World Centre for Materials Joining

TWI's Mission

To deliver world class services in joining materials, engineering and allied technologies to meet the needs of a global membership and its associated community

Dedicated to Materials Joining

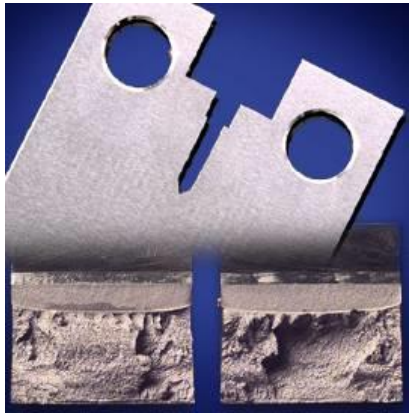
- Over $100m R+D per year
- Over 900 staff, 4 main centres
- 5 UK sites and 14 Intl. locations
- Over 800 industrial members in >3500 locations Worldwide
- 70 years track record

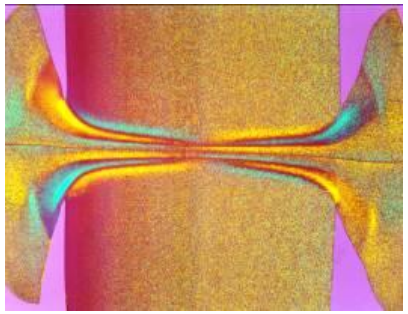
Specialist Areas of Expertise

1. How to join materials effectively
2. How do joints perform in service

- Metals
- Plastics
- Ceramics
- Composites

- Welding
- Adhesives
- Fasteners
- Surfacing

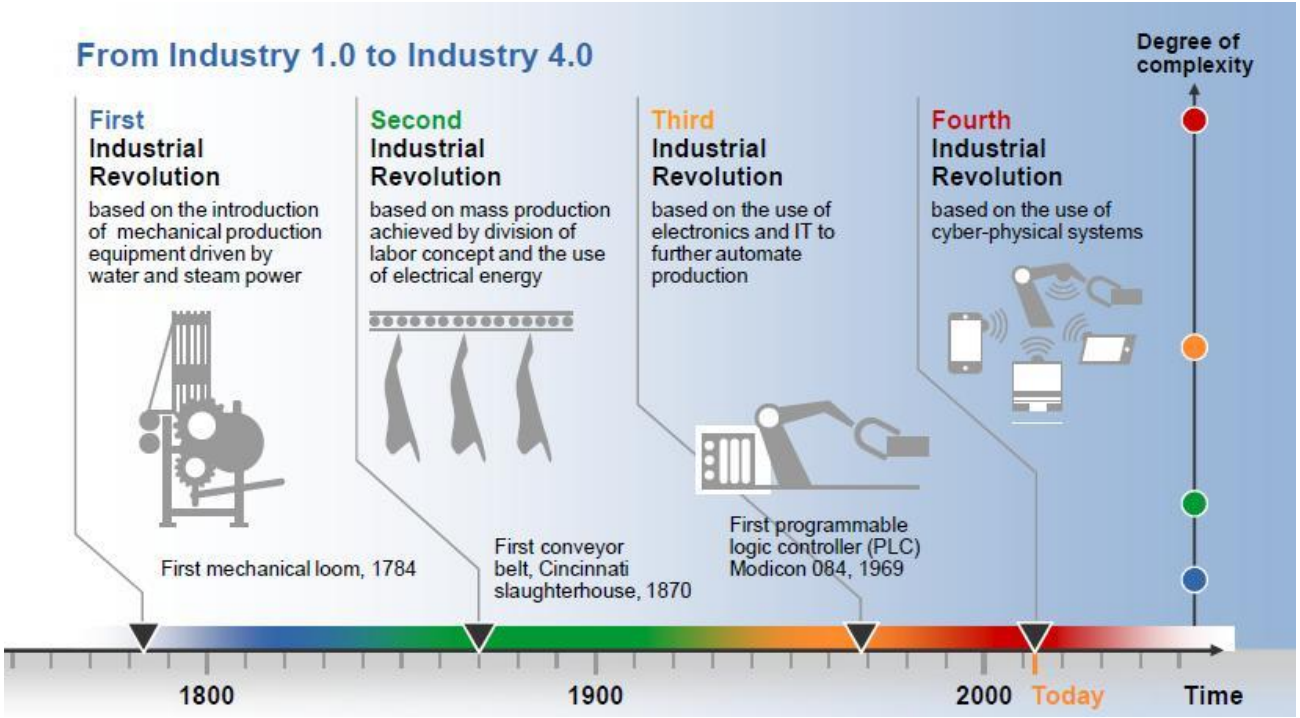




TWI - Industrial Sectors

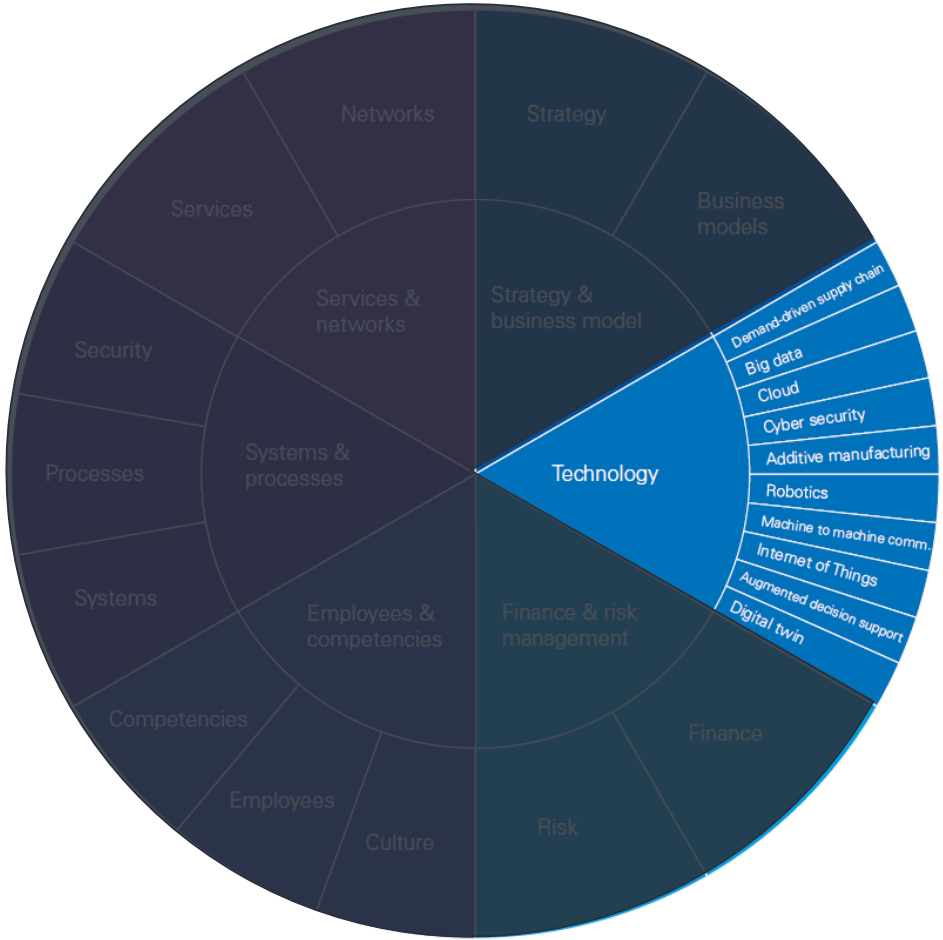
Digital Manufacturing

"Put simply Industry 4.0 represents the coming fourth industrial revolution on the way to an Internet of Things, Data and Services…"



Source: https://media.licdn.com/mpr/mpr/p/3/005/097/223/3190c81.jpg

The 6 dimensions of Industry 4.0

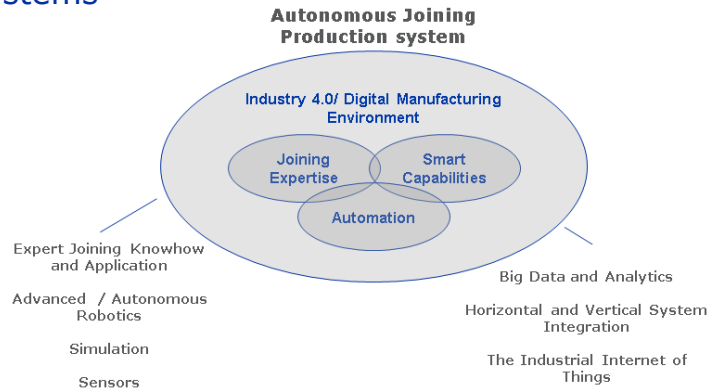


Source: KPMG International, i4.0 framework 2017

Digital Manufacturing Activities at TWI

- Q2 2015 - Formalised activities with the establishment of a new Welding Systems Integration (WSI) team

Welding Systems Integration Research Extending Processes into Robust Digital Manufacturing Systems



Strategic focus:

1. Assisting our members to define their digital manufacturing challenges and coordinate TWI's response to these opportunities by providing innovative project based solutions.

2. Defining, co-ordinating, and leading TWI's Digital Automation Strategy.

Digital Manufacturing Activities at TWI

- Q2 2017 – Strategic partnership with Lancaster University formed: The Joining 4.0 Innovation Centre

Technology Foundations for Industry 4.0 (IfM (2015))

Digital Manufacturing Activities at TWI

Awards & Events

- TWI Conferences
  - **Industry 4.0: What it means to TWI and its members** (Oct 2015)
  - **Digital Manufacturing: Applying the Industry 4.0 Philosophy** (Oct 2016)
  - **Digital Manufacturing at TWI** (Nov 2018)
- External recognition
  - '**Best New Catalyst**' May 2016: "Smart Industrial Manufacturing: Robots-as-a-Service"
  - '**Outstanding Ecosystem Design Using CurateFx**' May 2017: "Logical Factory: Virtualizing Manufacturing for Agility"

Single Client Projects:

1. Production line **systems support** (completed)
2. The **specification of a production welding cell** (completed)
3. **Applying monitoring techniques** to facilitate adaptive welding (completed)

Collaborative Involvements:

1. TiFab
2. Factories of the Future Impact
3. ModuLase
4. AM Motion
5. LaserSnake
6. Grow Industry
7. EBwireAM
8. DREAM
9. FSWBot

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Manufacturing Predictive Maintenance using 5G

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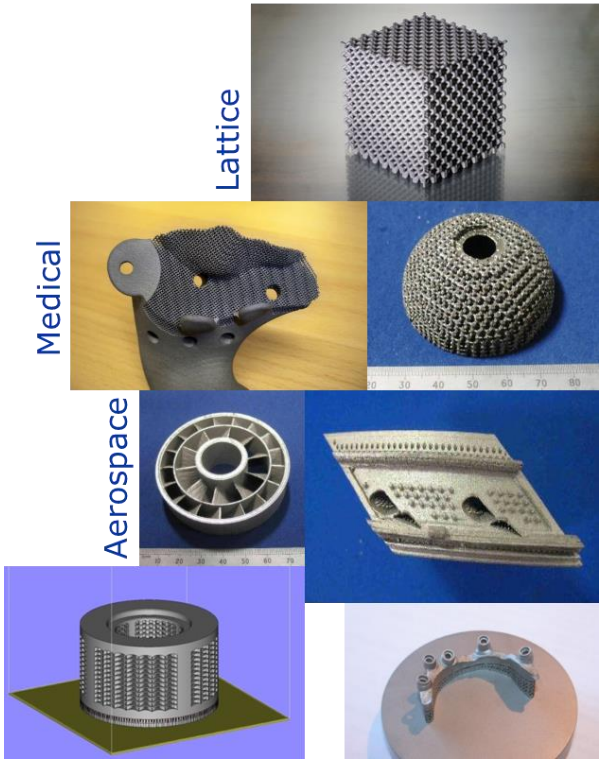
Catalyst Project Introduction – Selective Laser Melting (SLM)

- **Design freedom**
- **Complex components**
- **Highly customised parts**
- **Weight savings**
- **Reduction in waste material**
- **Internal lattice structures**
- **Integration of conformal cooling channels for Moulds and inserts**
- **Integration of many components into one**

Rapid Part 1kW

- Build volume: 250, 250, 300(z)mm
- 1000W fibre laser
- 75-200µm layer height
- Inert atmosphere



Catalyst Project Introduction

- Predictive Maintenance represents a great opportunity to **drive productivity increases** and **reduce costs** across the Manufacturing sector – **up to $140B globally*** by 2025

Unplanned outages from machine failures cost money

… but unnecessary preventative maintenance is inefficient

Accurate data-driven prediction of servicing saves significant cost

Project Goals

- Explore how 5G technology can benefit manufacturing control & predictive maintenance
- Understand the requirements on 5G networks to meet the needs of Manufacturing
- Explore the commercial business models required to bring Predictive Maintenance to market
- Understand how products can be developed to best serve the global manufacturing sector

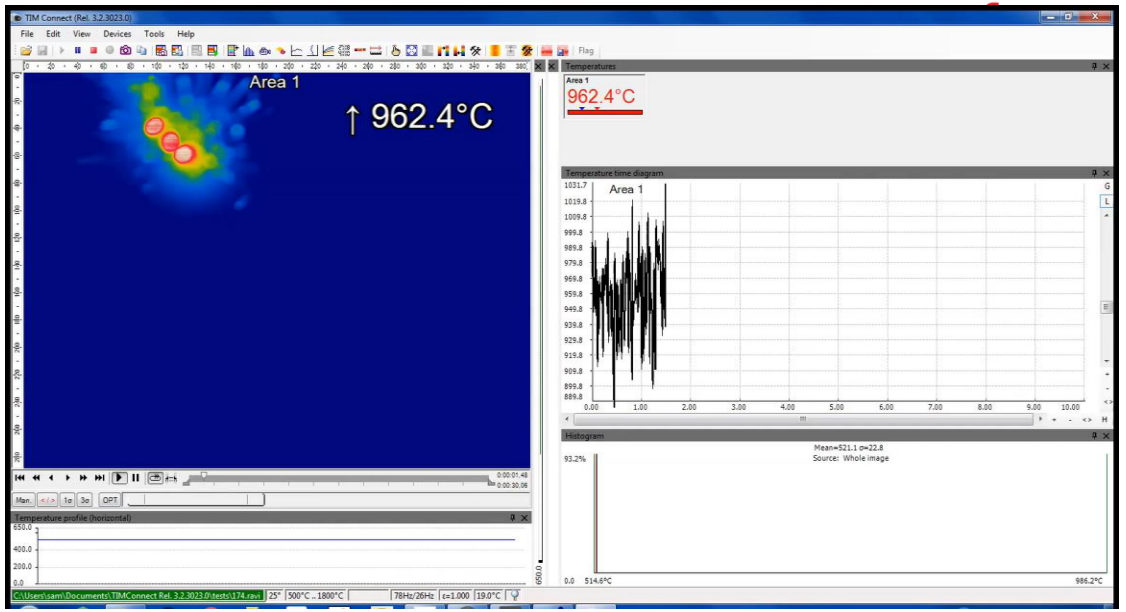
*Source: Harvard Business School study on behalf of Huawei in 2018

Catalyst Project Scenario

Selective Laser Melting process

TWI Selective Laser Melting (SLM)
Additive manufacturing using high power laser to melt metal powder, depositing layers to create a piece.

Requires protective atmosphere and very precise control over the laser power in order to create a good build.
https://www.youtube.com/watch?v=fa7aYCylNWM



The SLM build process is resource-intensive in terms of materials, technician skills, and time – so failed builds have a direct cost (as well as less tangible costs in terms of missed deadlines and customer disappointment).

Better control of the process can avoid annual failure costs of up to **$160,000 per machine**

Manufacturing site with 30 machines:

30 x $160K = $4.8M savings per annum

5G for Industrial & Manufacturing

tmforum

Scalable

5G enables IIoT on a massive scale

Huge industrial sites can have millions of machines, pipes, valves, mobile equipment and people. Connecting all these things with high bandwidth wireless comms requires orders of magnitude scale-up in connection densities.

Reliable Secure

5G network slices and Edge Compute increase availability

Industrial plant is Safety Critical – the cost of failure can be incalculable in human lives, environmental damage and lost production.

Purpose-specific Network Slices increase security and reliability

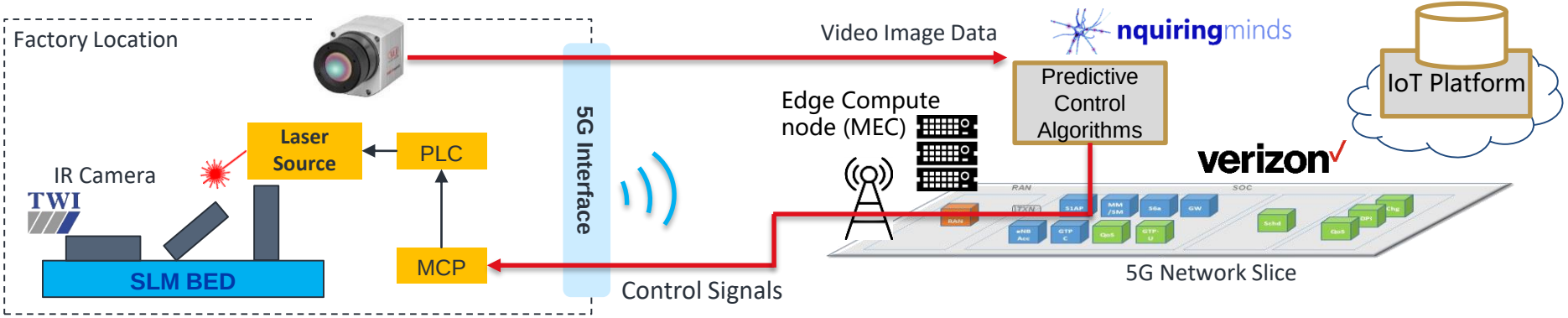
Fast

5G low-latency enables real-time control from the Cloud

Real-time control of Industrial equipment requires a sense-compute-act loop that can gather high-fidelity data at multi-gigabits per second, and send control signals back within a few tens of milliseconds

5G technology can meet latency, security, reliability and connection density requirements

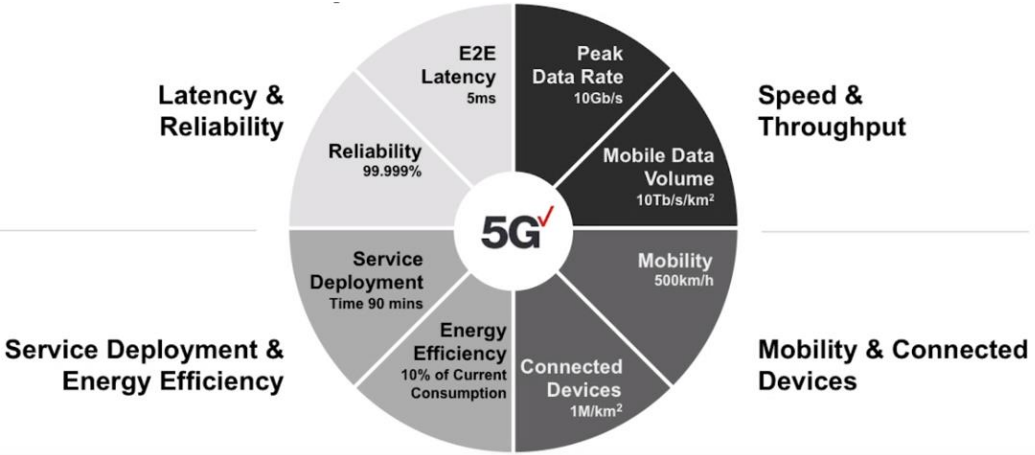
Catalyst Architecture: Cloud-hosted Predictive Control using 5G



High-definition Infrared video images used by predictive control algorithm to predict & prevent imminent failure

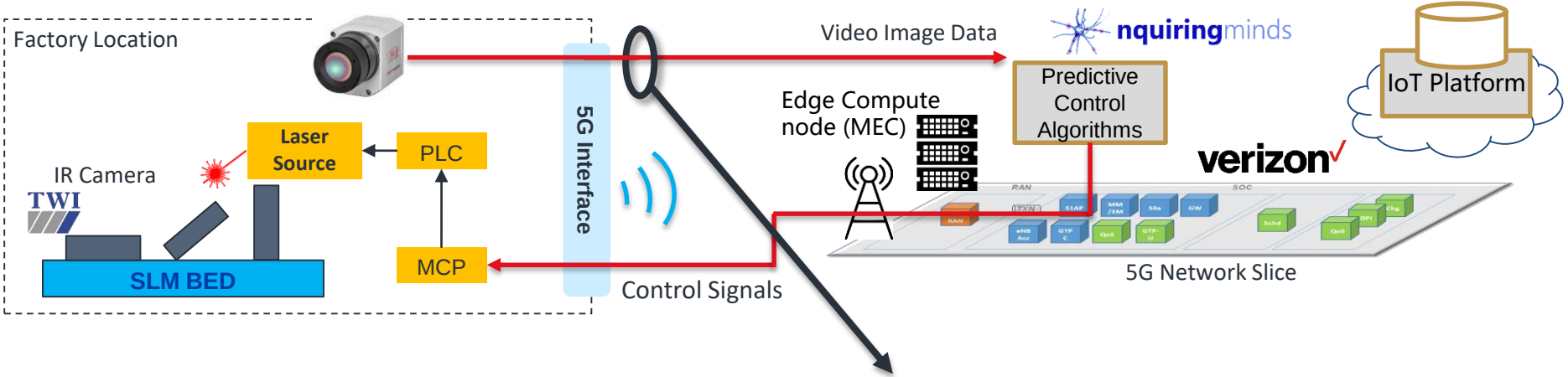
Round trip of sense – process – act takes place in milliseconds to prevent build failures

5G-enabled MEC Edge Cloud roundtrip is <20 ms compared to >120 ms for classic centralised Public Cloud.



Characteristics of 5G allow predictive control algorithms to be centralised in Edge Cloud rather than dedicated co-located hardware

Catalyst Architecture: Cloud-hosted Predictive Control using 5G

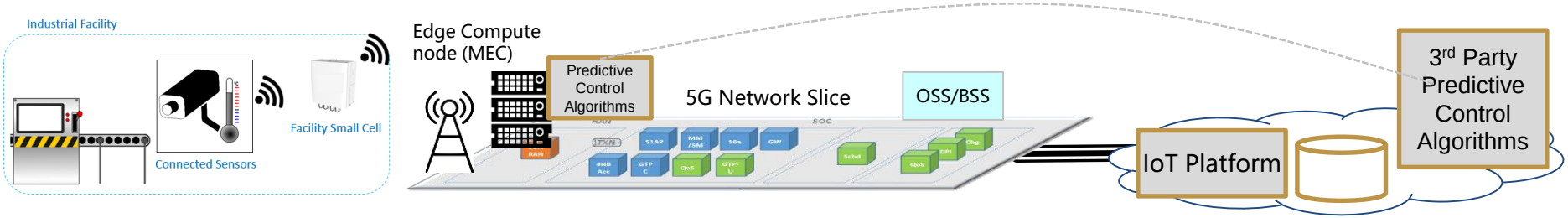


At scale a 3D Printing Bureau can generate ~200TB video data per hour

Control response round-trip latency of 80-120ms is required

5G and Edge Cloud enable centralisation of predictive control

5G Predictive control – an ecosystem offering



Connected Machines	5G Small Cell infrastructure	Edge Compute delivered via MEC node	Dedicated 5G network slice	General-purpose IoT Platform	Specialist predictive maintenance application
Machine Tool OEM	**System Integrator**	**Telco**	**Telco**	**IoT Service Provider**	**Software Startup**

- Manufacturing has complex problems to solve and needs more than raw connectivity
- Full-stack product offerings need broad skills and capabilities to be successful
- Innovation must include business models as well as technology

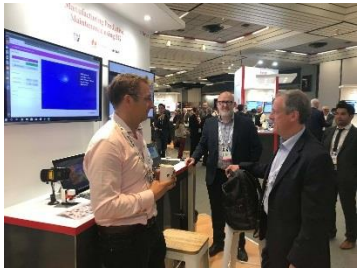
- **Collaborative Global Ecosystems are important**
- **Bundled product offering of Connectivity + Cloud + Software**

Catalyst Retrospective

What did we achieve?

- ✓ Demonstrated a real-world Manufacturing use case for 5G
- ✓ Explored the requirements on 5G networks for Manufacturing
- ✓ Explored the business models required to bring 5G-enabled products to market
- ✓ Demonstrated how manufacturing, telecoms and AI specialists can collaborate to deliver value

Phase II of the Catalyst project is seeking partners!



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