# Technology Roadmap 2023

THE ADVANCED MACHINERY
& PRODUCTIVITY INSTITUTE

Creating the new machines, technology and skills
needed to manufacture tomorrow's products

# Contents

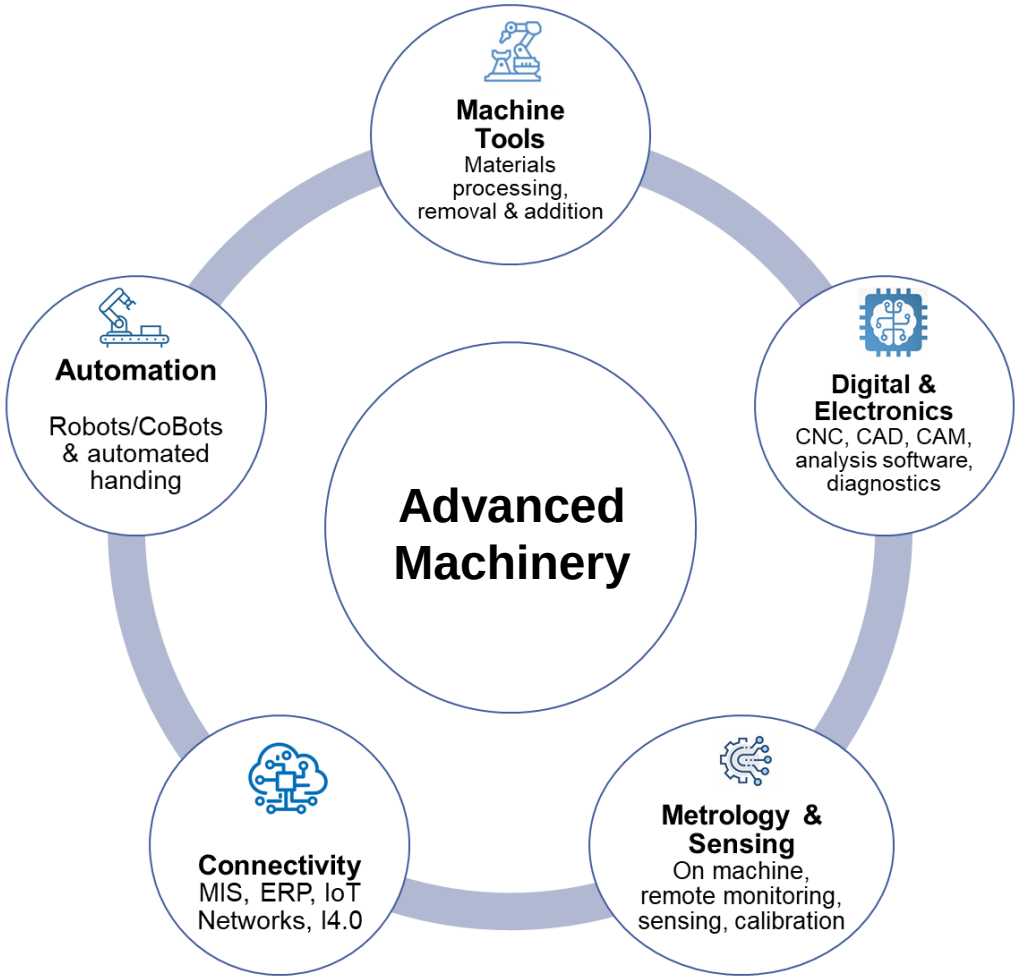
# The Advanced Machinery & Productivity Institute

AMPI is an industry led initiative that will stimulate and support rapid growth of the UK's machinery manufacturing sector, creating a £2bn UK export capacity within 10 years whilst establishing over 30,000 high value manufacturing sector jobs.

AMPI will drive innovation for the UK's advanced machinery manufacturers; creating a voice for the sector and identifying priorities and actions for future growth.

To support this objective AMPI has created a market-led technology roadmap which identifies key market drivers and future machinery capability needs.

This report describes high level technology roadmaps developed through consultation with UK industrial and academic stakeholders.



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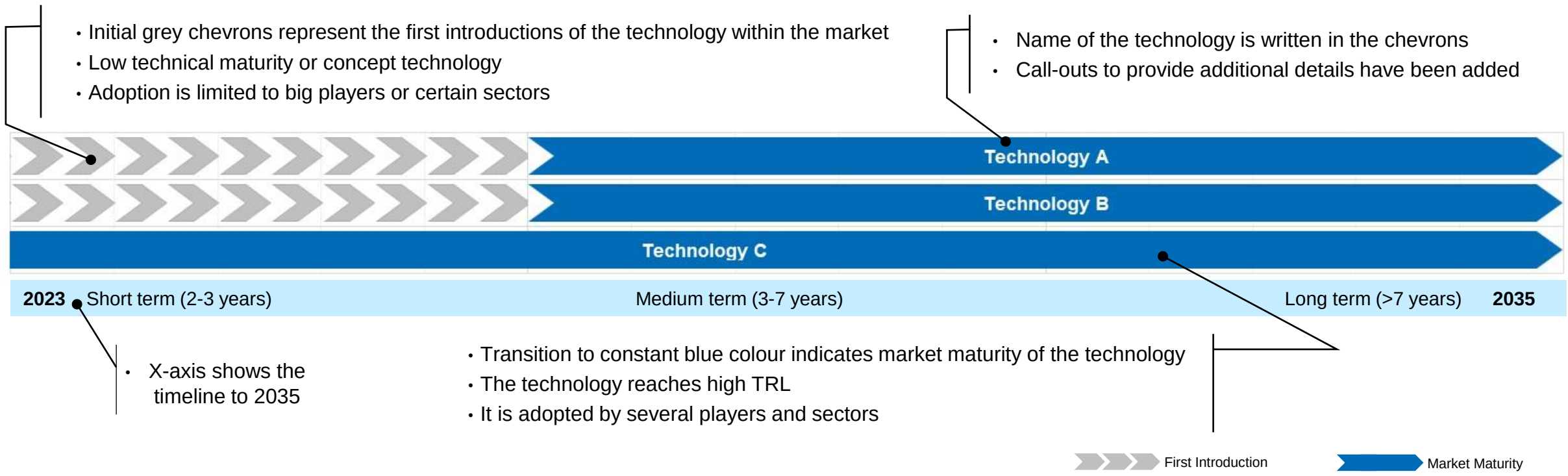
# Framework – Understanding Technology Roadmaps

- The technology roadmaps presented in the following slides aim to identify technologies, and the timeline for their deployment, categorised under actionable themes.
- The colours and chevrons represent different stages of technologies in the market, as explained below;



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# High Level Technology Roadmaps
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# Additive Manufacturing

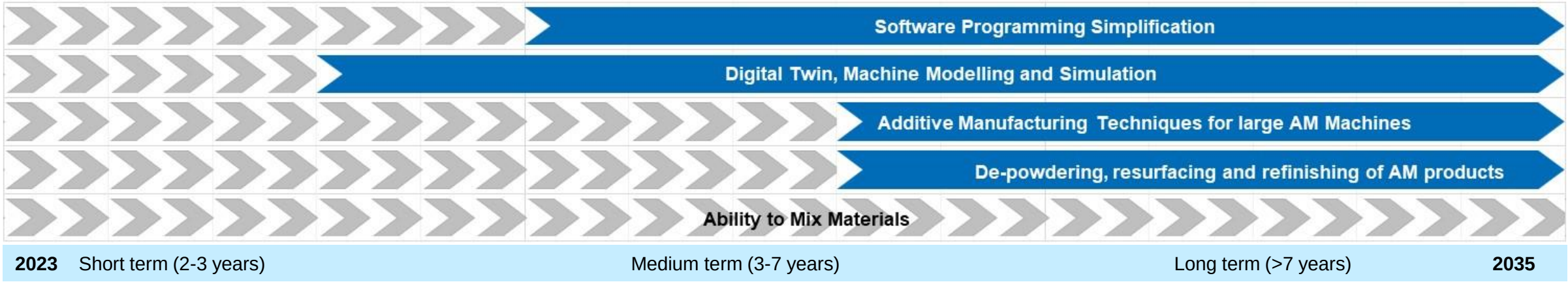
### Market Driven Needs and Concerns

- Large AM (Additive Manufacturing) machines  LPM (Layered Powder Metallurgy) SLM (Selective Laser Melting) 0.5-1m
- AM / Lasers

### Actionable Themes

- Capability development in Large AM (Additive Manufacturing) machines and related topics
- Capability development in Laser additive manufacturing processes

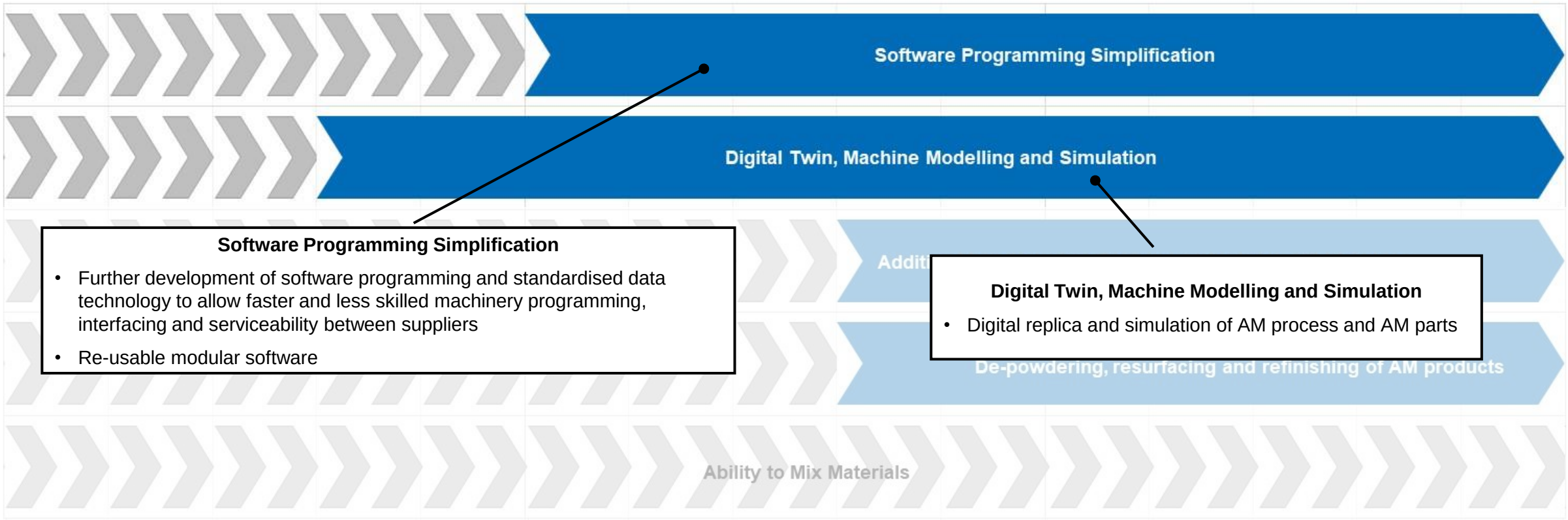
### Technology Roadmap




First Introduction  Market Maturity

# Additive Manufacturing – Commentary (1/2)

## Technology Roadmap




**Software Programming Simplification**

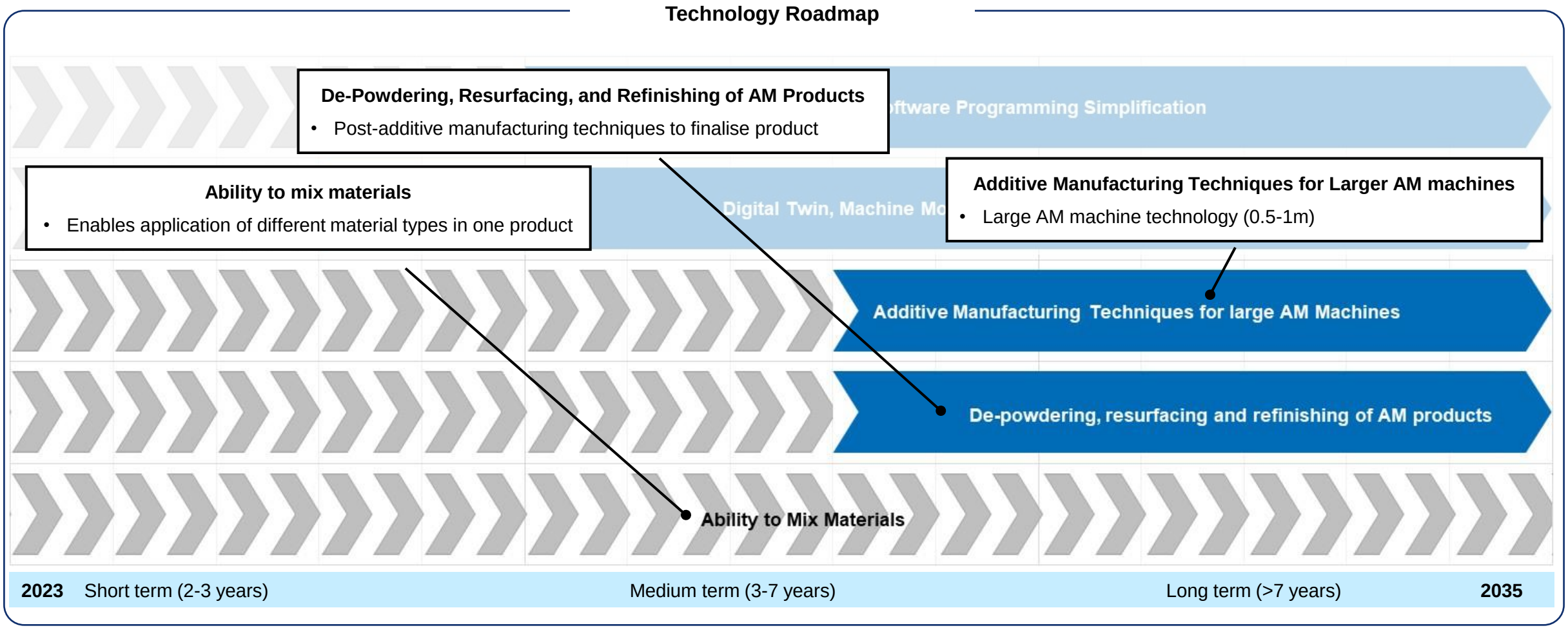
- Further development of software programming and standardised data technology to allow faster and less skilled machinery programming, interfacing and serviceability between suppliers
- Re-usable modular software

**Digital Twin, Machine Modelling and Simulation**

- Digital replica and simulation of AM process and AM parts

First Introduction  Market Maturity

# Additive Manufacturing – Commentary (2/2)

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# Advanced Materials

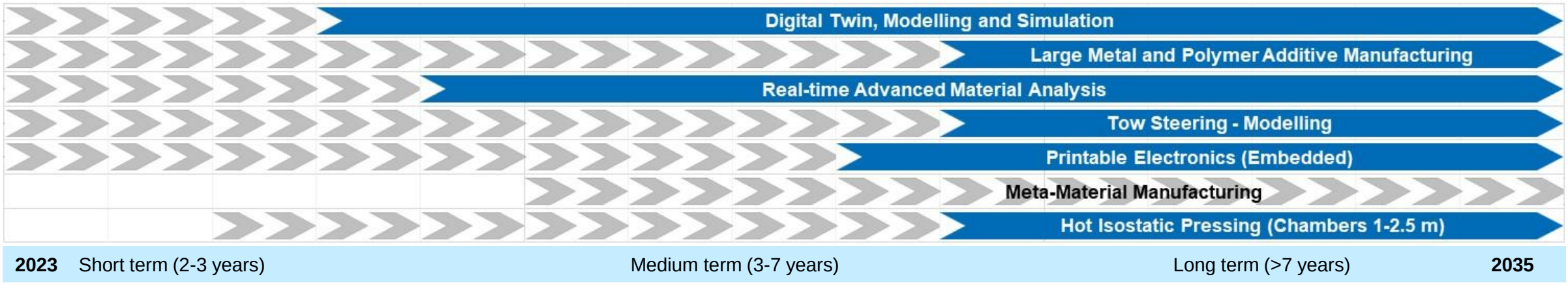
### Market Driven Needs and Concerns

- Automated CFRP composites expertise
- Large commercial HIP (Hot Isostatic Pressing) Chambers Ø = 1-2.5m;
- Automated high build coatings
- Powder suppliers
- Ability to work with materials of future (i.e. organics)
- Large Reinforced polymer Additive Manufacturing (AM) i.e. Nylon CF, PEEK

### Actionable Themes

- CFRP (Carbon-Fibre Reinforced Polymer) composite capability development
- Large commercial HIP capability development
- Powder metallurgy capability development
- Large reinforced polymer AM capability development

### Technology Roadmap

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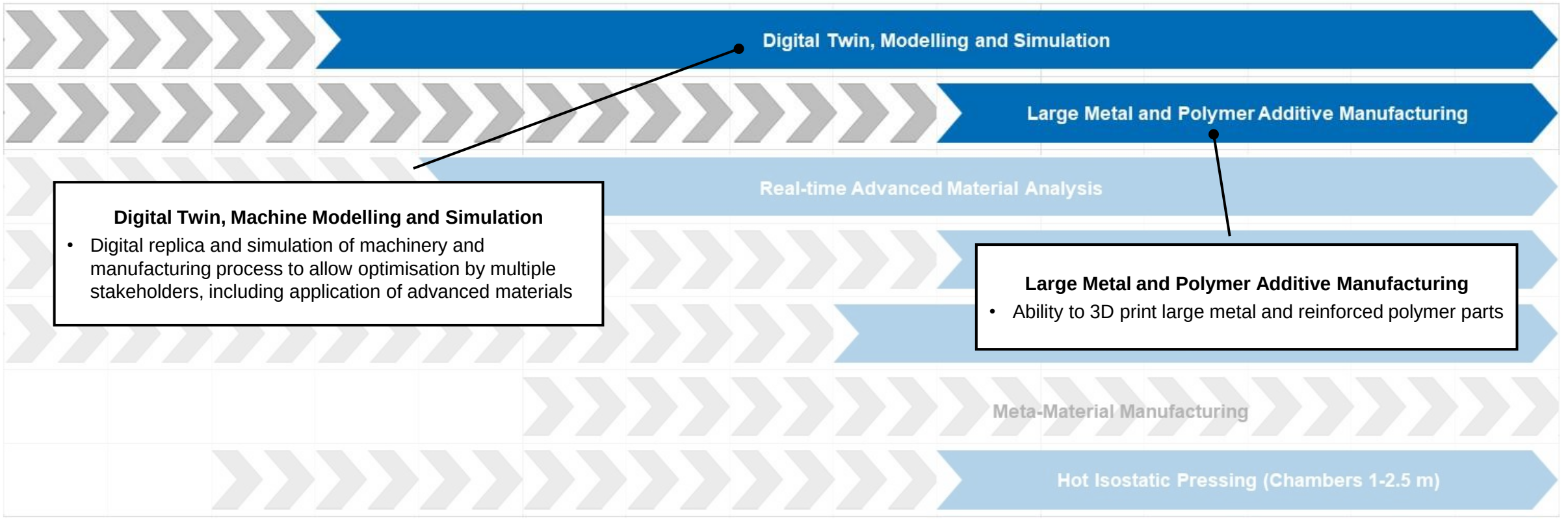
# Advanced Materials – Commentary (1/3)

**Technology Roadmap**




**Digital Twin, Machine Modelling and Simulation**

- Digital replica and simulation of machinery and manufacturing process to allow optimisation by multiple stakeholders, including application of advanced materials

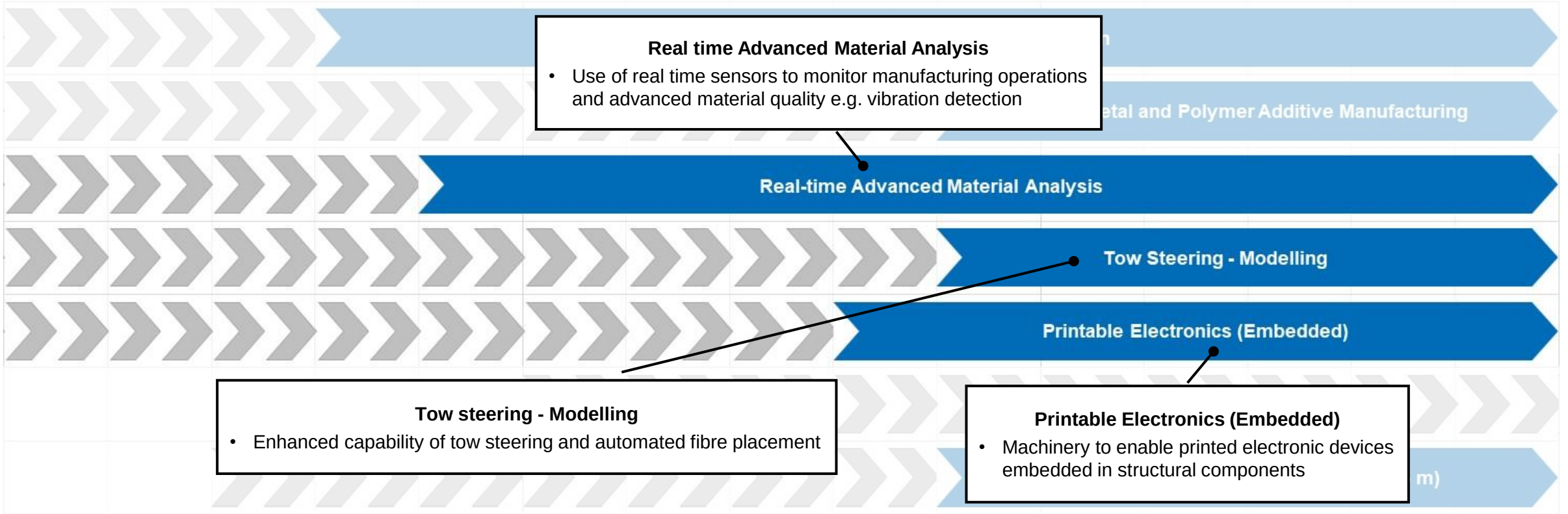
**Large Metal and Polymer Additive Manufacturing**

- Ability to 3D print large metal and reinforced polymer parts

First Introduction — Market Maturity

# Advanced Materials – Commentary (2/3)

**Technology Roadmap**

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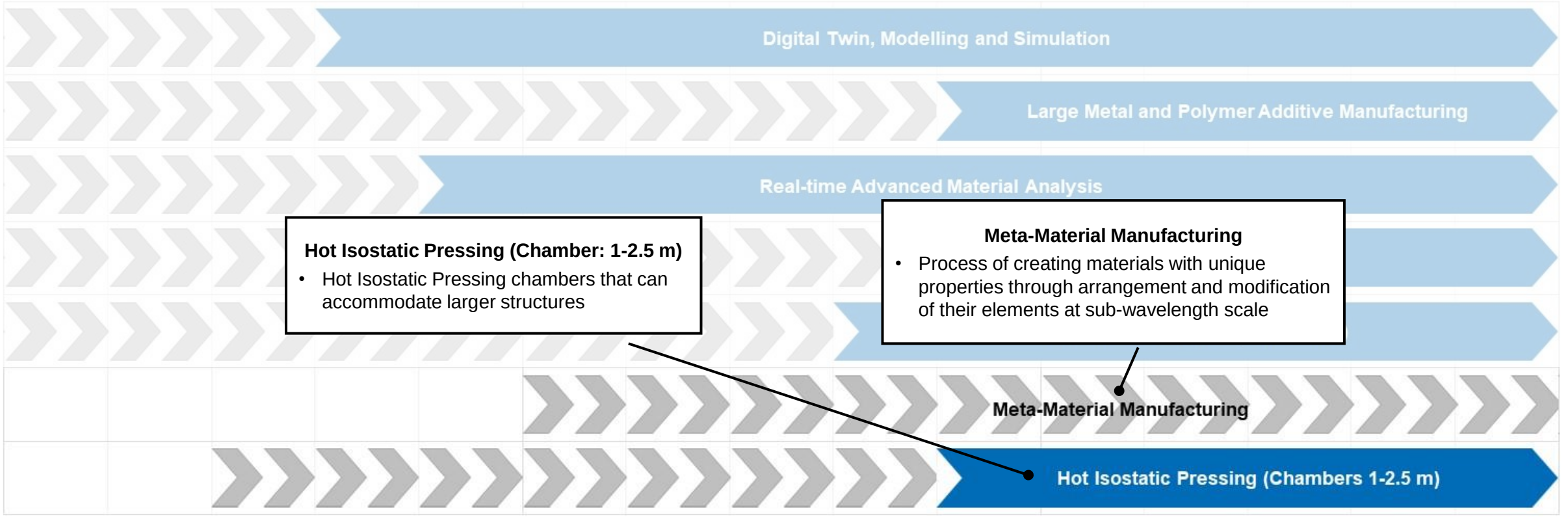
# Advanced Materials – Commentary (3/3)

**Technology Roadmap**




**Hot Isostatic Pressing (Chamber: 1-2.5 m)**

- Hot Isostatic Pressing chambers that can accommodate larger structures

**Meta-Material Manufacturing**

- Process of creating materials with unique properties through arrangement and modification of their elements at sub-wavelength scale

**2023** Short term (2-3 years) | Medium term (3-7 years) | Long term (>7 years) **2035**

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# Automation

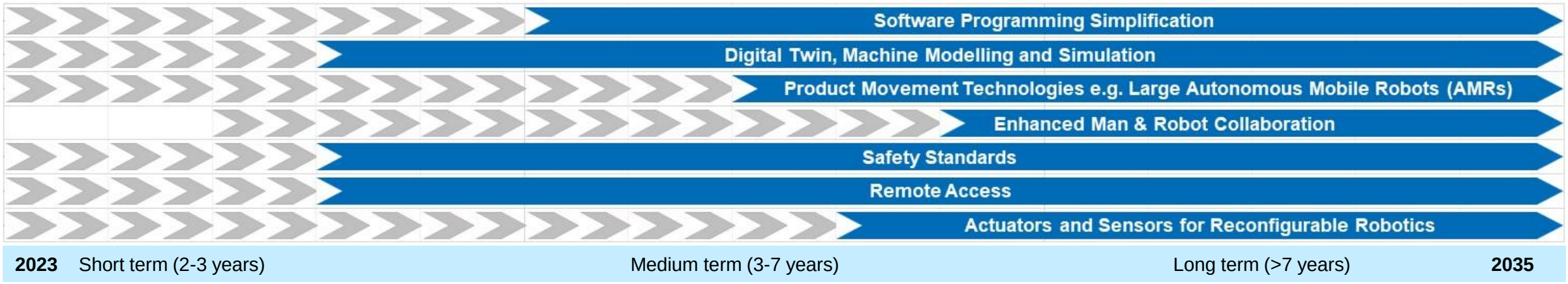
## Market Driven Needs and Concerns

- Large AMRs (Autonomous Mobile Robots)
- Accurate robots (Circa 0.1 mm) ; payload 250-500 kg
- Controls system(s) availability and expertise

## Actionable Themes

- Capability development in robotics (large AMRs and accurate robots)
- Low cost robots development
- Control systems for robotics development (industry and universities)
- Enhanced man and robot or and/or cobot interaction

## Technology Roadmap

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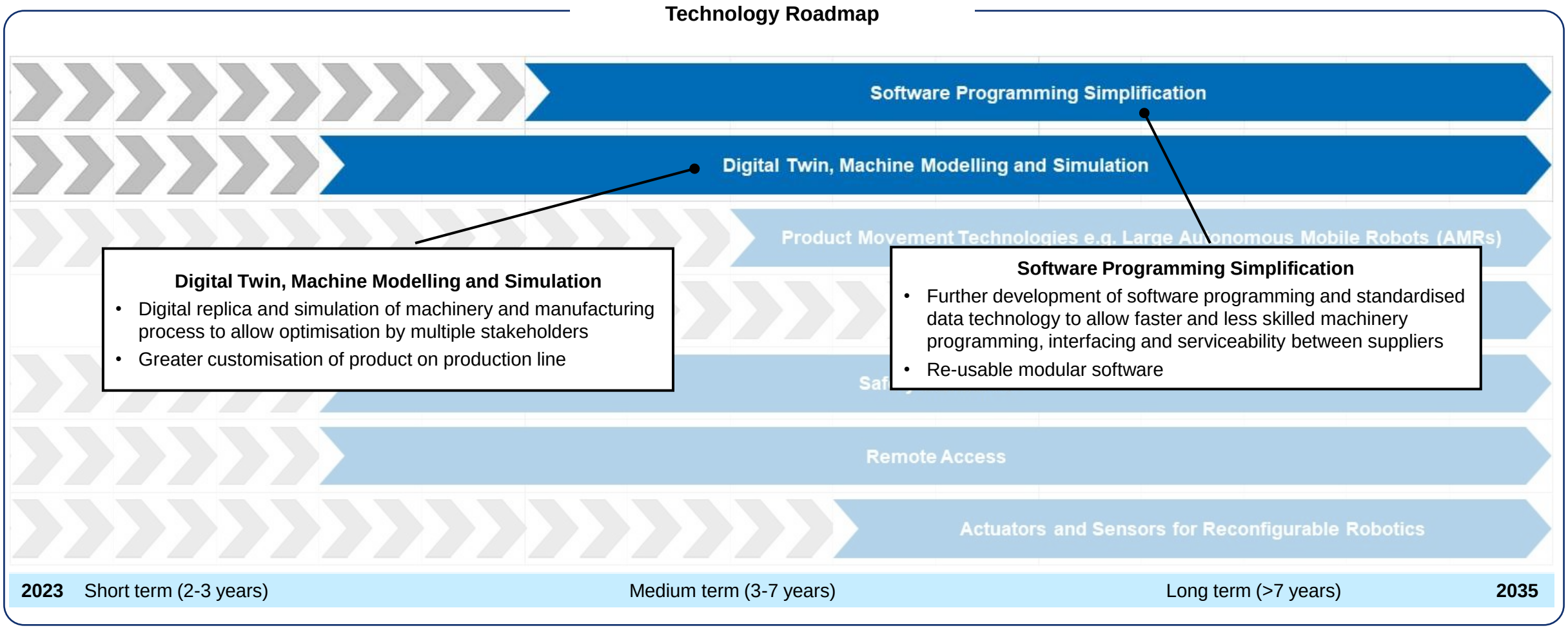
# Automation – Commentary (1/3)




**Digital Twin, Machine Modelling and Simulation**

- Digital replica and simulation of machinery and manufacturing process to allow optimisation by multiple stakeholders
- Greater customisation of product on production line

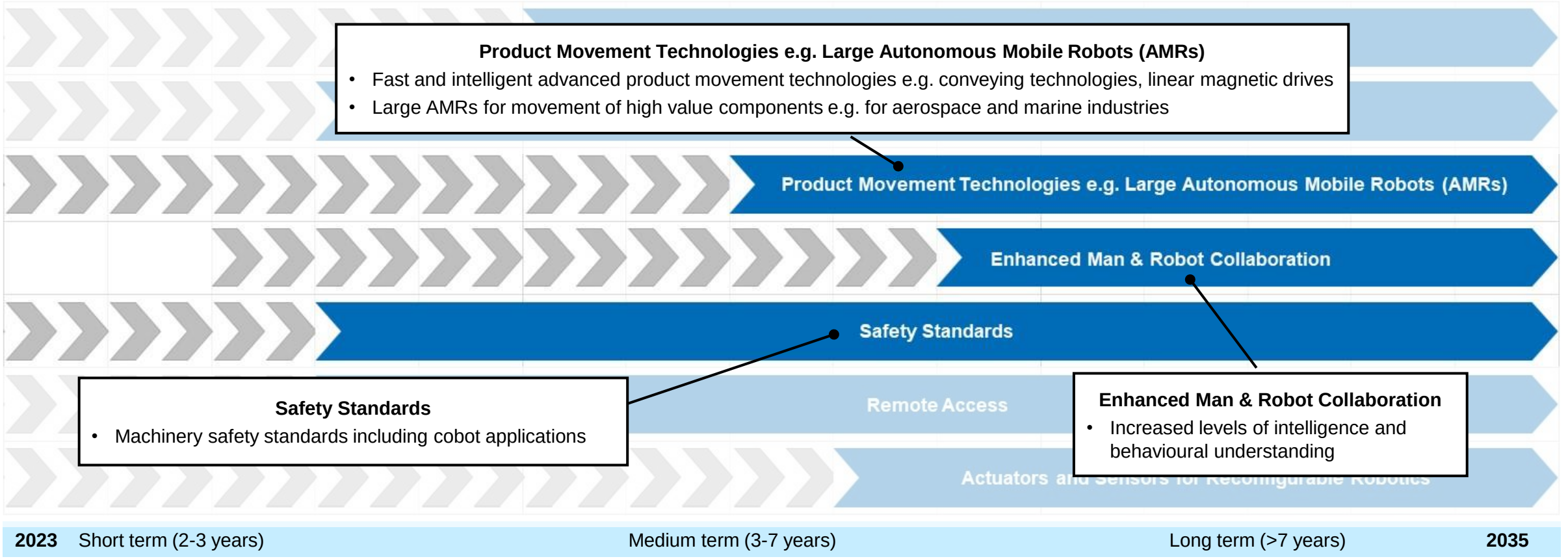
**Software Programming Simplification**

- Further development of software programming and standardised data technology to allow faster and less skilled machinery programming, interfacing and serviceability between suppliers
- Re-usable modular software

First Introduction  Market Maturity

# Automation – Commentary (2/3)

**Technology Roadmap**

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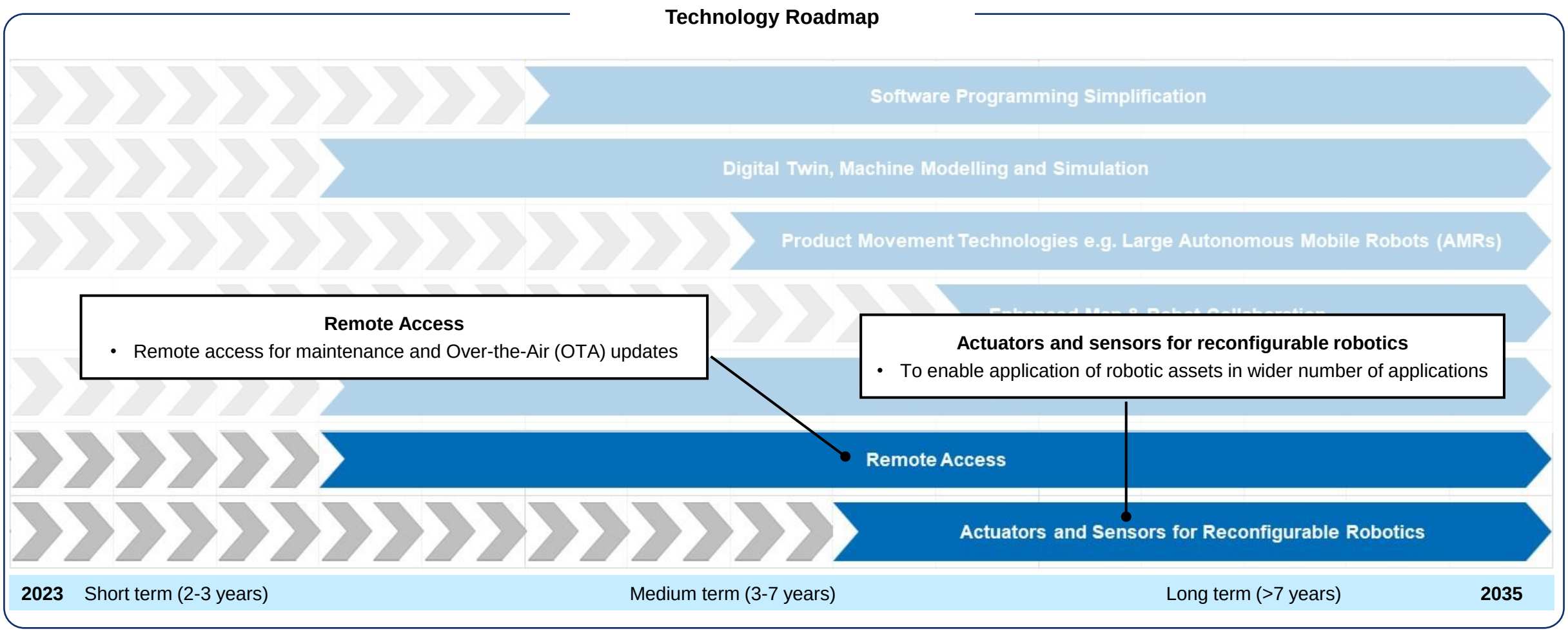

# Data and Communication Leveraging

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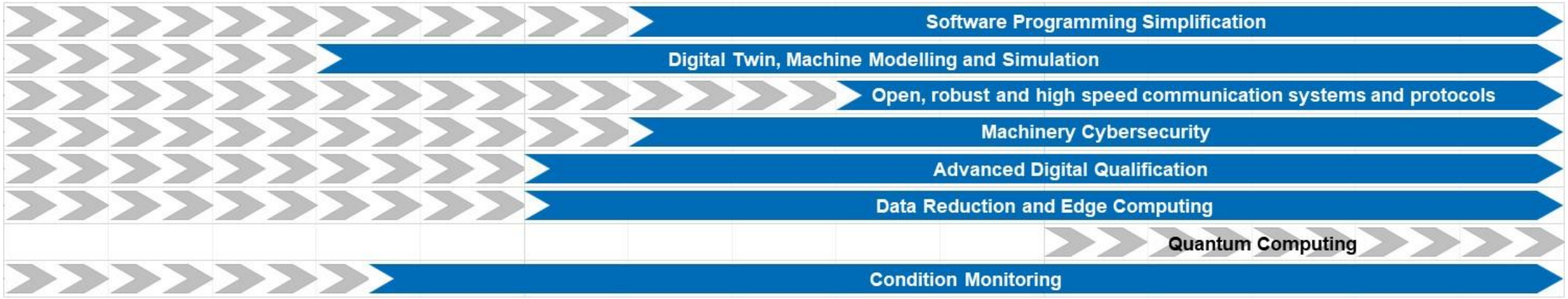
### Market Driven Needs and Concerns

- Open architectures of interfacing / serviceability needed to be shared by suppliers, to improve capability and serviceability
- OT (Operational Technology) networks, AI methods
- Need for increased software to manage materials supply
- In general there is either lack of data and lack of access to existing data
- Cyber security needed to enhance connectivity
- Sensorisation (e.g. wireless electrical test, increase use of actuators and sensors such as motors and encoders

### Actionable Themes

- Shared data architecture for M2M/IoT communication in production
- Production plant and value chain resilience to cyber attacks
- Condition monitoring
- Enabling of servitisation / PaaS business models

### Technology Roadmap

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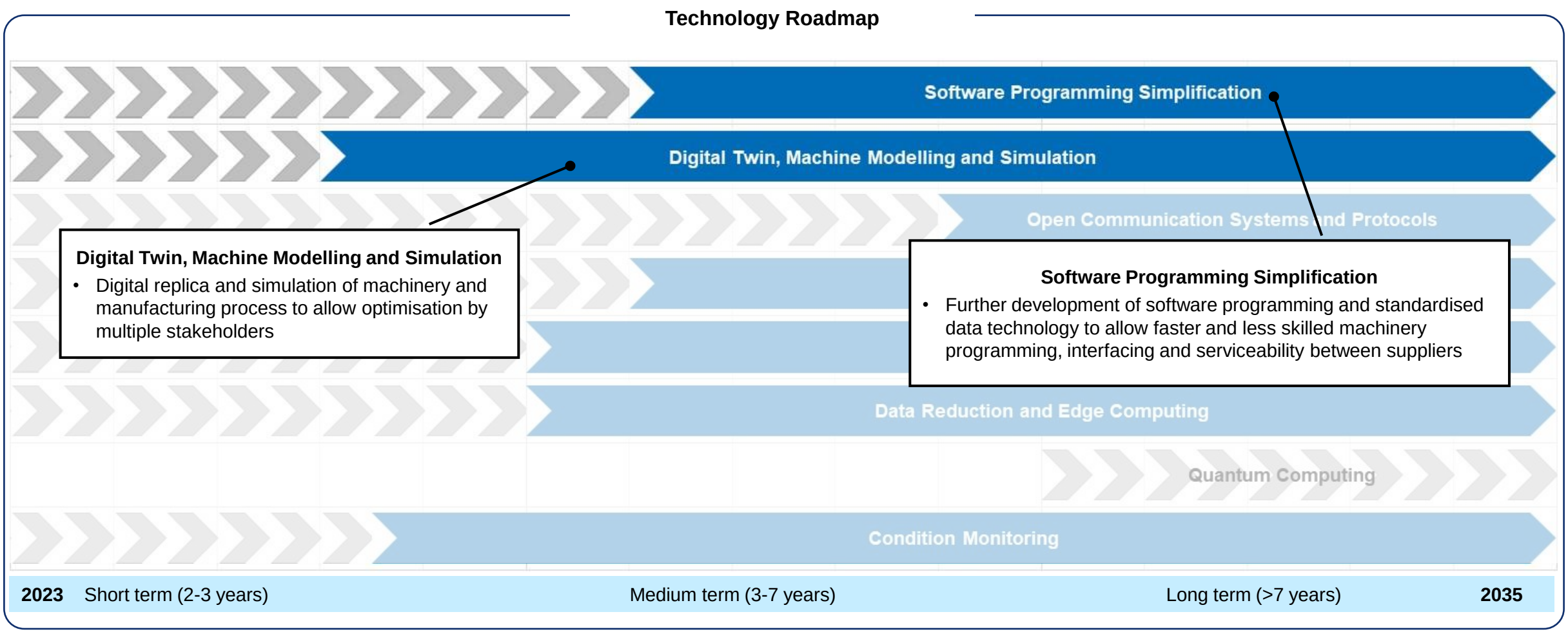
# Data and Communication Leveraging – Commentary (1/3)

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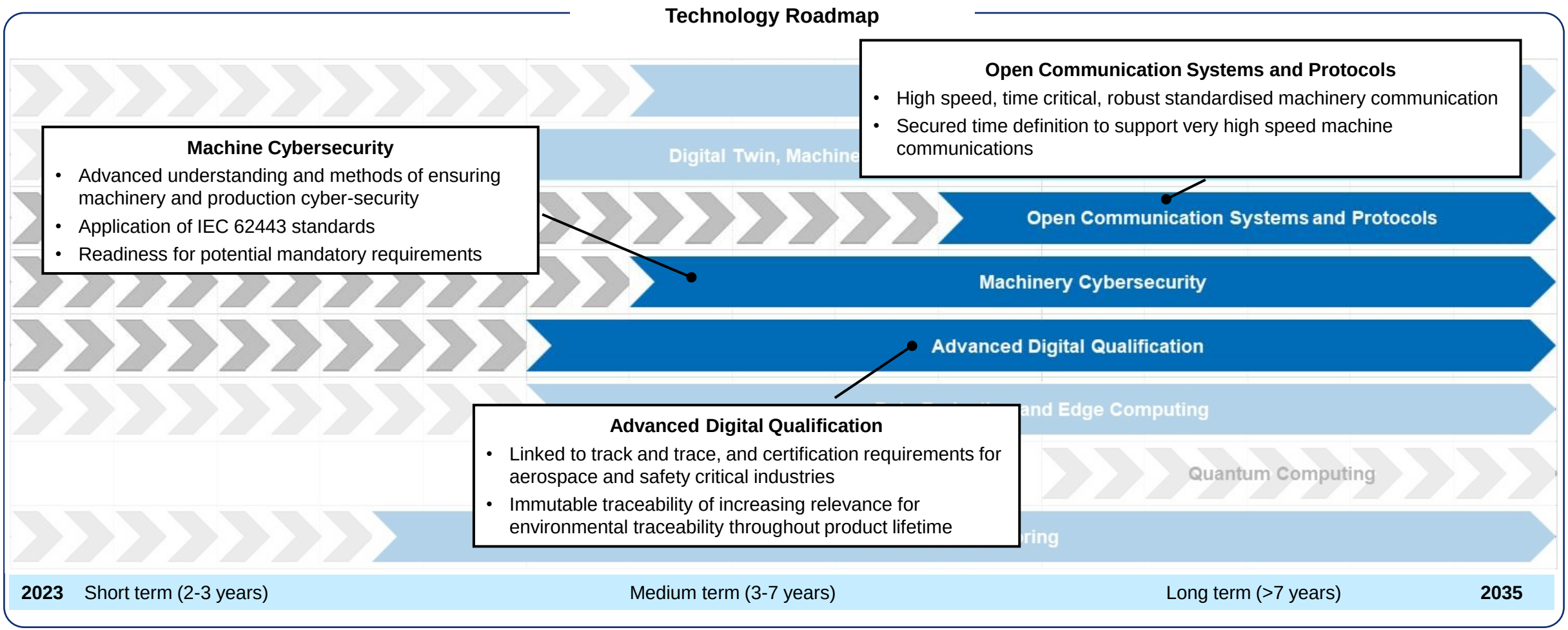
# Data and Communication Leveraging – Commentary (2/3)



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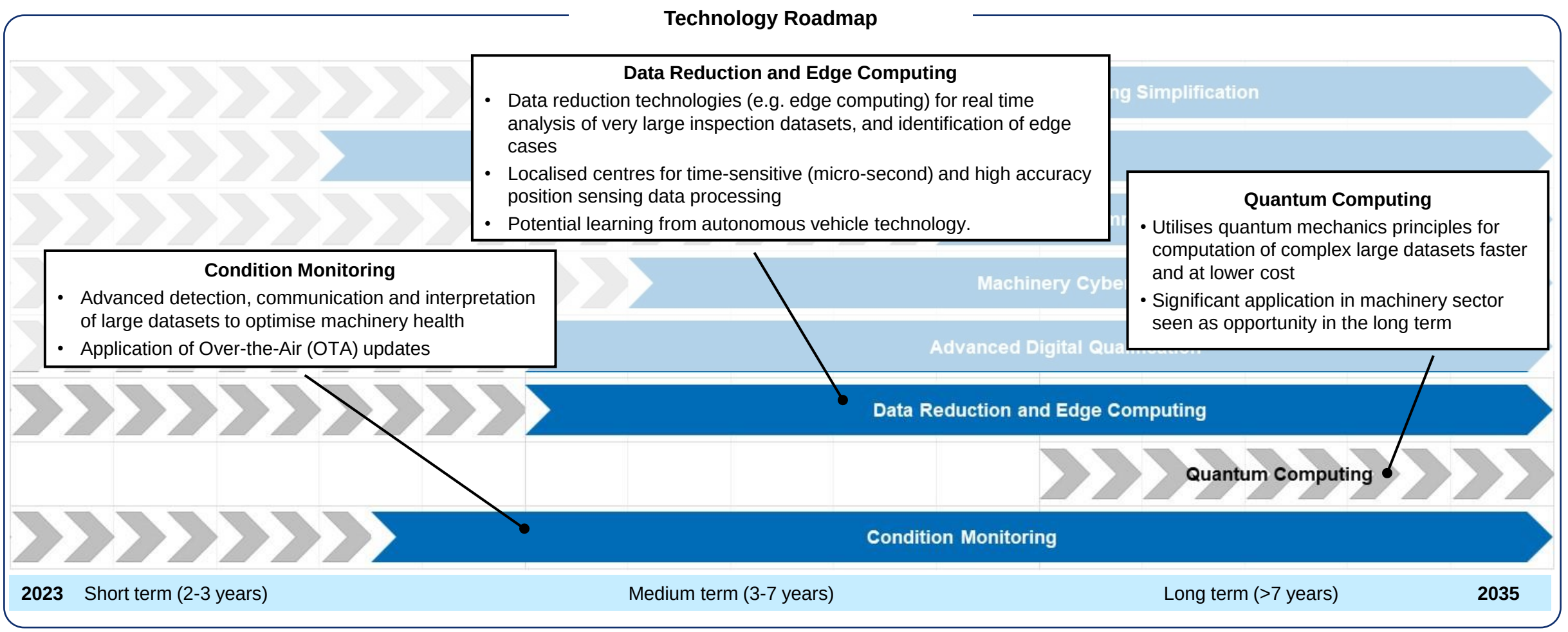


# Equipment Flexibility

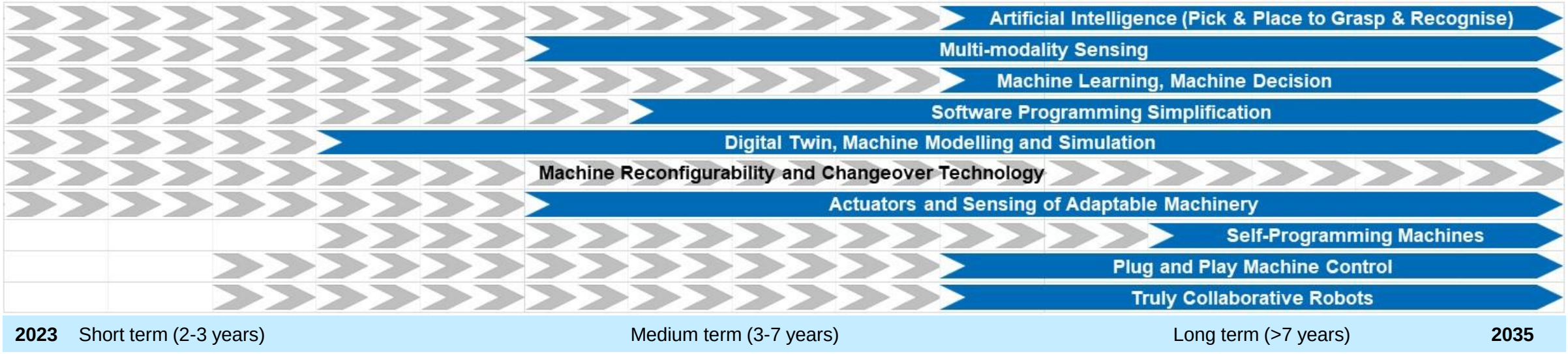
### Market Driven Needs and Concerns

- Reconfigurability of equipment and interoperability of machinery subsystems
- Need for industry standard
- Modularity and scalability
- Flexibility to manufacture variety of components - mass customisation
- Self healing / learning / adaptable machinery
- Easy to use, adaptable to new technology

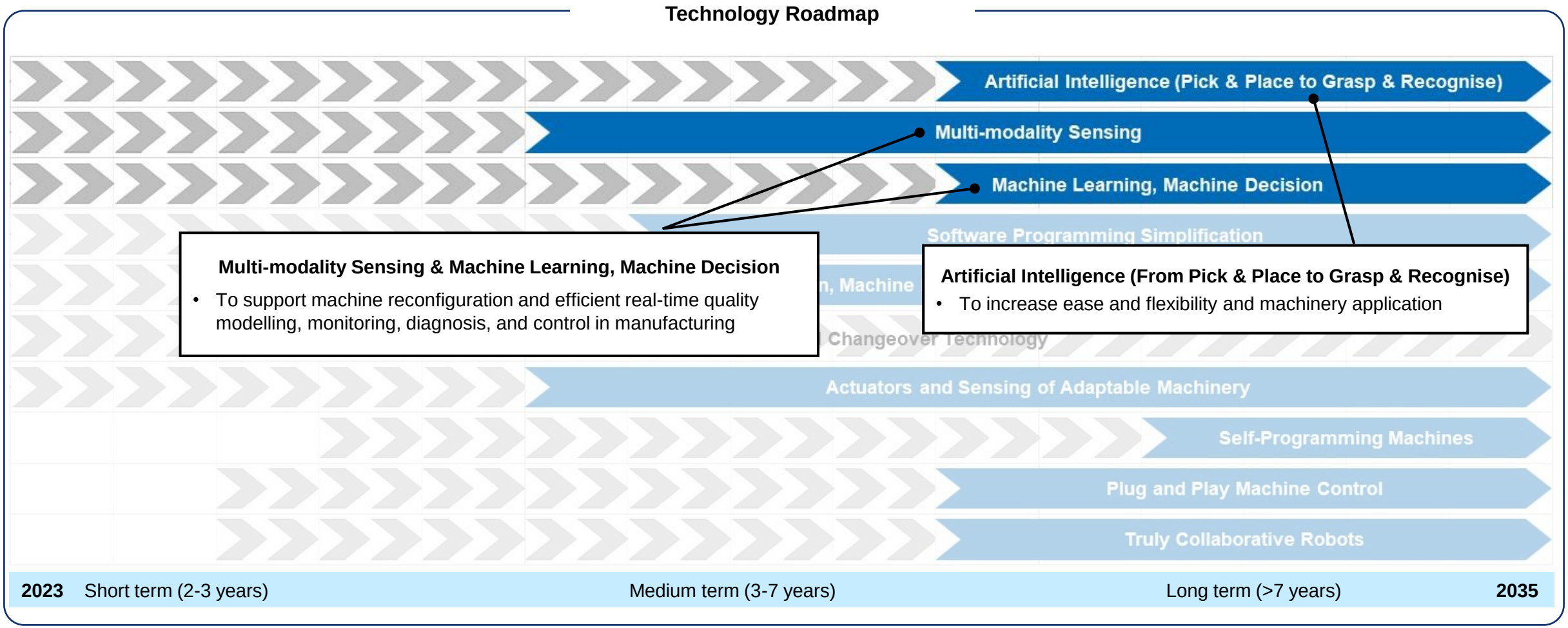
### Actionable Themes

- Machinery and production plant design for reconfigurability
- Self healing machinery development

### Technology Roadmap



# Equipment Flexibility – Commentary (1/3)

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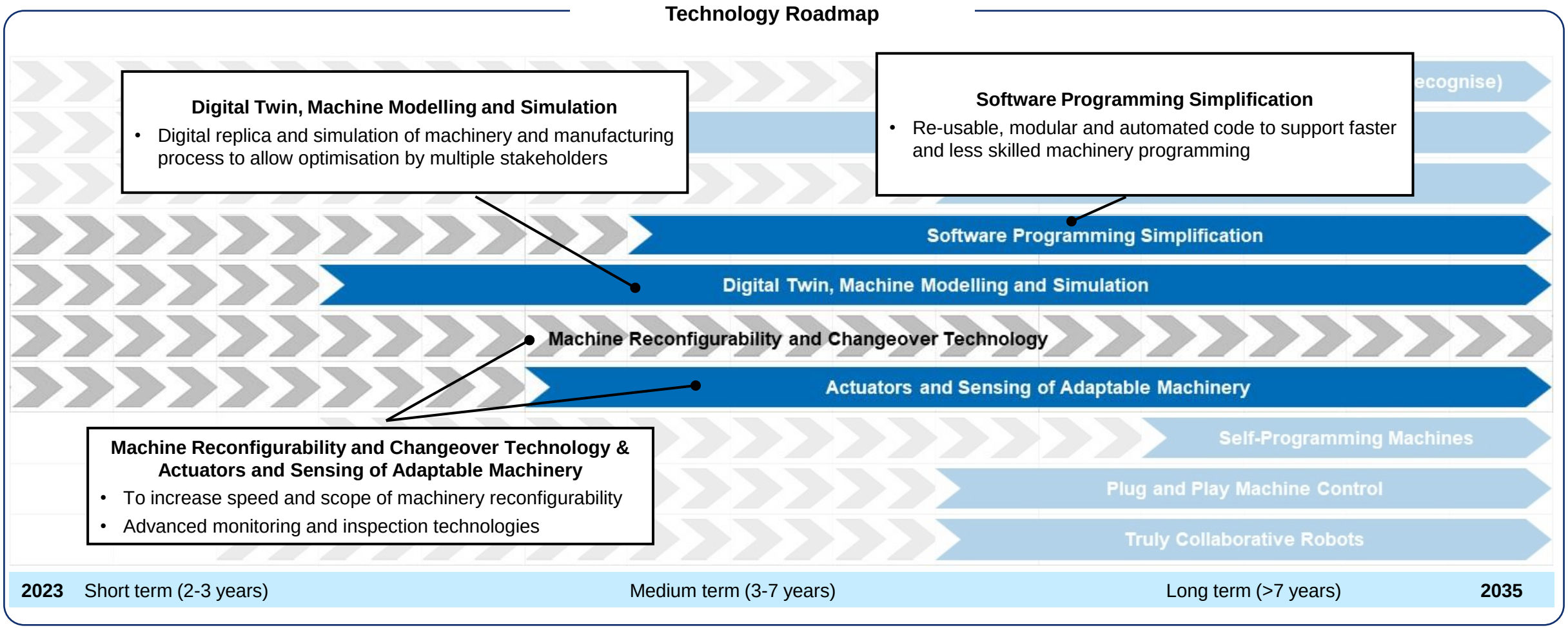
# Equipment Flexibility – Commentary (2/3)

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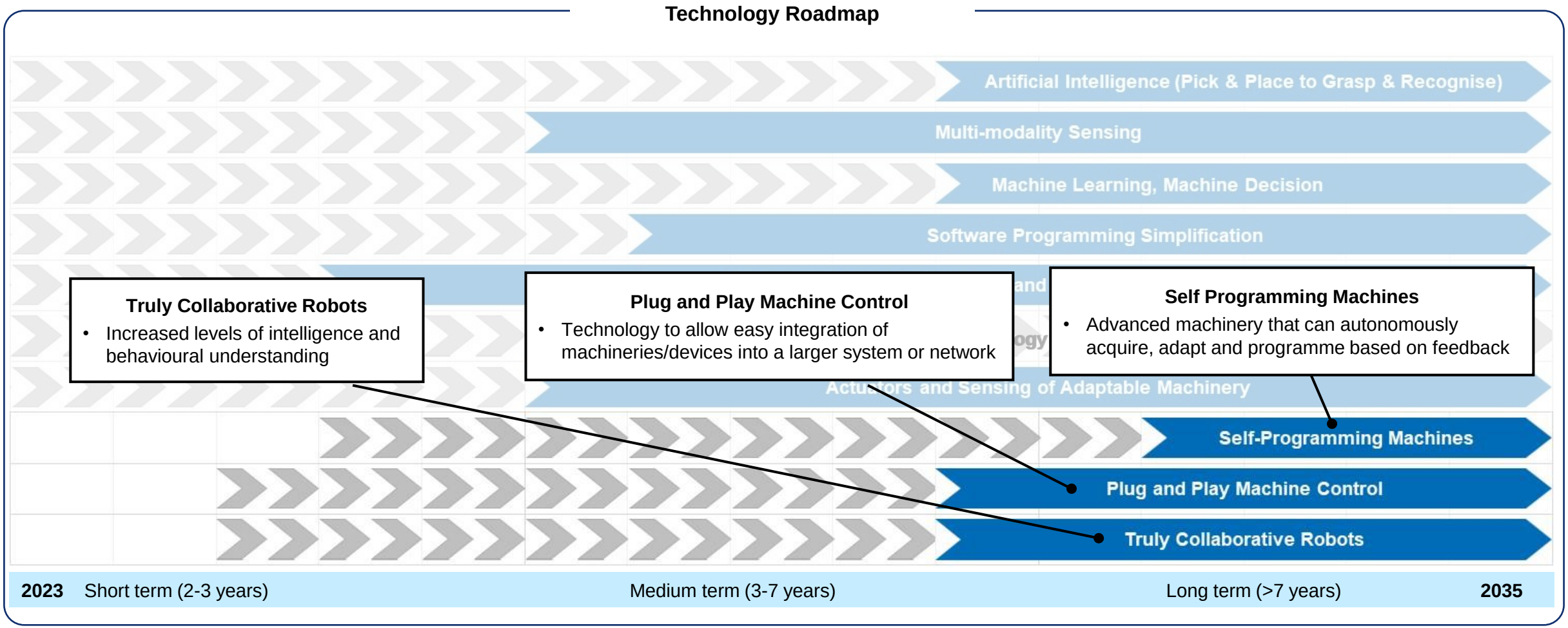
# Equipment Flexibility – Commentary (3/3)



# Managing the Supply Chain

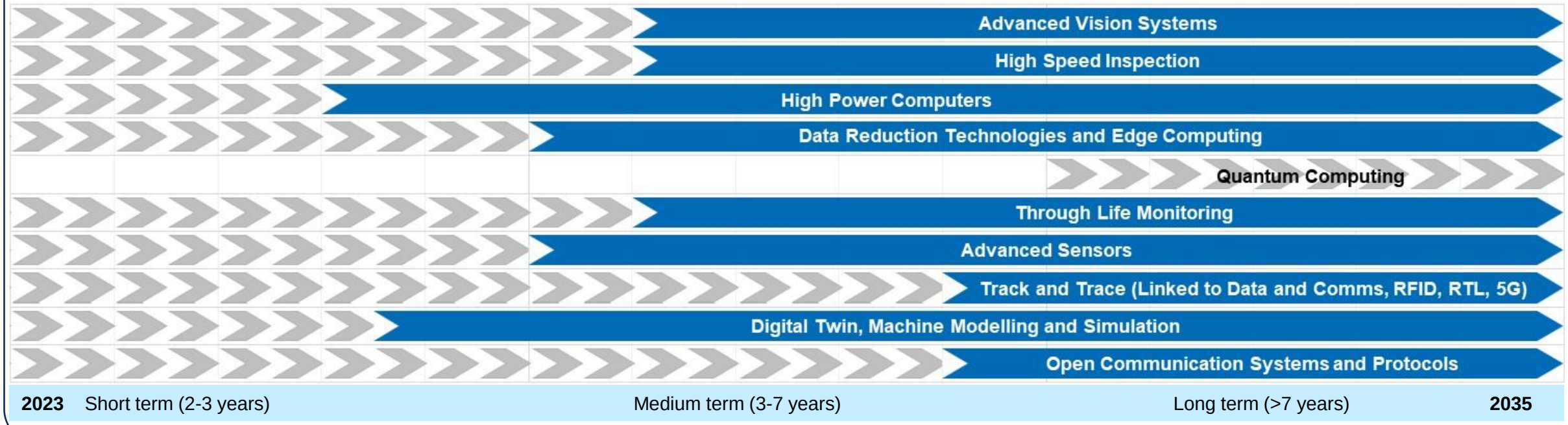
**Market Driven Needs and Concerns**

- Management of variability of both supply quantity and quality
- Access to key rare materials such as rare earths, advanced graphene

**Actionable Themes**

- Value chain quantity and quality variability management
- Value chain traceability

**Technology Roadmap**

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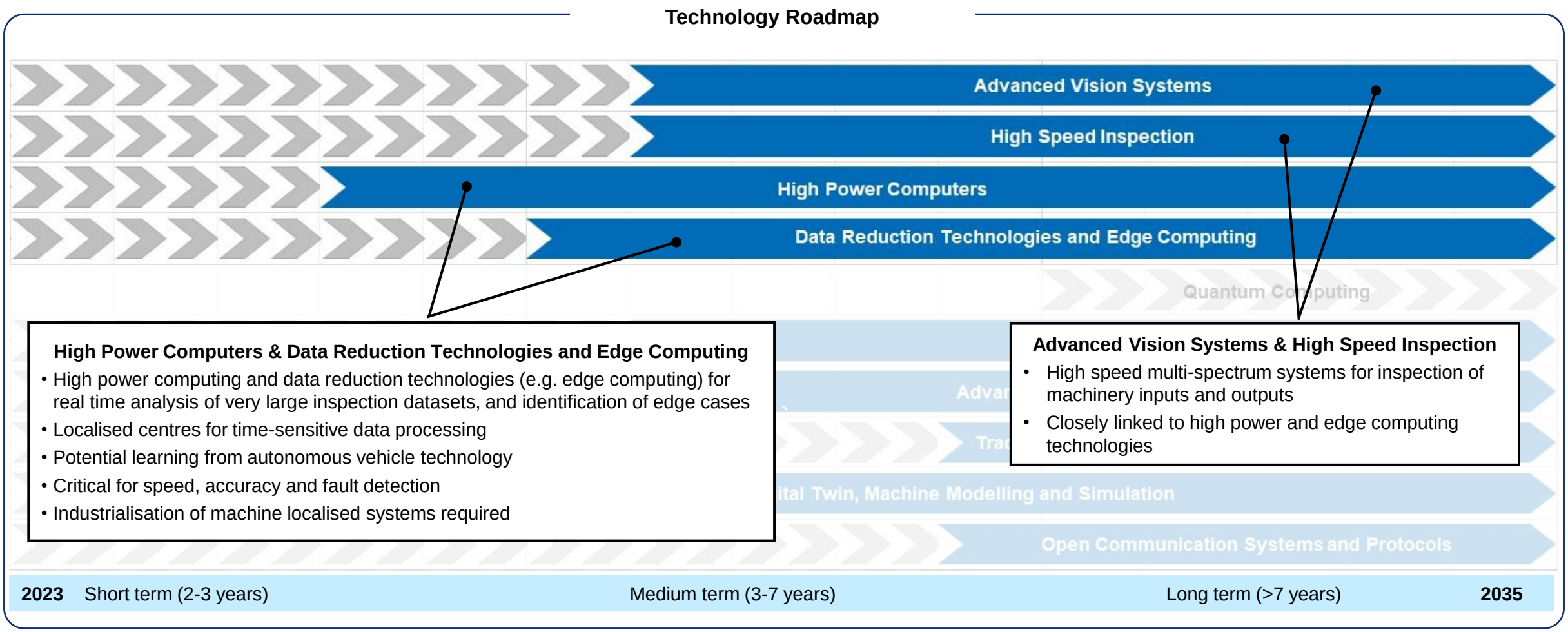
# Managing the Supply Chain – Commentary (1/3)




**High Power Computers & Data Reduction Technologies and Edge Computing**

- High power computing and data reduction technologies (e.g. edge computing) for real time analysis of very large inspection datasets, and identification of edge cases
- Localised centres for time-sensitive data processing
- Potential learning from autonomous vehicle technology
- Critical for speed, accuracy and fault detection
- Industrialisation of machine localised systems required

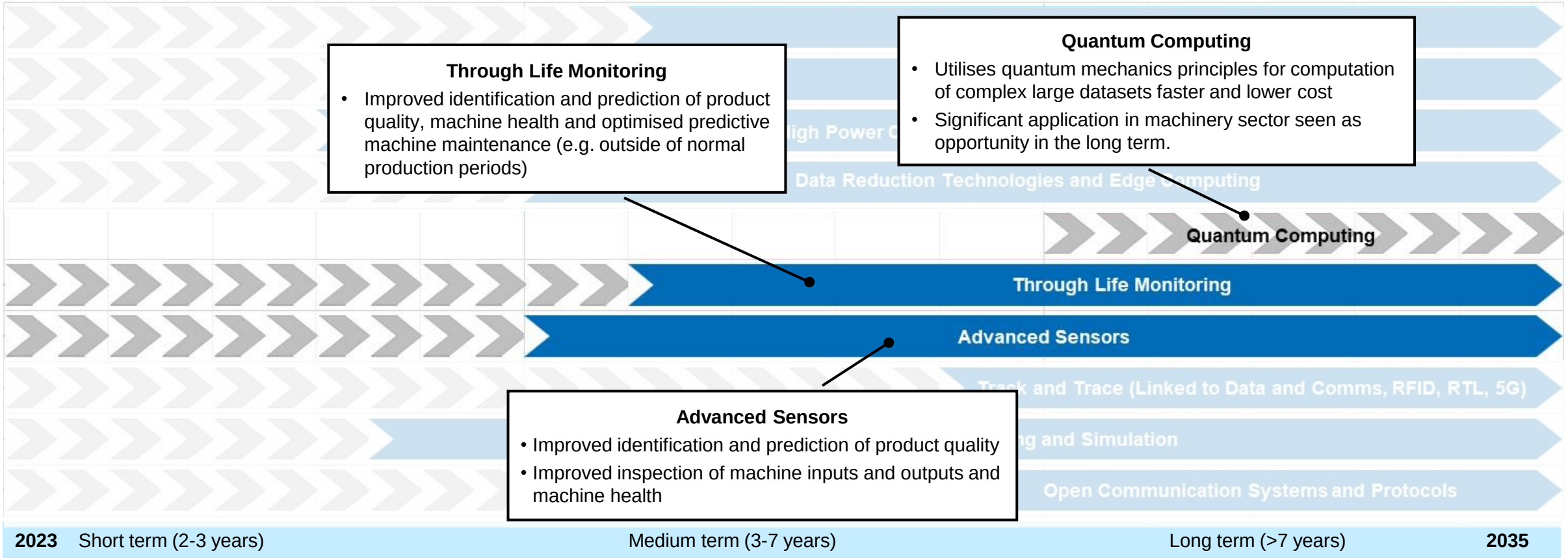
**Advanced Vision Systems & High Speed Inspection**

- High speed multi-spectrum systems for inspection of machinery inputs and outputs
- Closely linked to high power and edge computing technologies

First Introduction  Market Maturity

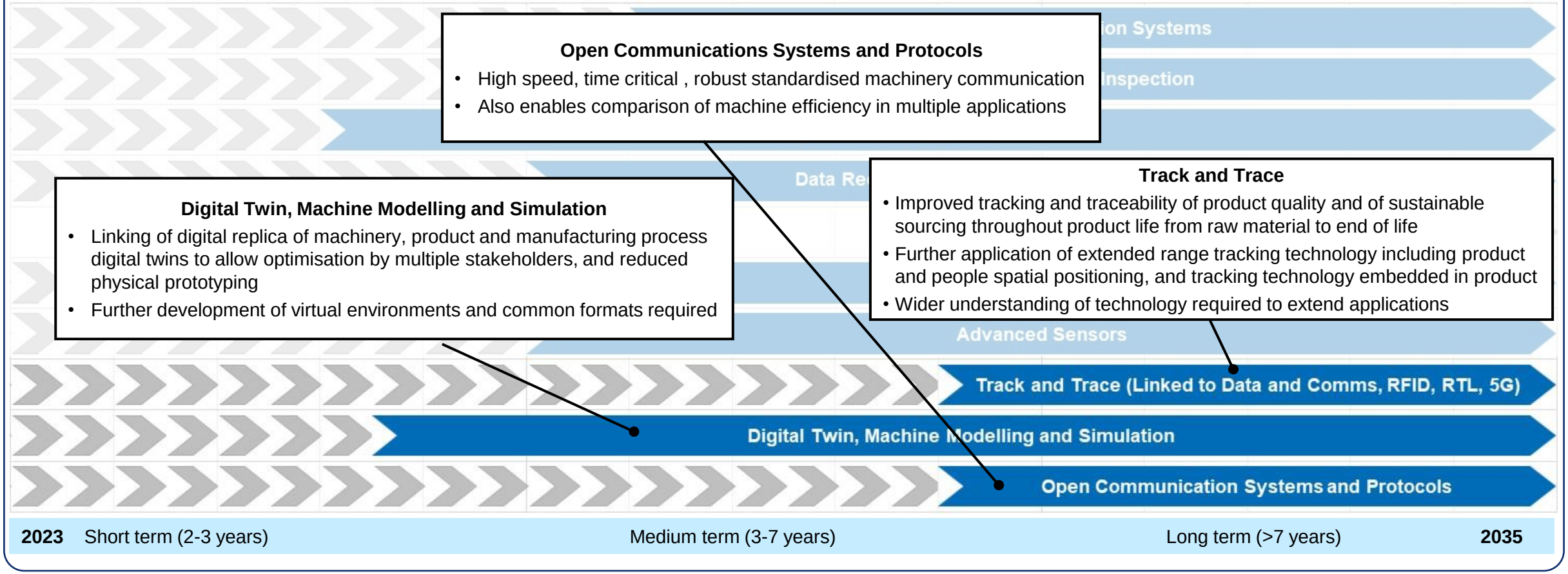
# Managing the Supply Chain – Commentary (2/3)

**Technology Roadmap**



# Managing the Supply Chain – Commentary (3/3)

## Technology Roadmap



# Sustainability and Decarbonisation

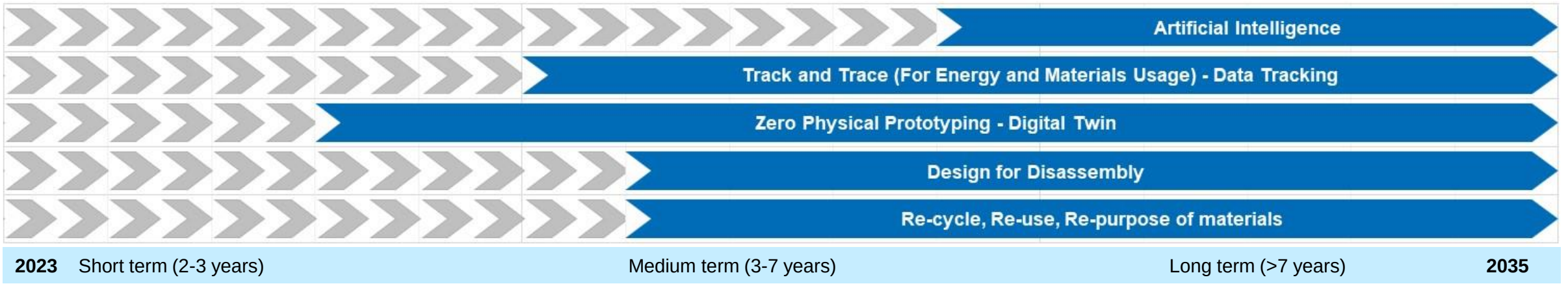
### Market Driven Needs and Concerns

- Decarbonisation of high energy processes e.g. heating / heat treatment
- Reclaiming and recycling systems / components
- High energy producers want to understand how hydrogen energy impacts process line – e.g. for heating
- Industrialisation of ZE (Zero Emission) energy
- Local heat and electricity supply
- Materials validation, provenance

### Actionable Themes

- Machinery and product design for recyclability/reuse/repurpose
- Production line and value chain energy and carbon footprint monitoring
- Machinery life extension development

### Technology Roadmap

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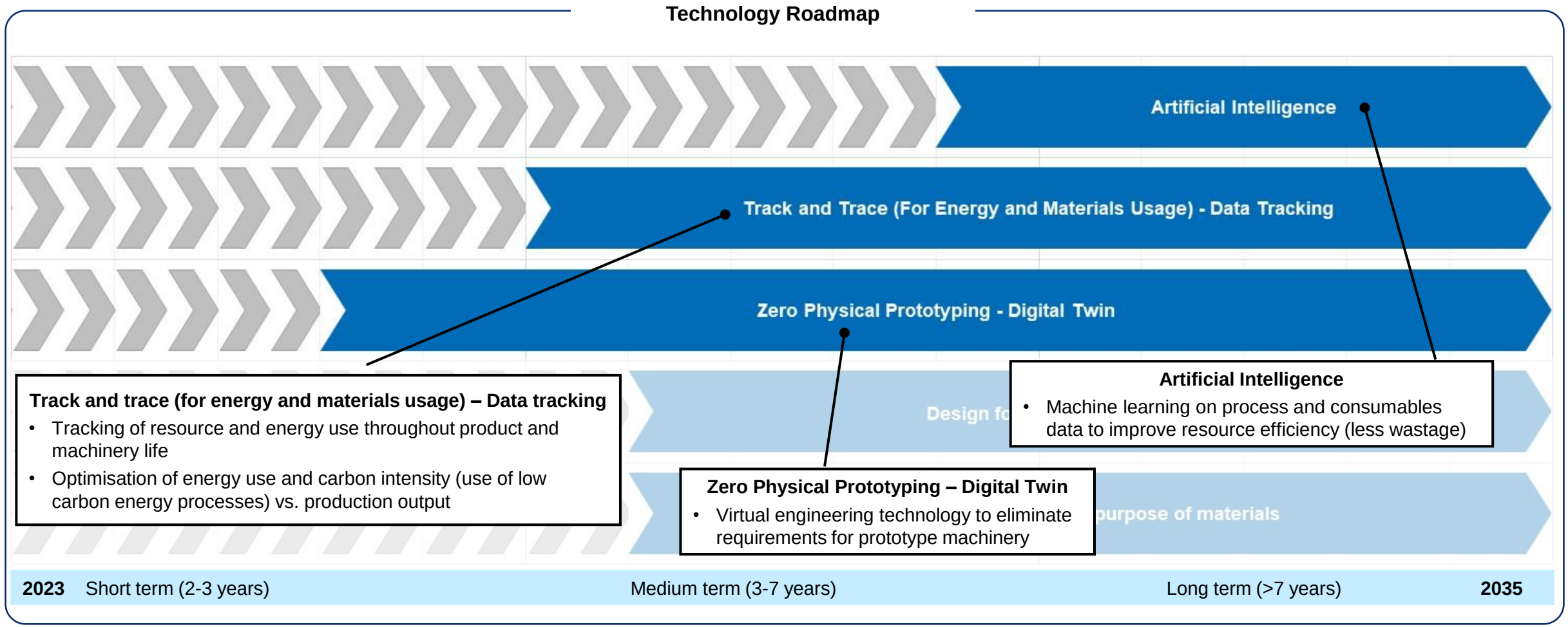
# Sustainability and Decarbonisation – Commentary (1/2)

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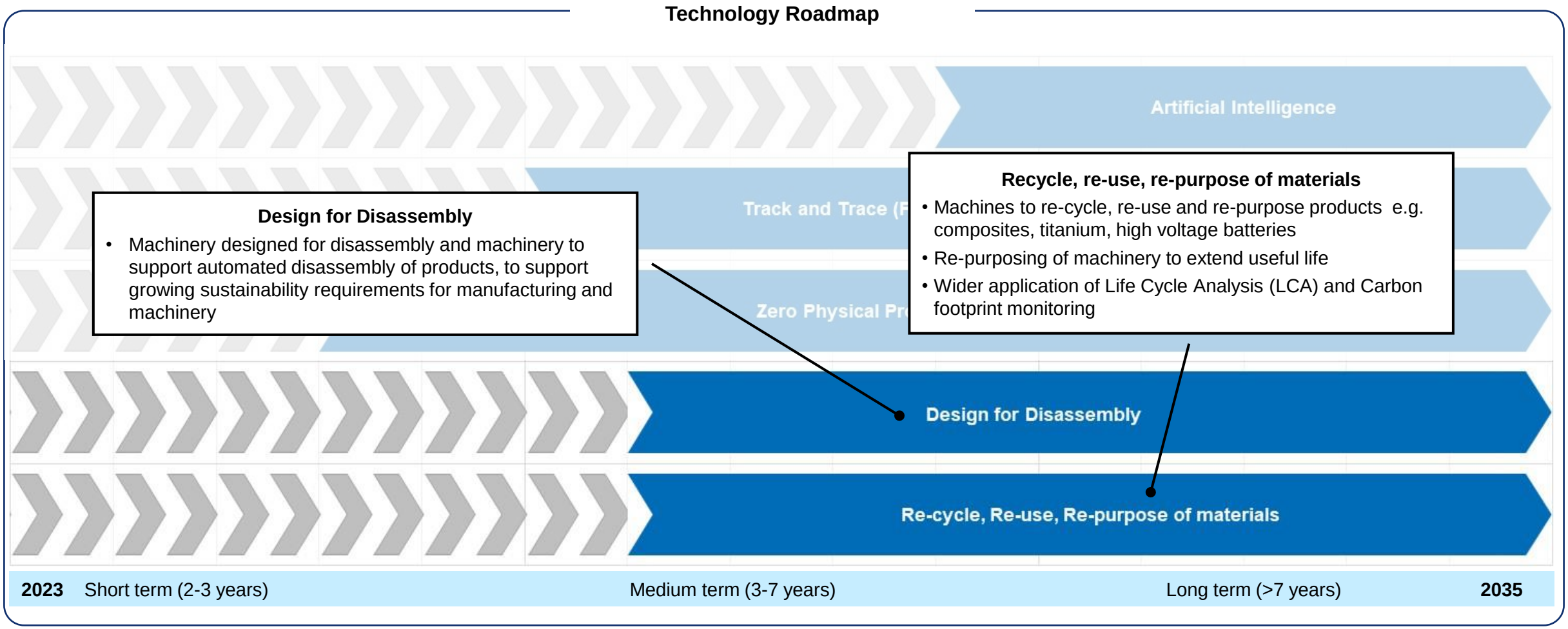
# Sustainability and Decarbonisation – Commentary (2/2)



# Contents

# Conclusions

- Following industry and academic consultation across key industrial sectors, 7 actionable market-driven themes were identified:

1. Managing the supply chain; 2. Data and communication leveraging; 3. Sustainability and decarbonisation; 4. Equipment flexibility; 5. Advanced materials; 6. Automation; 7. Additive manufacturing

- Addressing a lack of understanding of available technology could lead to significant short-term benefits in the short term.
- Improved training, technology transfer, and engagement with Centres of Excellence could all be mechanisms to address a skills shortage in the machinery sector.
- The roadmaps should be considered as live documents to be refined over time. Future work will explore refining roadmaps based on the needs of individual and emerging sectors and technology trends.
- It is recommended that the technology roadmaps are used to identify whether current R&D portfolios are aligned to market needs, whilst framing the development of future advanced machinery R&D around the market driven actionable themes.

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