Non-destructive Evaluation for Industry 4.0

Inspection technology for the 21st Century

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"Strong relationships with industrial partners have led to a successful centre that is internationally recognised" EPSRC

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Contents

- Introduction to RCNDE
- The classical role of NDE
- The impact of, and to, Industry 4.0
- The roadmap
- Technology examples
- Conclusions

The way NDE works now:

Basic data processing and imaging
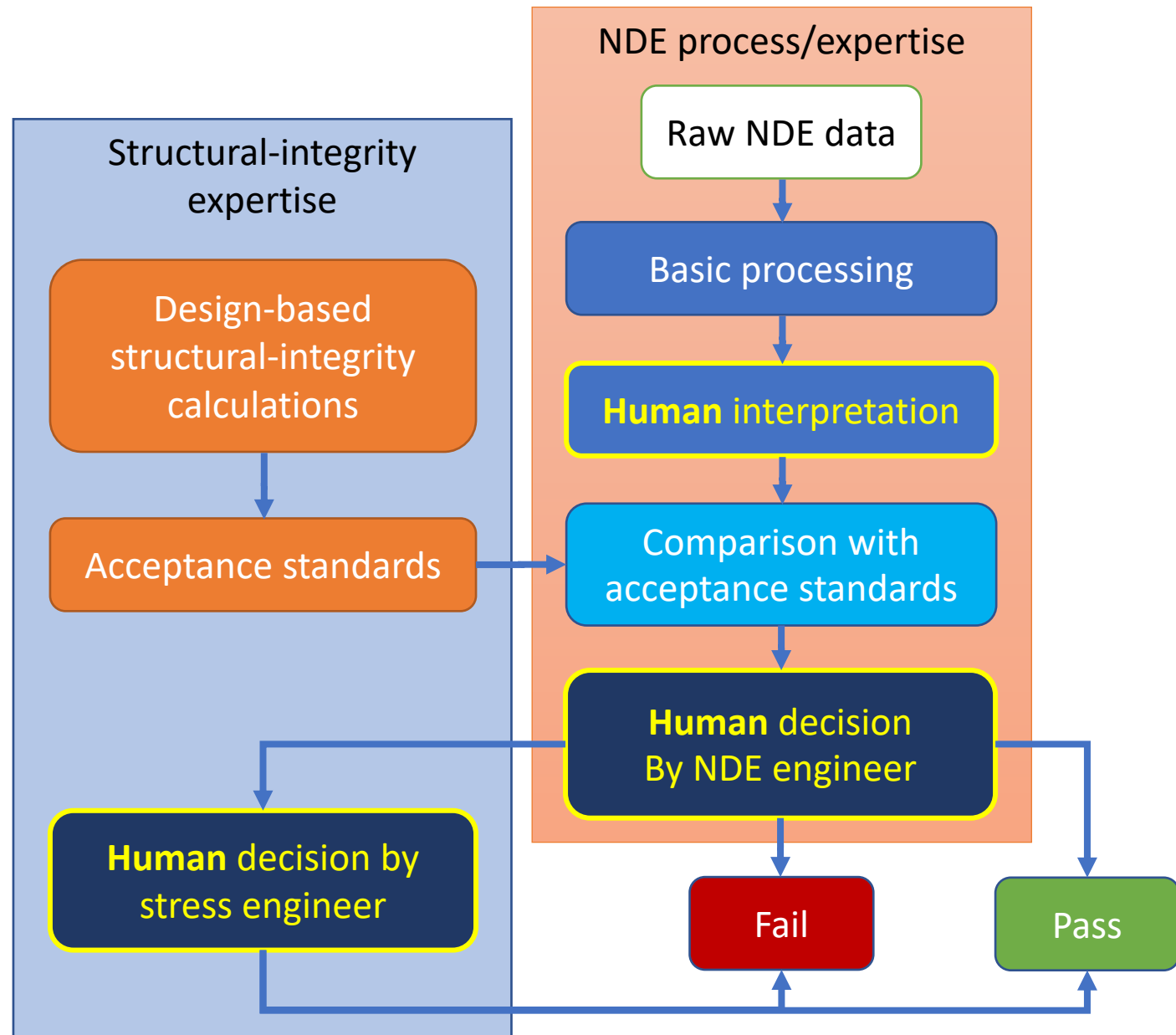
Human interpretation and decisions

Constrained in data rate and complexity by **human** cognitive ability

Structural integrity calculations at design stage – lead to acceptance standards

Calculations performed for specific defect cases in service, leading to **human** decision – ignore/monitor, repair or scrap.

Hand-offs between discipines

Slow and labour intensive, hence costly.

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NDE process/expertise

Raw NDE data

Basic processing

Human interpretation

Comparison with acceptance standards

Human decision
By NDE engineer

Structural-integrity expertise

Design-based structural-integrity calculations

Acceptance standards

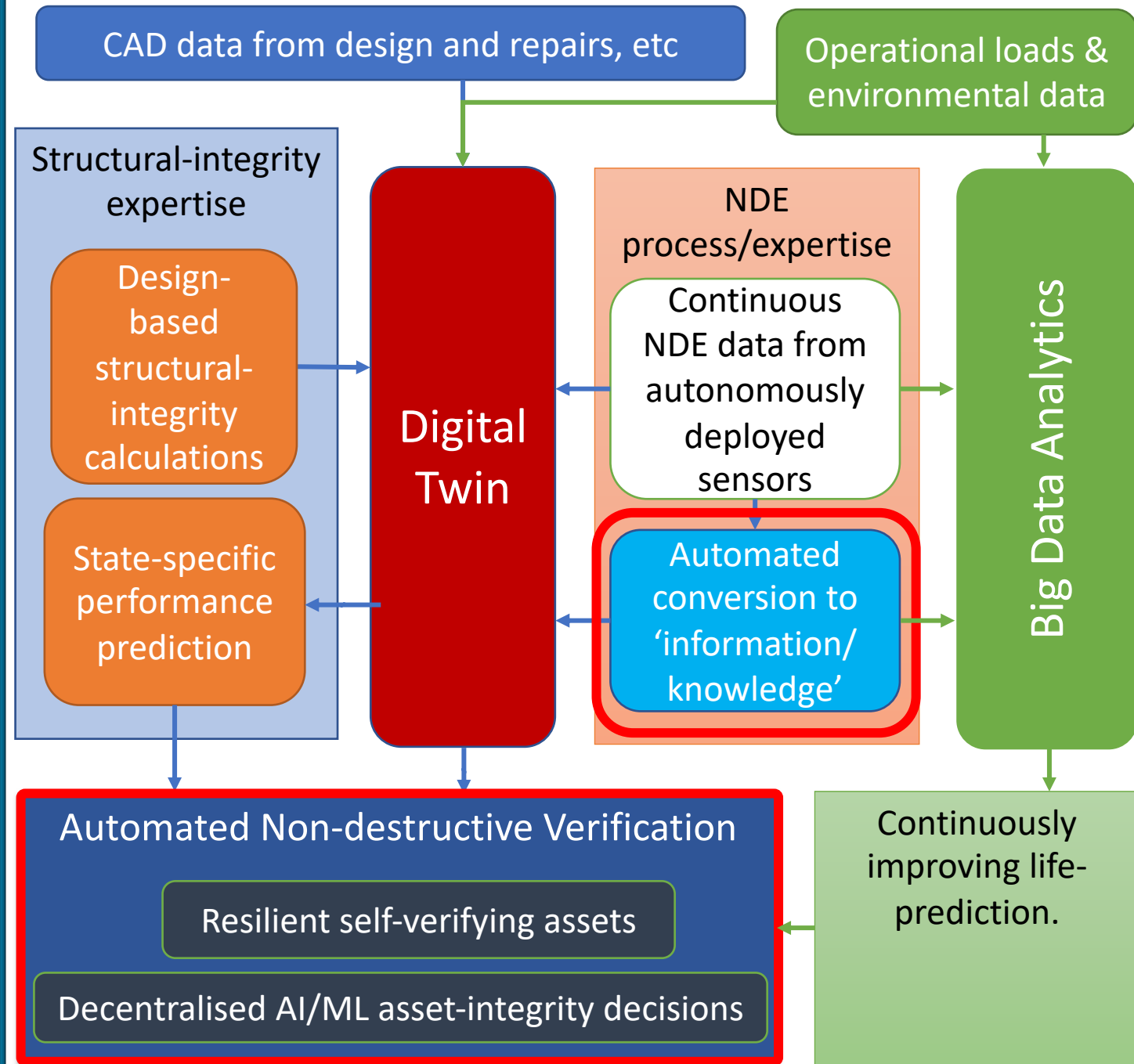**Human** decision by stress engineer

Fail

Pass

A Future of In-Process NDE

Rapid, large and complex raw data from numerous installed sensors.

Automated big-data analytics with artificial intelligence to convert data to information and knowledge.
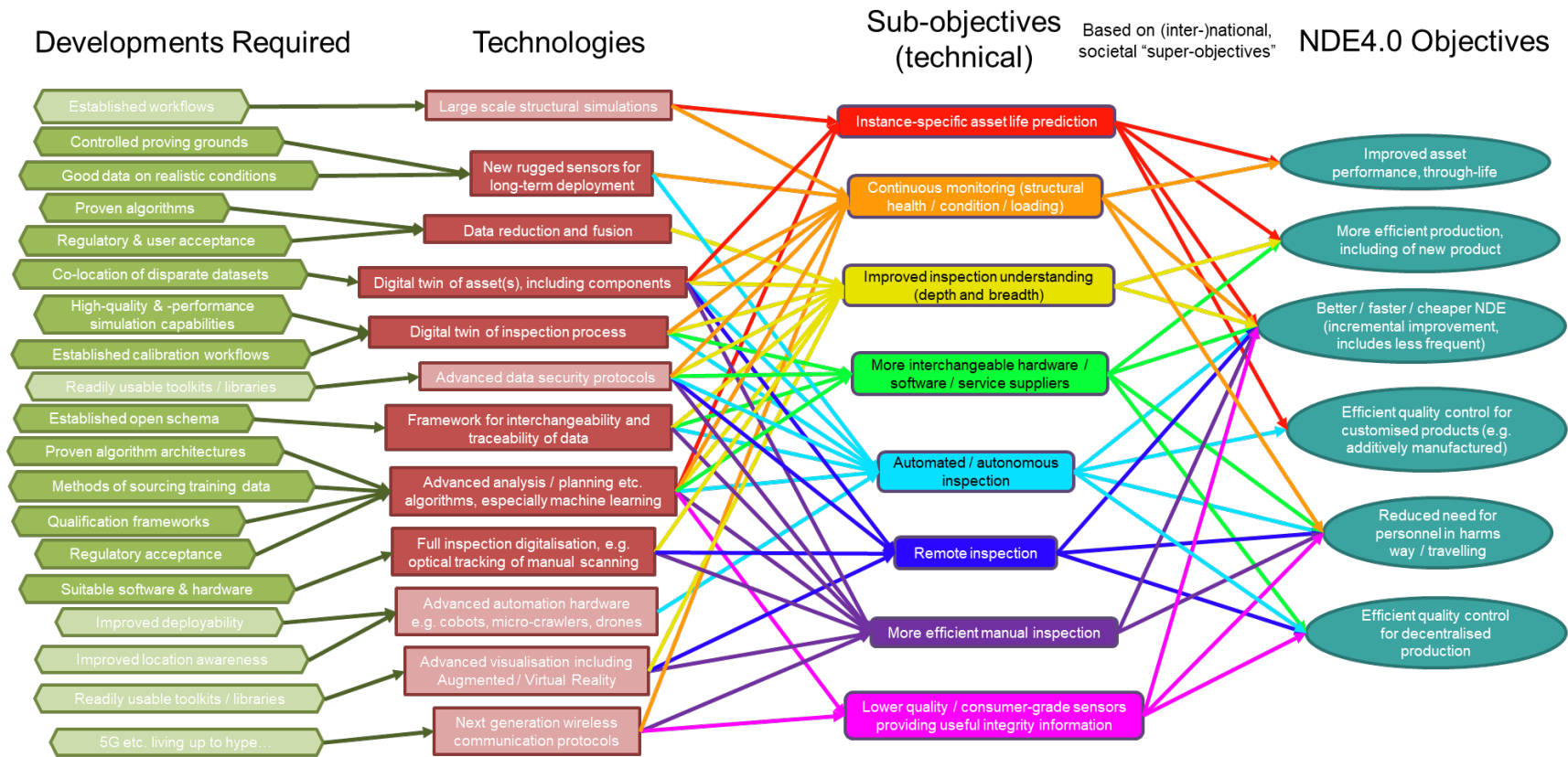
Digital Twin to keep all information in a virtual replica of the real component.

This feeds further state-specific structural calculations and automated decision making.

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CAD data from design and repairs, etc

Operational loads & environmental data

Structural-integrity expertise

Design-based structural-integrity calculations

State-specific performance prediction

Digital Twin

NDE process/expertise

Continuous NDE data from autonomously deployed sensors

Automated conversion to 'information/knowledge'

Big Data Analytics

Continuously improving life-prediction.

Automated Non-destructive Verification

Resilient self-verifying assets

Decentralised AI/ML asset-integrity decisions
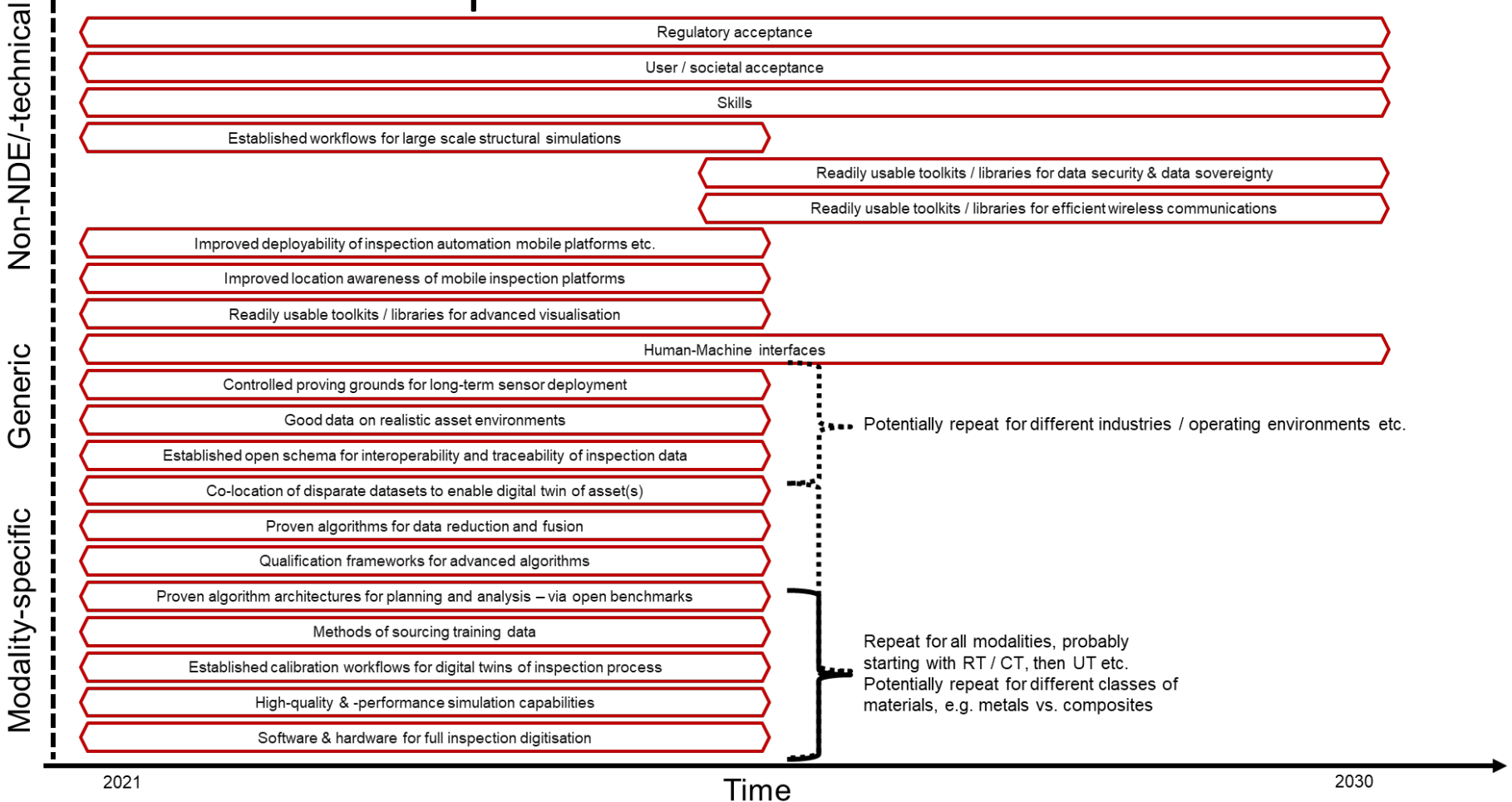
NDE 4.0 Roadmap Precursor

Contributions & Dependencies

Note: arrows are not considered to represent requirements of end-points as much as contributions of start-points, reflecting multiple ways of reaching some objectives, depending on specifics.
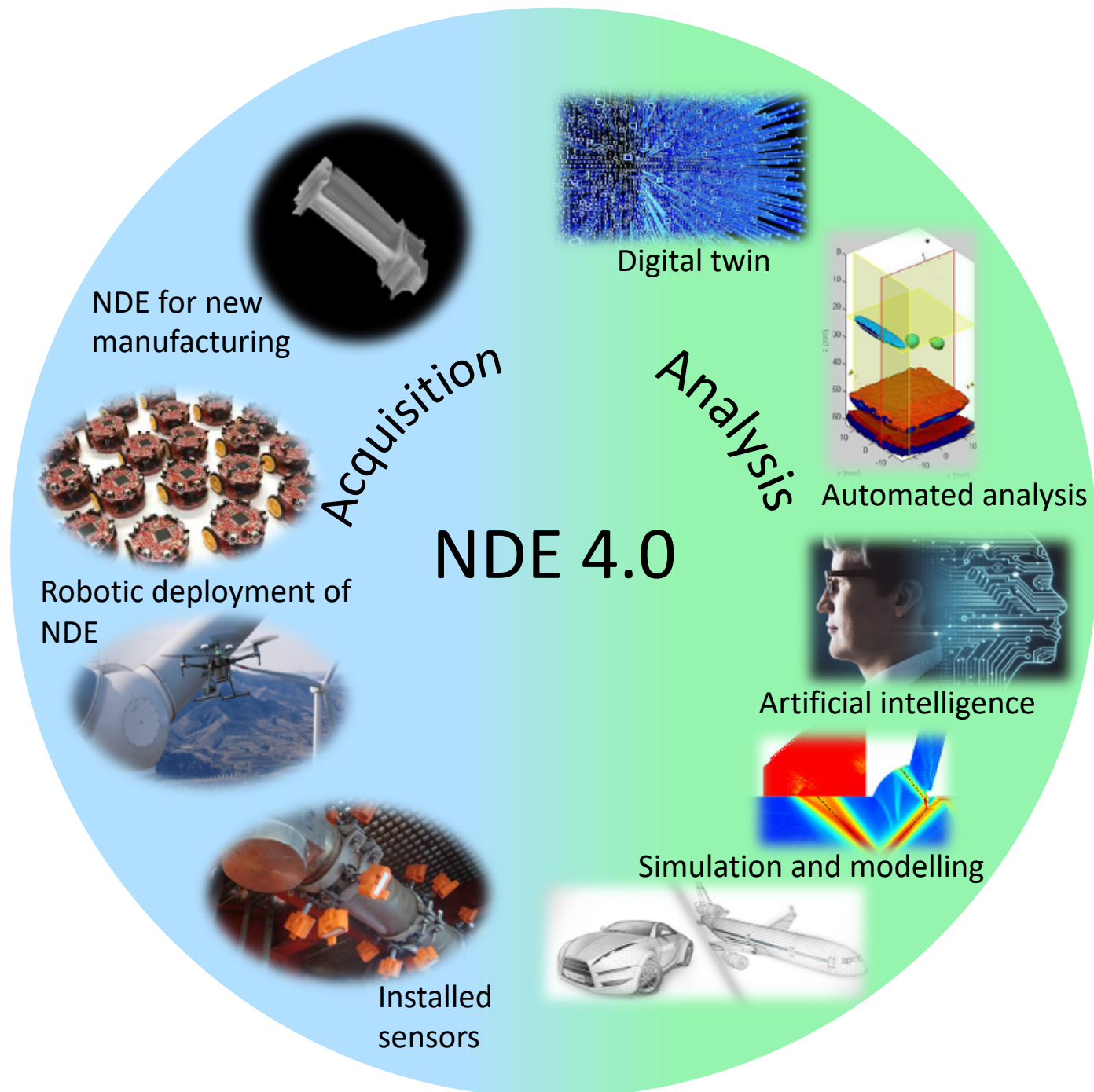
Courtesy of BINDT

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NDE 4.0 Roadmap Draft

Future technology

Digital twin

Automated analysis

NDE for new manufacturing

Acquisition

Analysis

NDE 4.0

Robotic deployment of NDE

Artificial intelligence

Simulation and modelling

Installed sensors

Meeting the needs of the 4th industrial revolution, or 'Industry 4.0'

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Successful technology examples

Permanently installed sensors

- High-temperature ultrasonic thickness gauge for permanent installation at up to 600°C.
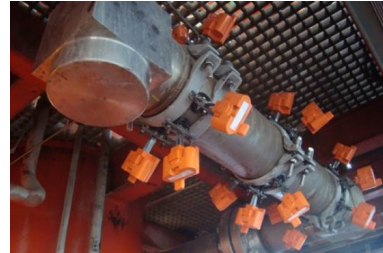
Wireless ultrasonic SHM sensors

- PZT sensor with a coil - permanently attached to a structure
- Wand is moved over sensor and ultrasound waves are transmitted and received.
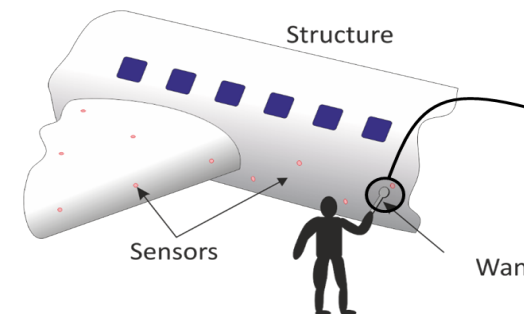
Successful technology examples

Robotic NDE

- Development of small robotic vehicles to deliver NDE in hazardous or limited access locations.

- Use of large industrial robotic systems for inspection tasks during plant or component manufacture.
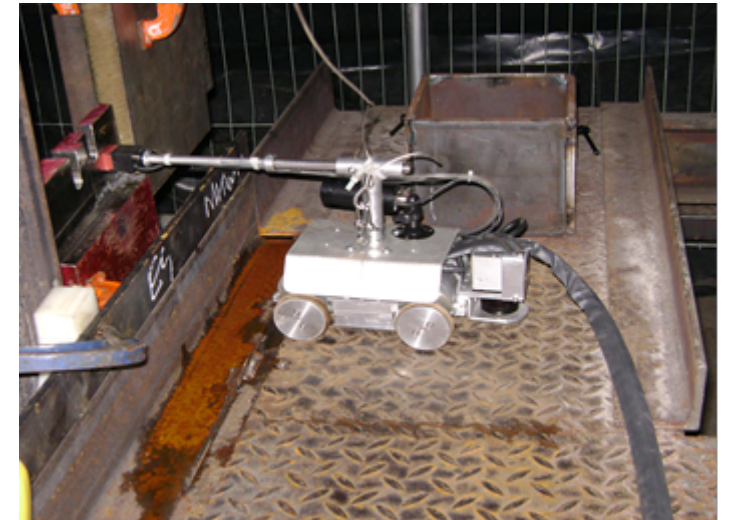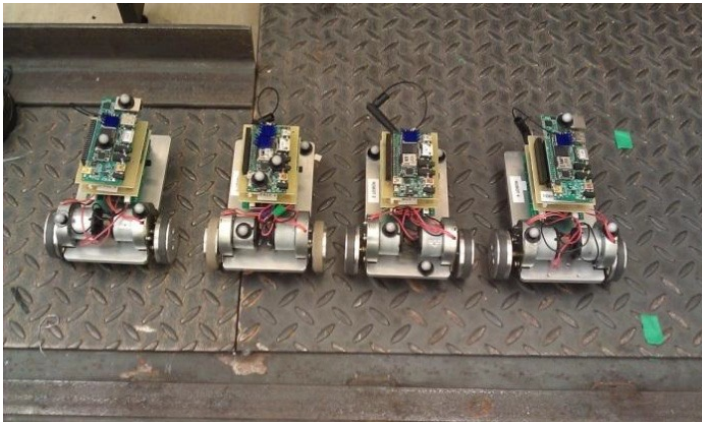
ML Enhancement to Coating Measurements

➤ A model based non-destructive testing approach to estimate the turbine blade coating degradation using multi-frequency (MF) eddy current (EC) measurements and machine learning (ML) models are considered here

➤ A finite element forward model replicating physical and electromagnetic properties of turbine blade using frequencies ranging between 500 kHz and 30 MHz was implemented

➤ The forward model is implemented to study the MF EC responses to different coating thickness scenarios and collect sufficient datasets to train the ML models

➤ The trained machine learning (ML) models were tested using additional unseen datasets covering various coating thickness
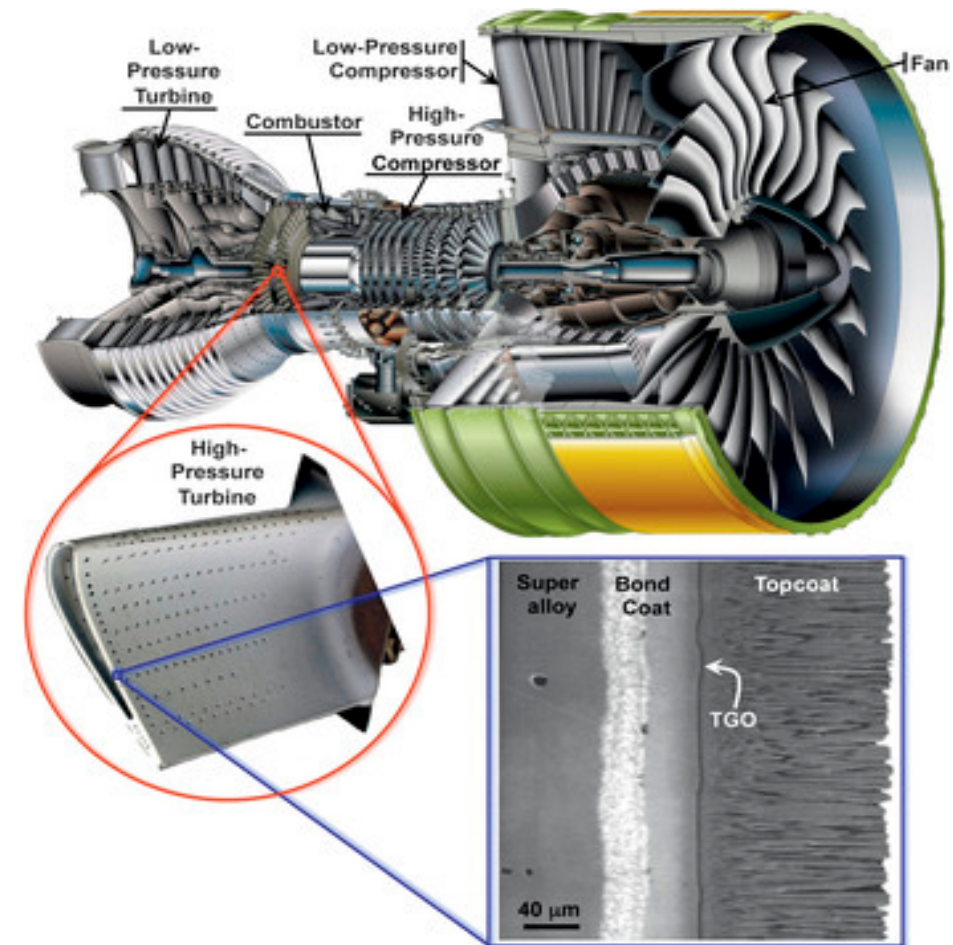
Conclusions

- NDE processes can be either a threat to a more connected, autonomous world

- Or

- NDE technology can be fused with future systems to deliver enhanced performance, reliability and safety

- RCNDE and it's partner organaisations are keen to work with ETN to explore the opportunities presented by these emerging technologies

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Our Stakeholders

Questions?…

Ways to connect…

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