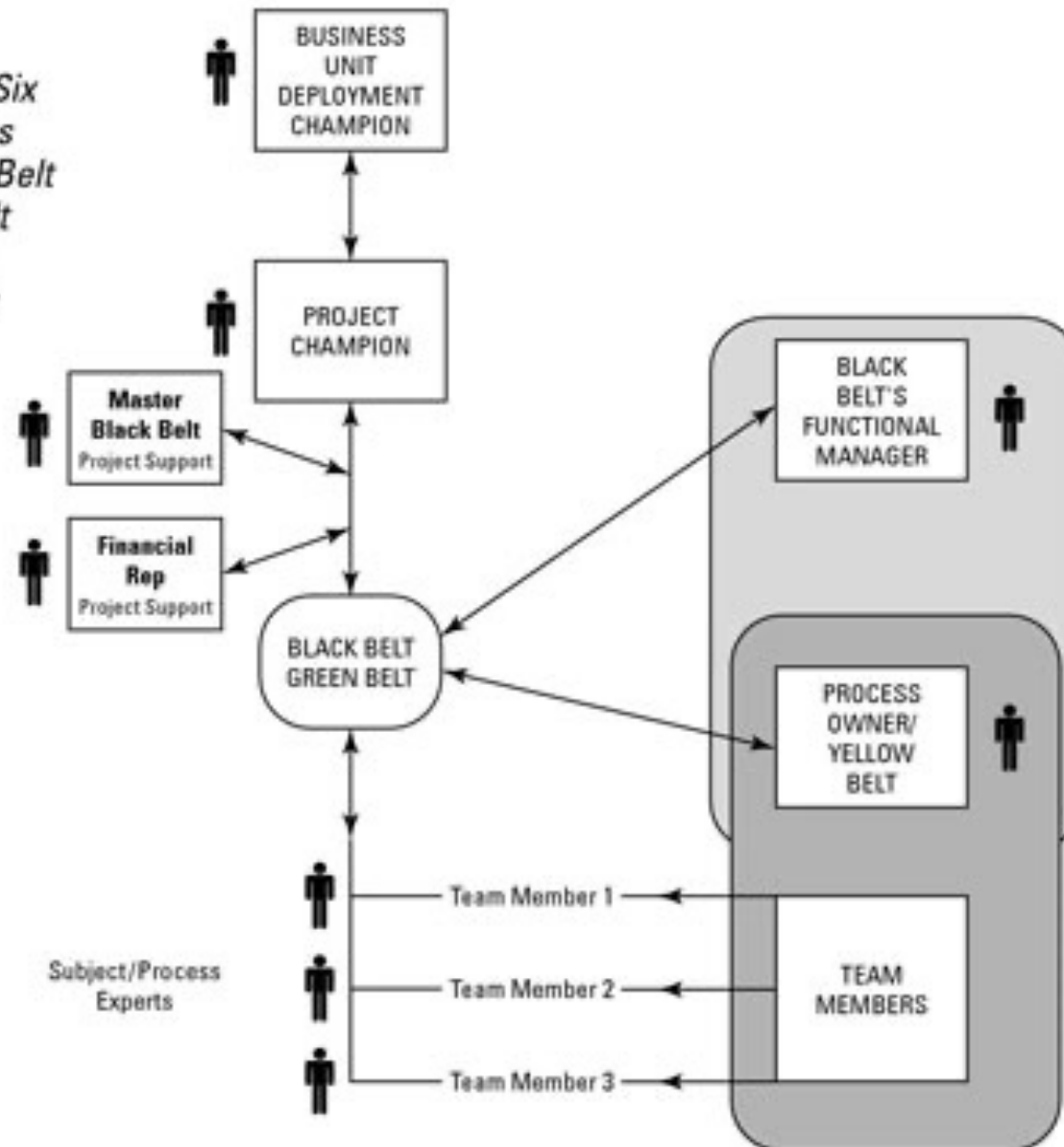


Skills and their Relative Importance



Six Sigma Deployment and Roles

The power of Six Sigma revolves around Black Belt and Green Belt projects, and involves many others.



SIX SIGMA

Statistical based and data driven

Eliminate defects within product, process, service

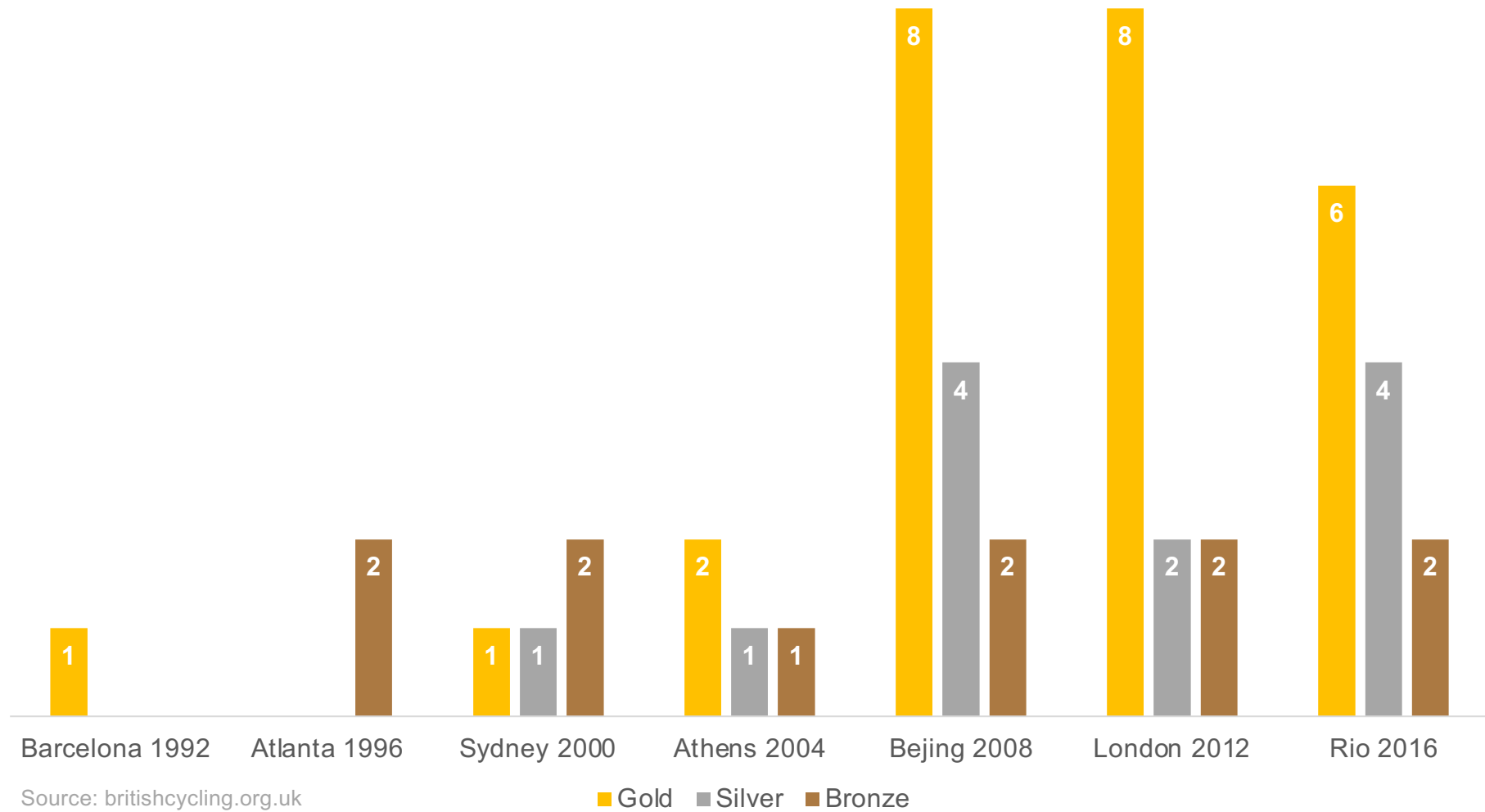


What is Lean?

MADE



Team GB Olympic Track and Road Medals



Marginal Gains



What is Lean?

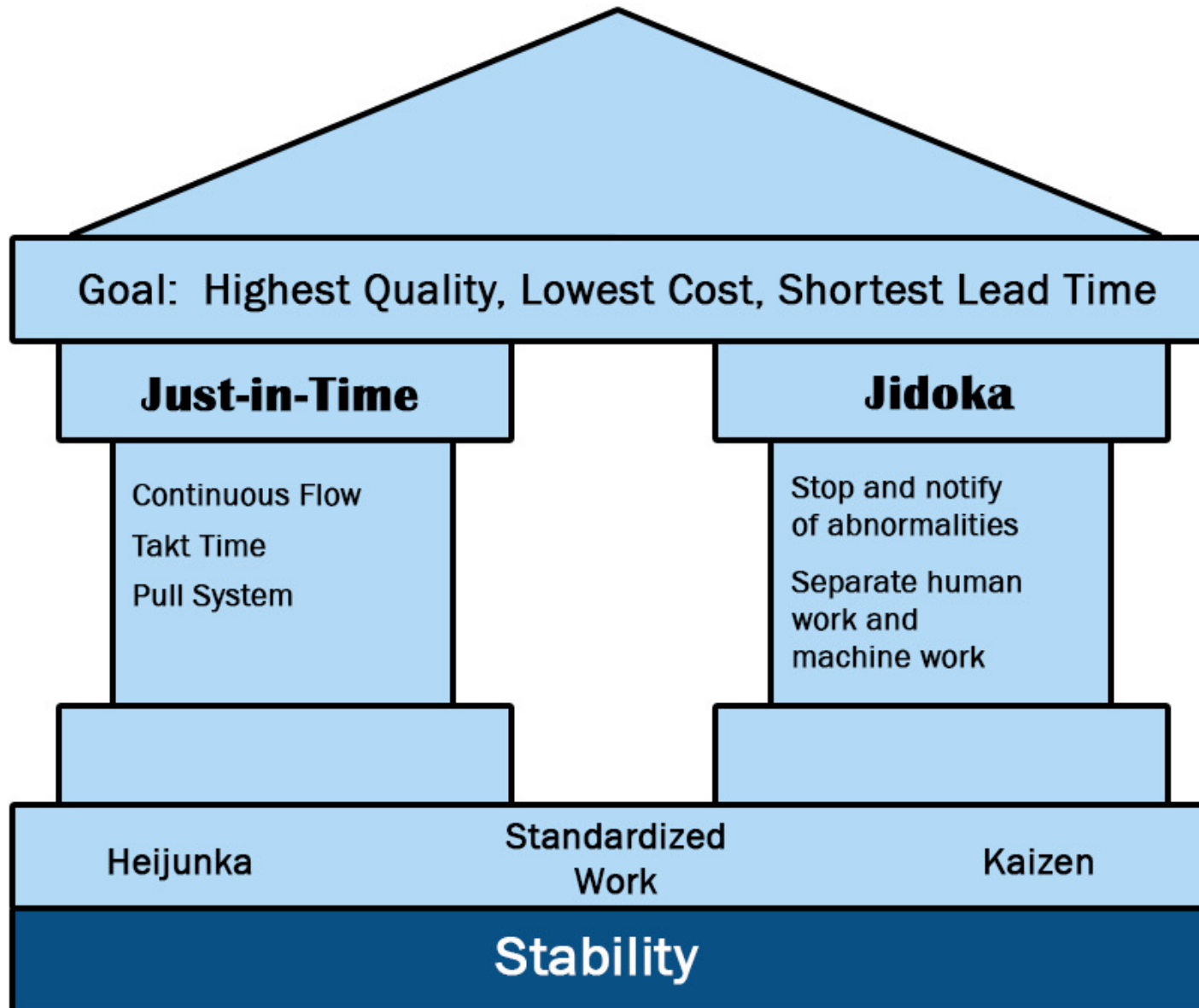
- The term "lean production" was coined around 1989 with the popularity of Womack and Jones book, The Machine that Changed the World.
- According to Womack and Jones, Lean is based on 4 principles;
 1. minimize waste
 2. perfect first-time quality
 3. flexible production lines
 4. continuous improvement



If we just copy the tools, then it won't work.

We need to develop 'critical thinkers' in our businesses.

Toyota Production System 'House'



Toyota Production System & Toyota Way



**Toyota Way
& Culture**



**Developing People
and Process**



**Toyota Production
System**



Passion to do	On the Job Training
Will to do	
Skills to do	
Understanding	Education
Knowledge	

Three meanings of Six Sigma...

1. Six Sigma is a Management Philosophy

- Customer based approach used to recognise that product and service defects are expensive.

2. Six Sigma is a Statistic

- Six Sigma processes will produce less than 3.4 defects or mistakes per million opportunities.

3. Six Sigma is a Process

- Define, Measure, Analyse, Improve and Control

Who is Tim Woods?



YouTube GB made cymru

Embracing New Technologies

MADE Website

MADE Cymru

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Have you Met Tim Woods?
38 views • 2 months ago
1:43

What is Six Sigma?
24 views • 2 months ago
2:41

PDCA Cycle
2 views • 2 months ago
1:09

Nelsons Rules
3 views • 2 months ago
2:23

The Circular Economy
21 views • 6 months ago
1:46

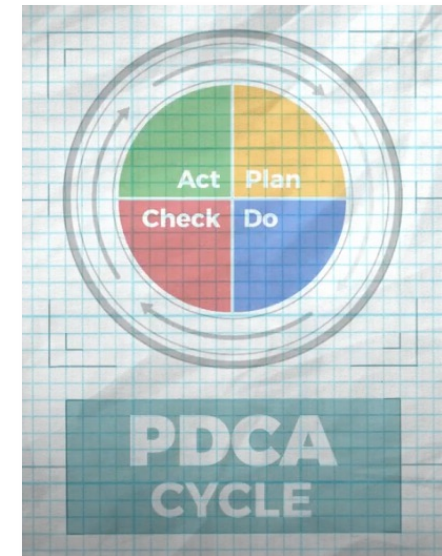
MADE - The Student Journey
2:17

Welcome to MADE
1:37

What is MADE?
1:24

W. Edwards Deming

- One of the fathers of quality control
- Key insight was the use of statistics for quality control
- Another insight was the difference between common- and special-cause variation
- Best known for defining the “**seven deadly diseases of the workplace**” and “**14 points for management.**”
- **PDCA ((Observe) > Plan > Do > Check > Act)**



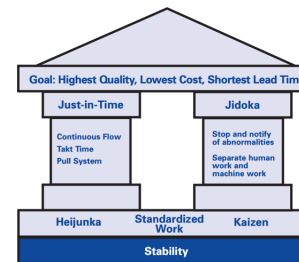
Lean Principles in Toyota

• The Toyota Way

These are the beliefs and values that create the working environment that allows Toyota to challenge the way we do things and not to be afraid to raise concerns.

No Fear No Blame, Toyota culture.

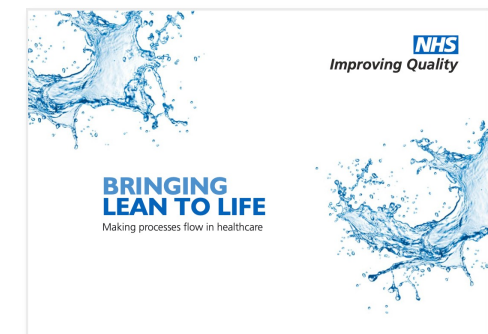
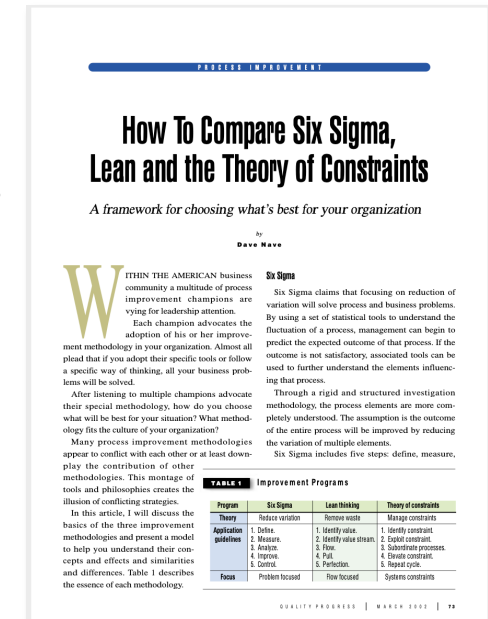
Respect for People, Respect for Teamwork



• The Toyota Production System

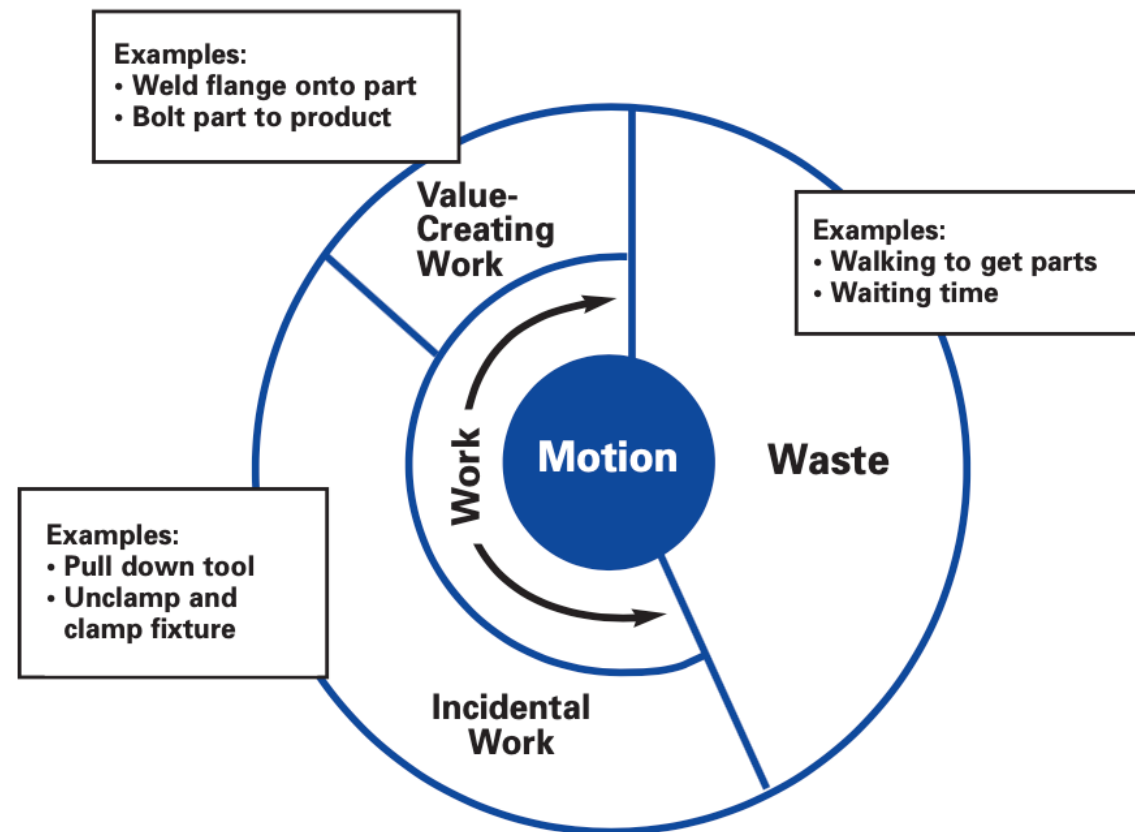
These are the tools and techniques we use to highlight problems and inefficiencies within our processes to try to continuously improve how we work.

Opportunities (problems or necessity)



Value-Added vs. Non-Value-Added Activities

- Value chain is a chain of activities that an organization performs in order to deliver a valuable product or service to its customers
- **Value is defined by the customer, not by management**
- Process is then improved to reduce or eliminate non-value-added activities thus improving the value chain



Initial Assessment and treatment

Purpose: Diagnostic Testing + Treatment

Purpose: Testing + Result Interpretation

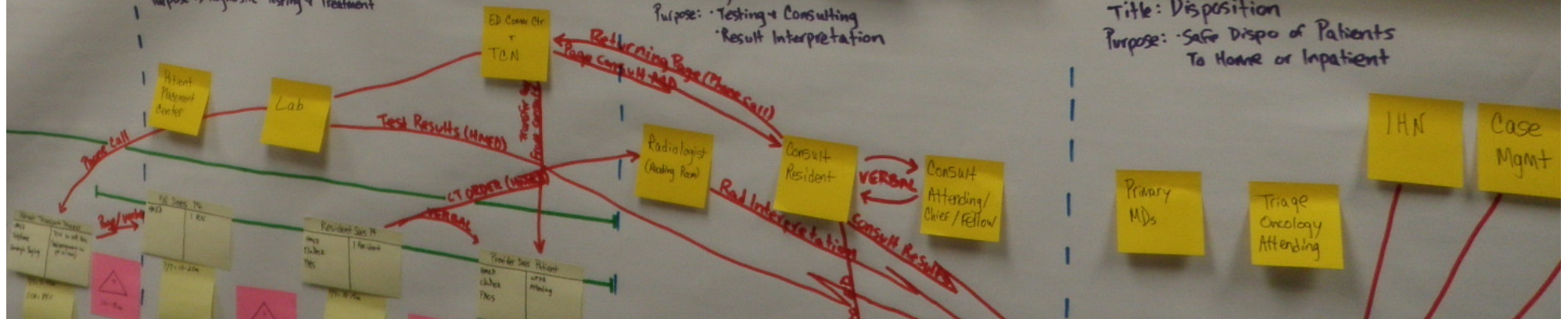


It's dynamic!
Post-it Notes
Pens and Markers

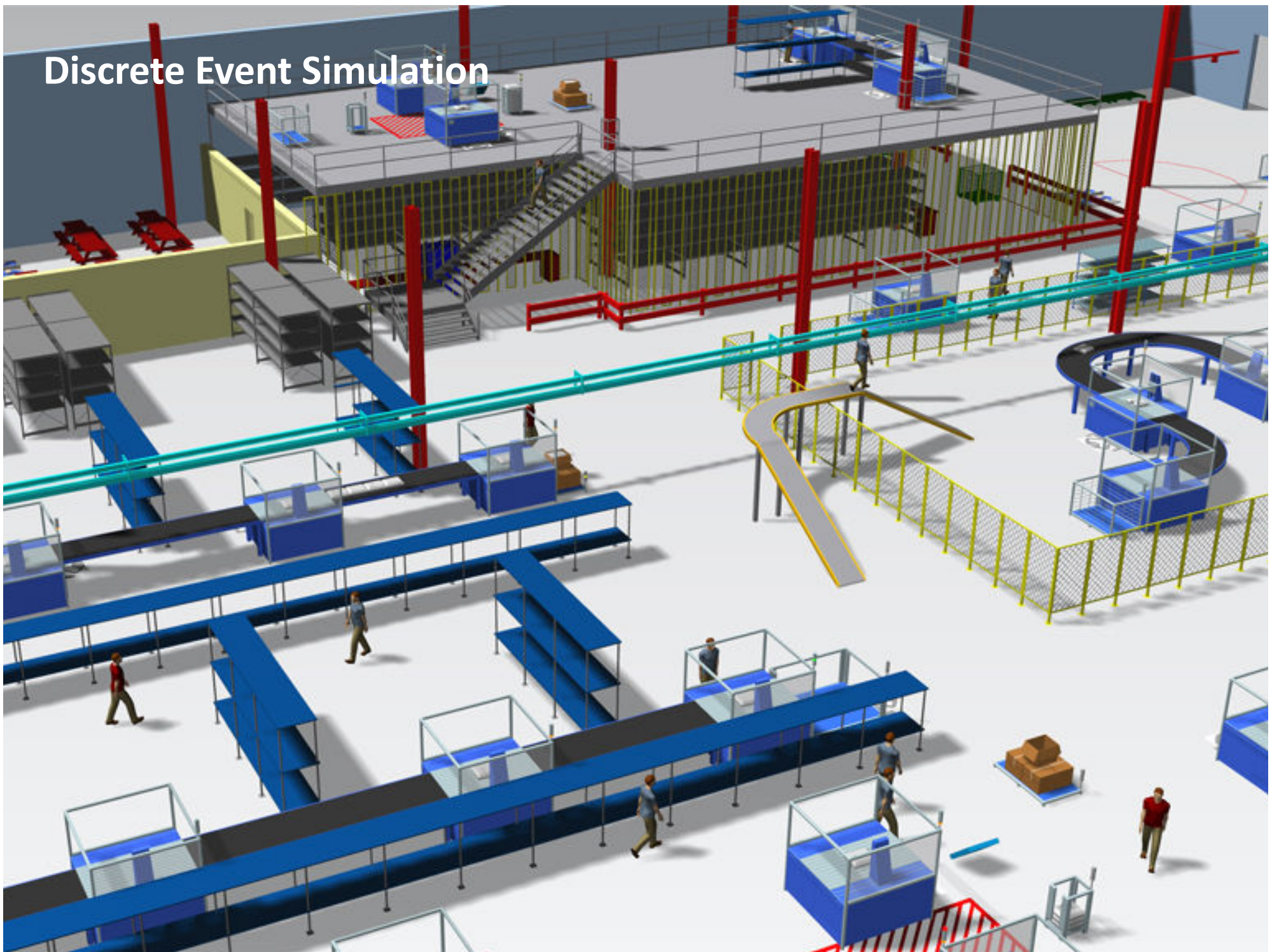
Title: Initial Assessment + Treatment
Purpose: Diagnostic Testing + Treatment

Title: Diagnosis
Purpose: Testing + Consulting
Result Interpretation

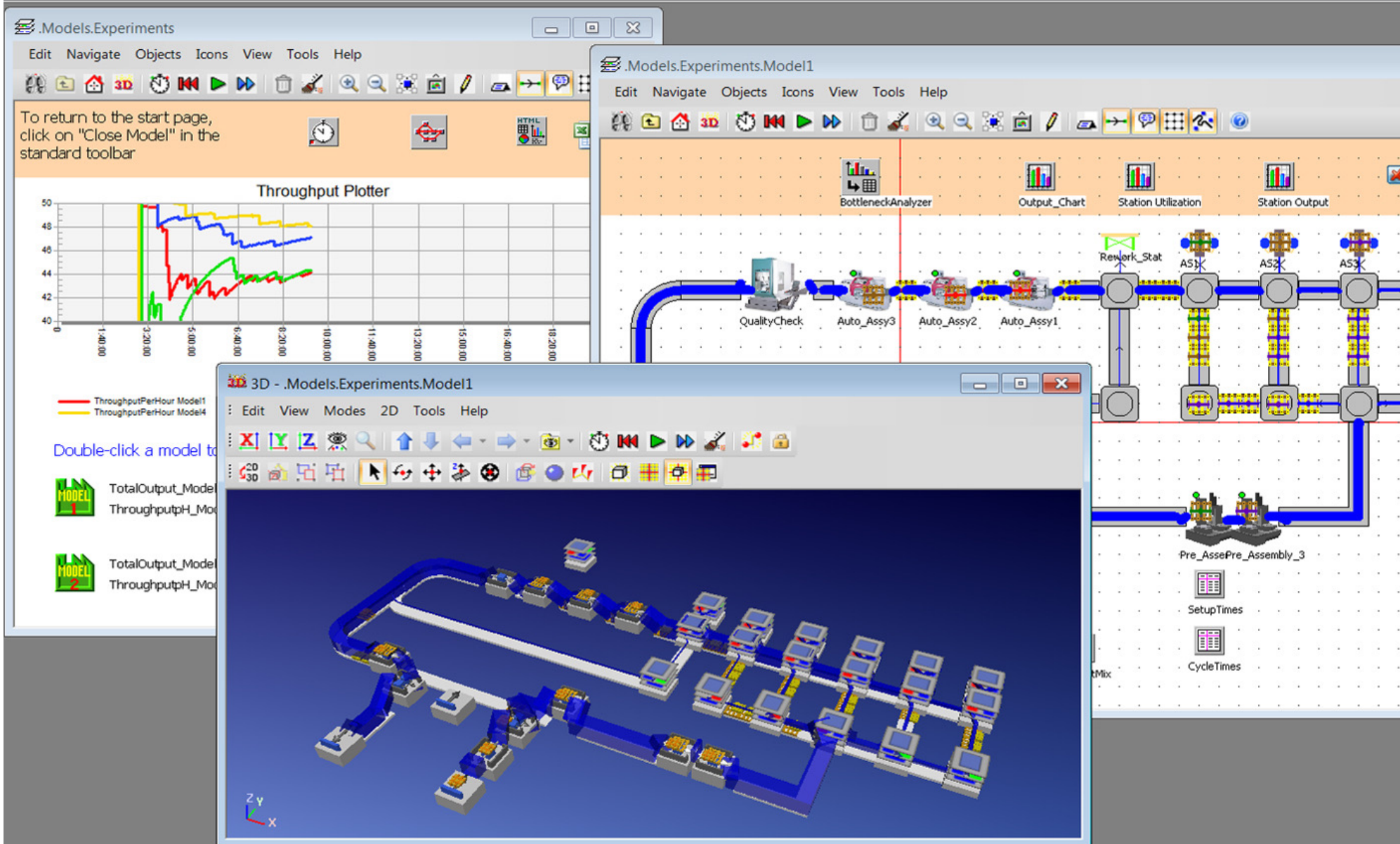
Title: Disposition
Purpose: Safe Dispo of Patients
To Home or Inpatient



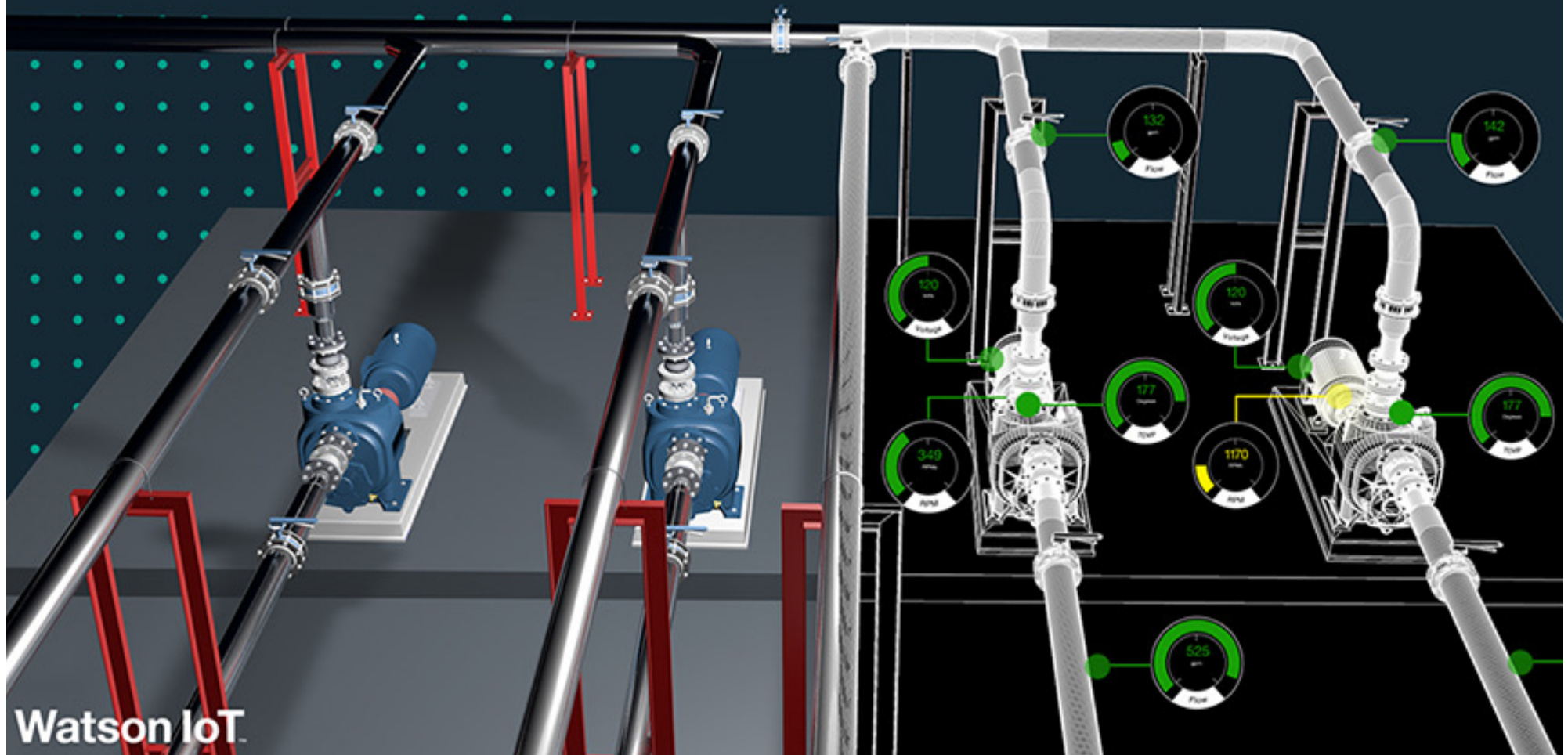
Discrete Event Simulation

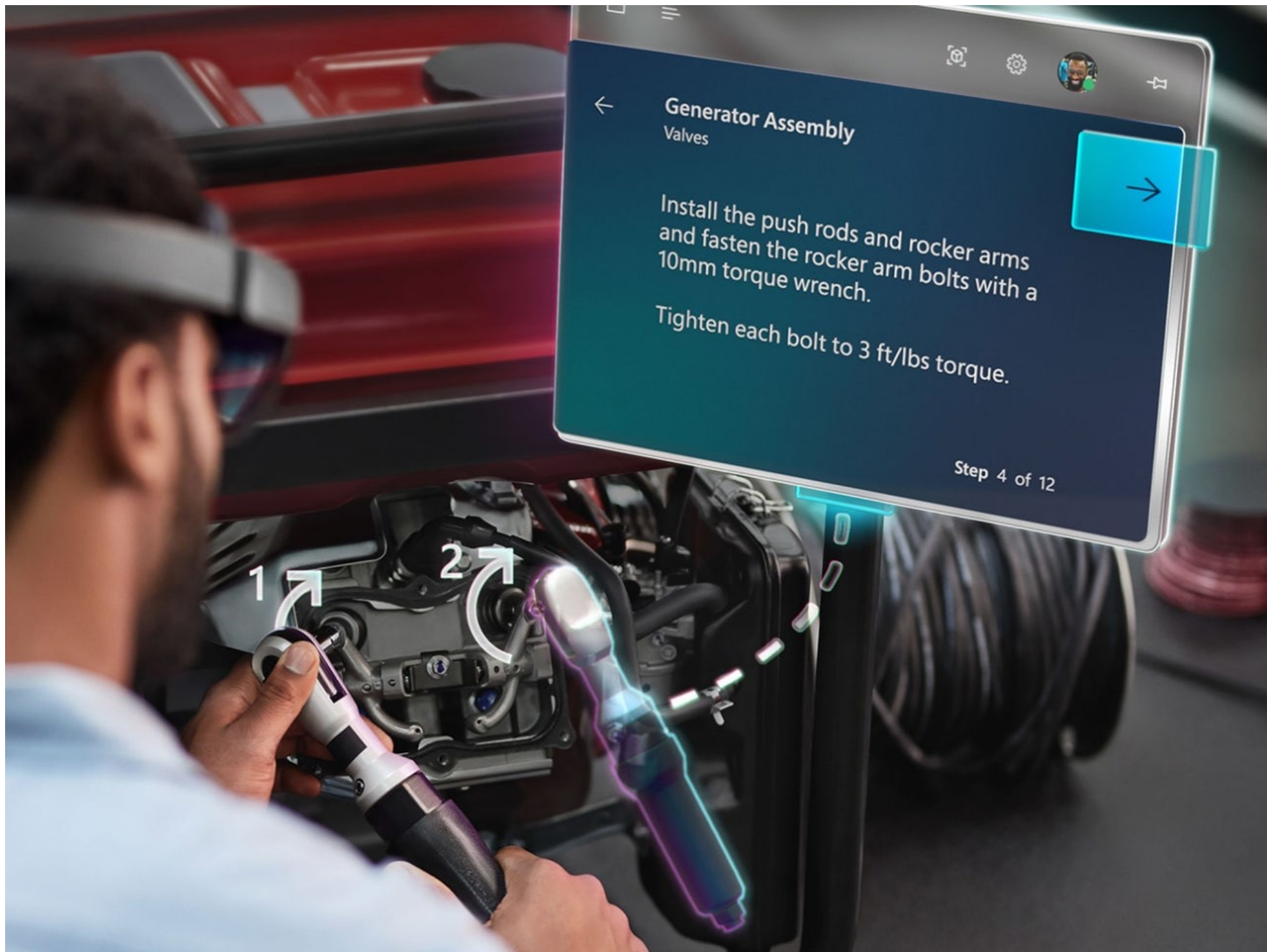


Process Simulation



Digital Twins





Generator Assembly

Valves



Install the push rods and rocker arms and fasten the rocker arm bolts with a 10mm torque wrench.

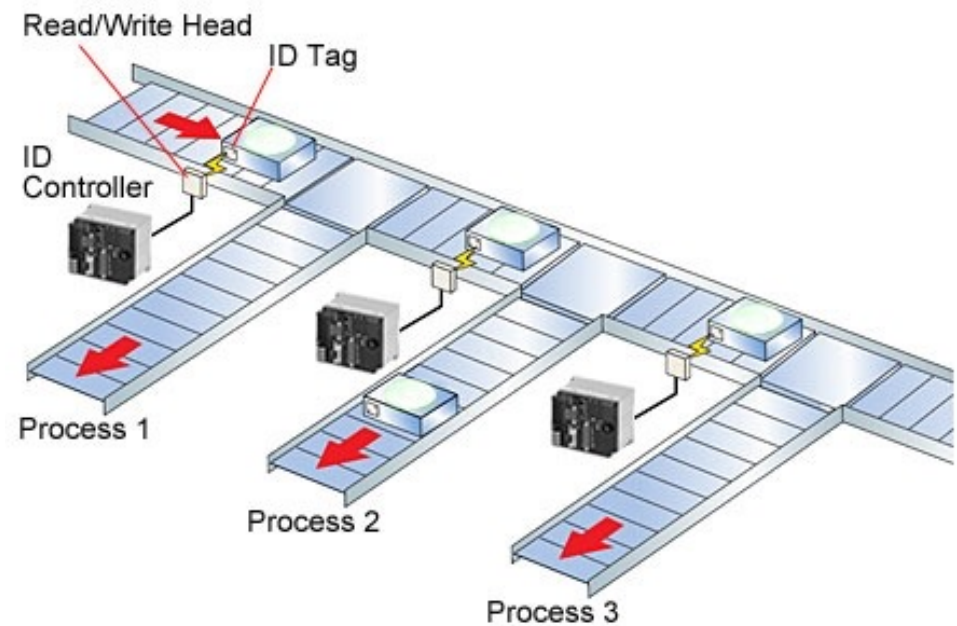
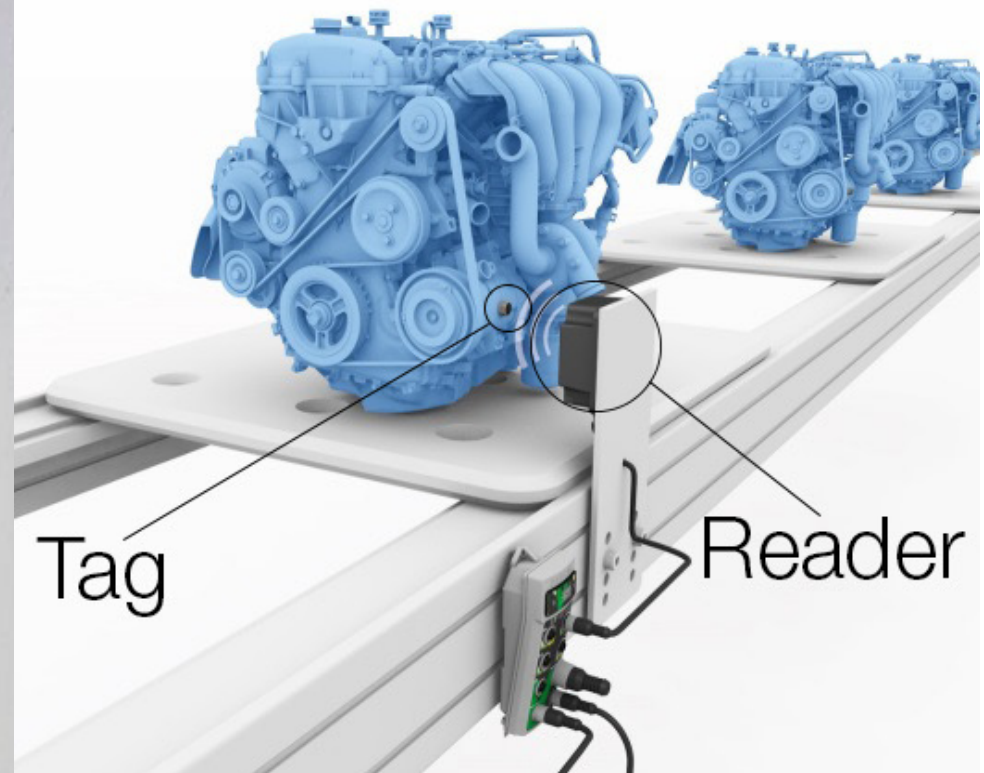
Tighten each bolt to 3 ft/lbs torque.

Step 4 of 12

1

2

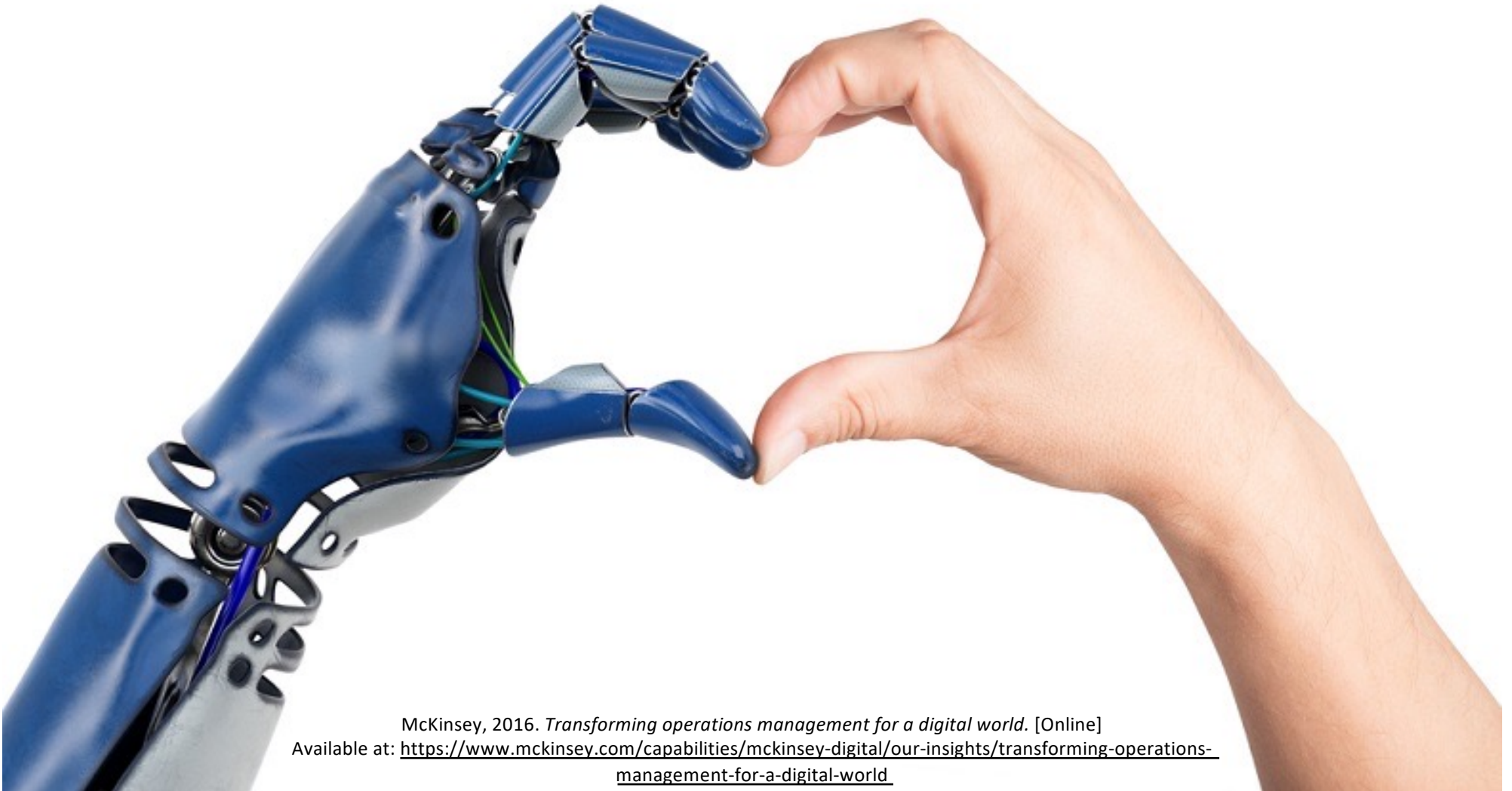
Kanban + RFID



Simplify first, and then use the technology to manage the complexity that you are left with.



“Digitization can be dangerous if it eliminates opportunities for productive human (or “analogue”) intervention. The goal instead should be to find out where digital and analogue can each contribute most.”
McKinsey (2016)



McKinsey, 2016. *Transforming operations management for a digital world*. [Online]
Available at: <https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/transforming-operations-management-for-a-digital-world>

EXHIBIT 2 | With an Integrated Approach, Lean and Industry 4.0 Are Mutually Enabling



INITIAL STATE

- Multiple process flows
- Different layouts and processes
- High level of manual labor
- Poor quality that forces frequent rework



LEAN OPTIMIZATION ALONE

- There is a single lean and flow-oriented layout
- Workers follow SOPs to improve efficiency
- Ergonomic work stations promote safety

15%–20% cost reduction

OR



INDUSTRY 4.0 ALONE

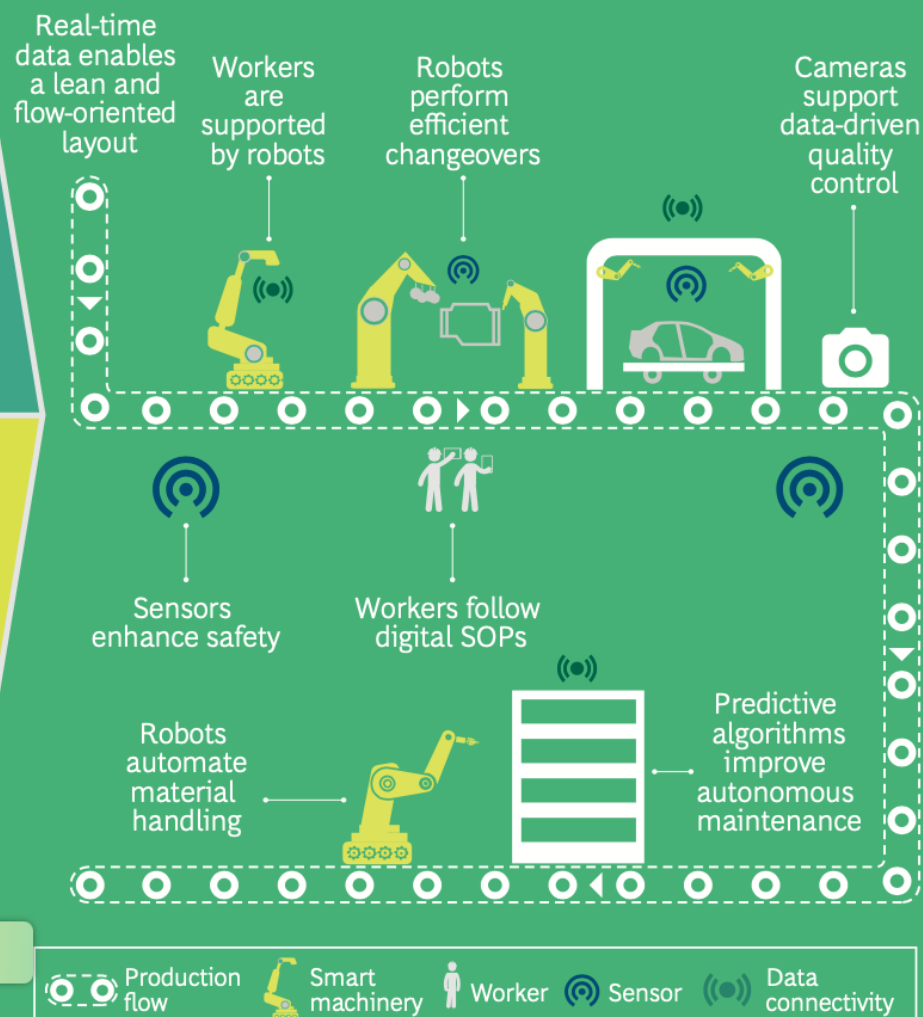
- Workers follow digital SOPs
- Robots support workers
- Cameras support data-driven quality control
- Robots perform efficient changeovers
- Robots automate material handling
- Predictive algorithms improve autonomous maintenance
- But process inefficiencies and quality issues persist

10%–15% cost reduction

Screenshot

LEAN INDUSTRY 4.0 GENERATES BENEFITS BEYOND THOSE THAT EITHER APPROACH ACHIEVES SEPARATELY

Up to 40% cost reduction



Characterise the Process

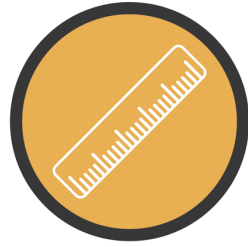
Optimise the Process



DEFINE

Define the problem
Listen to the customer (VoC)

Raise project charter



MEASURE

Collect data
Listen to your process (VoP)

IoT provides data about various process parameters

Robotics & Automation accelerate repeating operation.



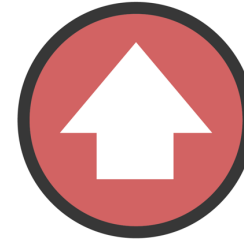
ANALYSE

Identify the factors which are the main contributors.

AI recognizes patterns in the data and helps draw out connections between inputs and outputs.

Virtual Reality can provide insights into unfamiliar processes and situations.

Augmented Reality can be used to visualise 3D graphs to gain additional insights from the data.



IMPROVE

Determine the optimal values for the factors.

Blockchain could provide reliability to the processes ensuring full traceability.

Additive Manufacturing allows fast prototyping of new ideas.

Robotics & Automation optimize efforts and leadtimes. Improving quality of repeating transactional processes.



CONTROL

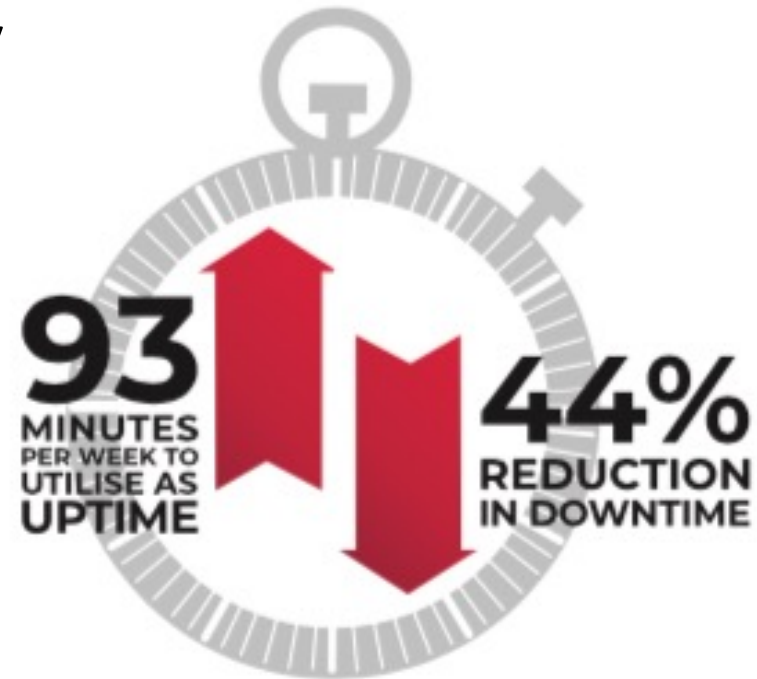
Determine the long-term controls so improvements identified and are embedded in the organization

AI recognizes patterns in the data and helps draw out connections between inputs and outputs.

Augmented Reality could be used to manage process performance and provide remote assistance where required.

What does it mean for you?

- Which tools are right for you?
- Our taught modules help you identify the most appropriate technologies.
- One case study from our Level 5 module identified ‘a **44% reduction in downtime, contributing an additional 93 minutes per week to utilise as uptime**’
- **Focused on Operational Excellence**



Climbing Snowdon's 1085m starts with small steps

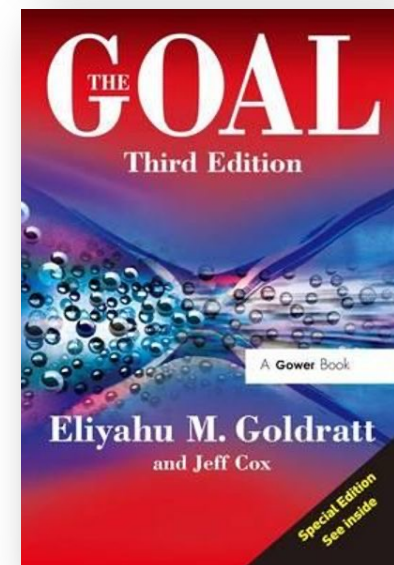
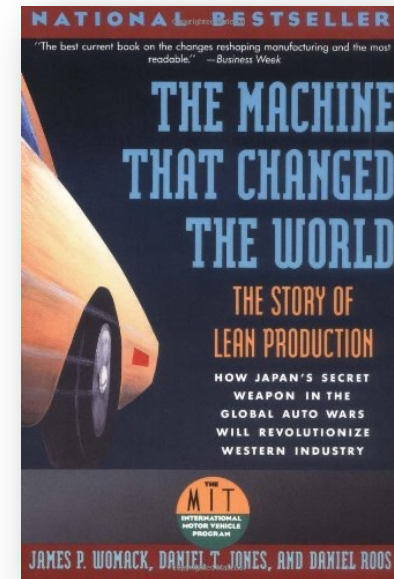


Further reading....

Lean production is a term that embraces many topics such as flexible manufacturing, minimizing work-in-process, "pull" systems of production control, and setup time reduction

The term "lean production" was coined around 1989 with the popularity of Womack and Jones book, *The Machine that Changed the World*.

Alex Rogo is a plant manager working ever more desperately to try and improve performance. His factory is rapidly heading for disaster. He has 90 days to save his plant - or it will be closed by HQ, with hundreds of job losses. It takes a chance meeting with a colleague from student days; Jonah - to help him break out of conventional ways of thinking to see what needs to be done.

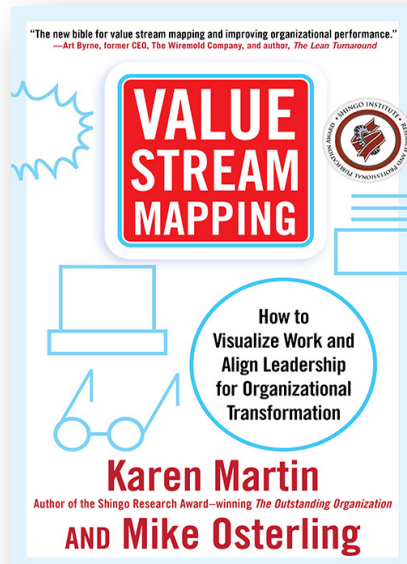
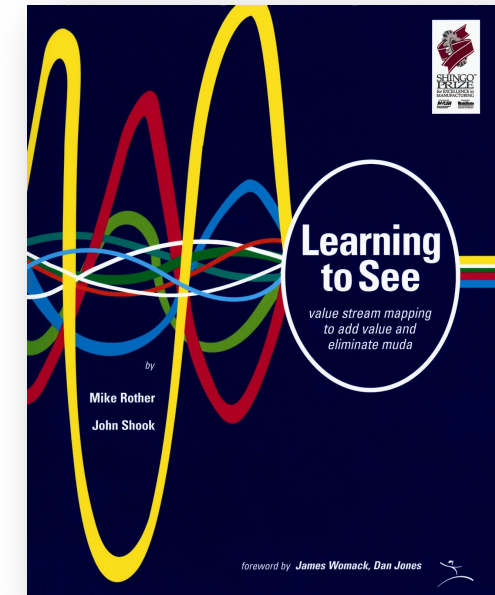


Further reading...

Rother & Shook (1998) Learning to See

This simple tool makes it possible for you to see through the clutter of a complex plant. You'll soon be able to identify all of the processing steps along the path from raw materials to finished goods for each product and all of the information flows going back from the customer through the plant and upstream to suppliers.

With this knowledge in hand it is much easier to envision a "future state" for each product family in which wasteful actions are eliminated and production can be pulled smoothly ahead by the customer.



Martin & Osterling (2014) Value Stream Mapping

In most organisations, no one person can describe the complete series of events required to transform a customer request into a good or service. At least not with the level of detail around organisational performance. This gap in understanding is the kind of problem that leads to making improvements in one functional area only to create new problems in another area.

“Wherever there is a request and a deliverable, there is a Value Stream.”

Lean Toolbox – John Bicheno

We've got a copy of John Bicheno's 'The Lean Toolbox' on it's way to you.

Other books available online....

