

EPSRC Centre for Innovative Manufacturing

Through-life Engineering Services



Through-life Engineering Services (TES): Now and the Future

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MINISTRY OF DEFENCE



Pioneering research and skills



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Through-life Engineering Services (TES)

are the technical services that are necessary to guarantee the required and predictable performance of a complex engineering system throughout its expected operational life with the optimum whole-life cost





**Degradation study:
component and
systems.**

*Service
Intelligence: data
analytics*

Autonomous
Maintenance.

Diagnostics and
Prognostics: RUL

**Obsolescence
Management.**

**Design and
Manufacturing for
Maintenance.**



Service Cost Modelling.

Virtual Service
Engineering

**Maintenance Training
and visualisation:
augmented reality.**

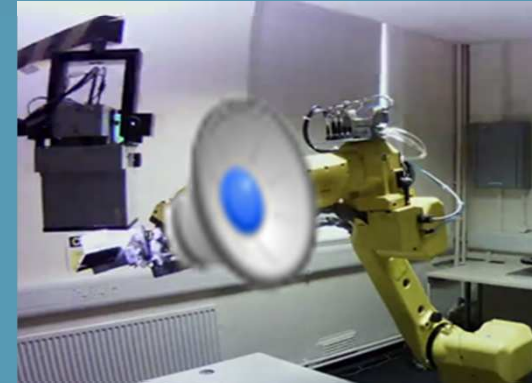
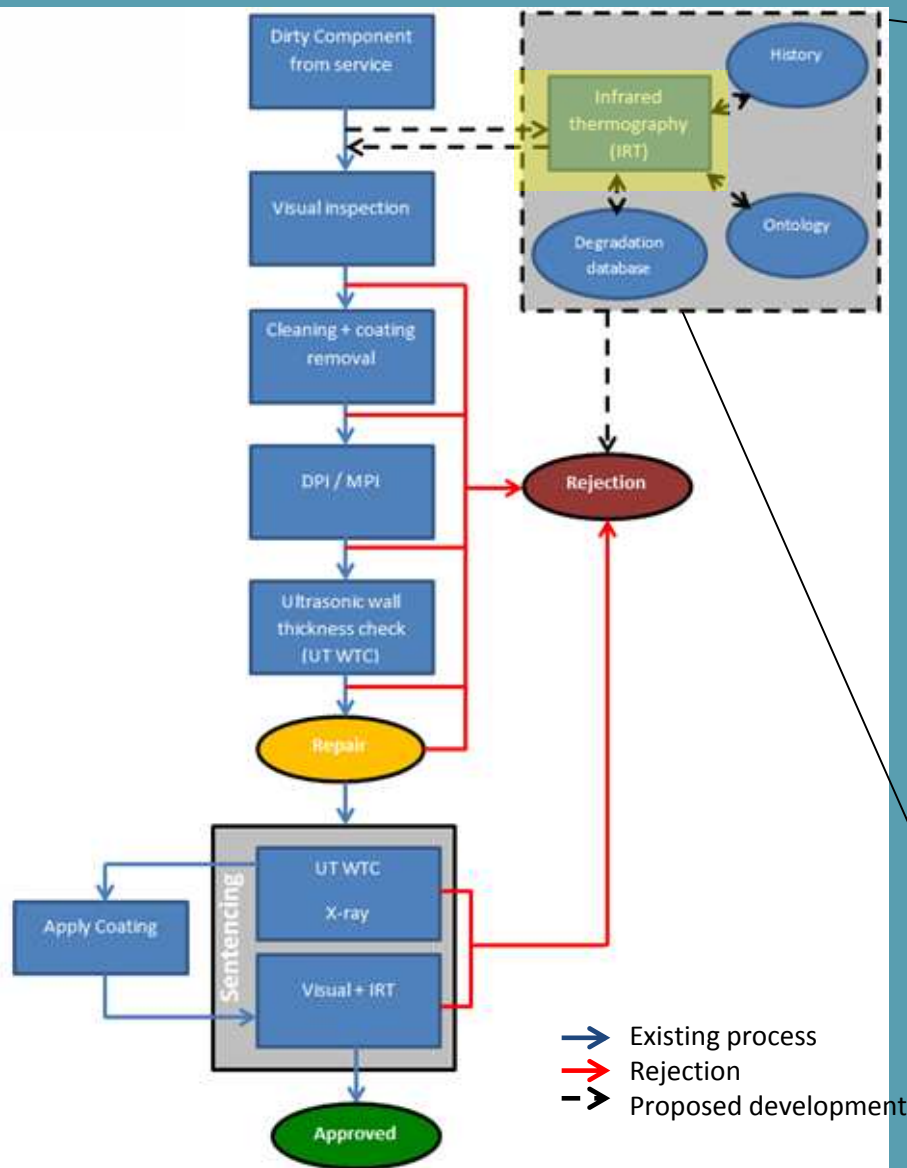
*Maintenance,
Repair and
Overhaul (MRO)*



Examples of experimental research



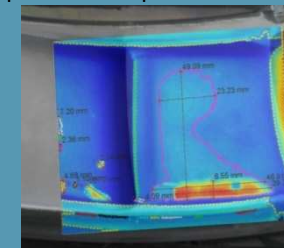
Developments in Thermography inspections



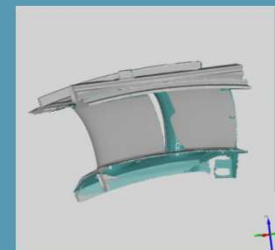
Automated Thermographic NDT Inspection



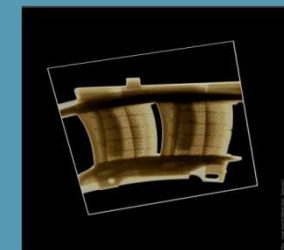
Visual image



IR Image superimposed on digital image – with damage characterisation



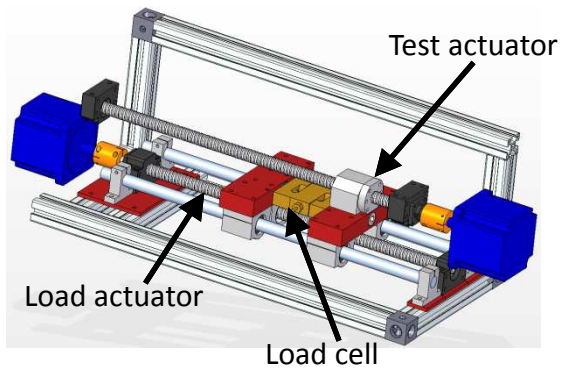
3D Data / Image



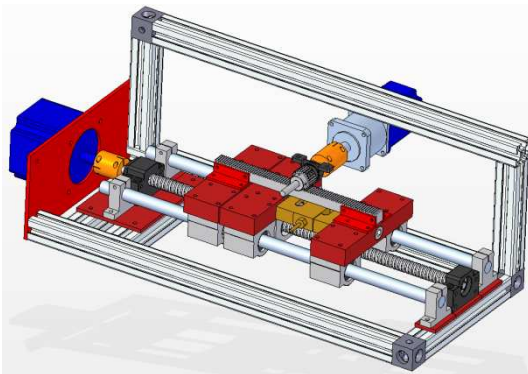
X-Ray CT image

Degradation of Linear Actuators

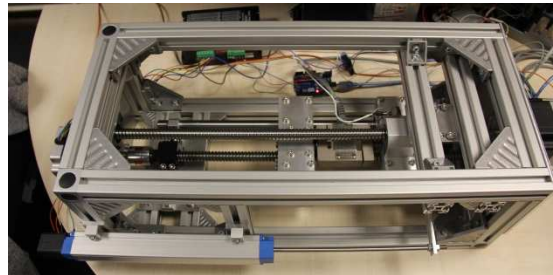
Ball-screw configuration:



Rack and pinion configuration:



Actual Rig:



Main features:

- Up to 120mm stroke
- Variable speed up to 30mm/s
- Variable load up to ± 50 kg
- Ball-screw and rack-and-pinion configurations
- Portable design
- Instrumentation: Position, motor current, vibration and temperature measurements
- Faults to be tested: spalling, wear, jamming, backlash, lack of lubrication, etc.

Damaged balls and gear rack:



Degradation at the System Level: No-Fault-Found (NFF): AFCS Testing



Degradation study of heat exchangers using thermography



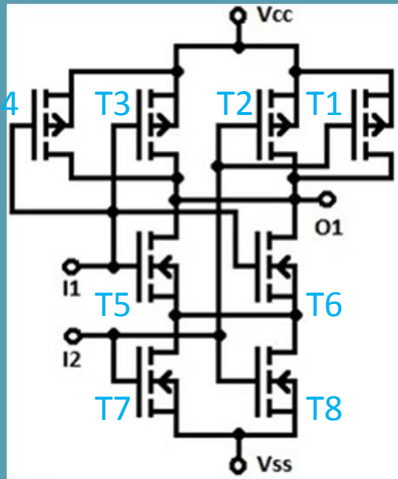
The heat exchanger life testing rig at the centre laboratory

Test rig novelty: the heat exchange process is introduced into an environment chamber capable of cycling between -40C to 120C to simulate service environmental conditions

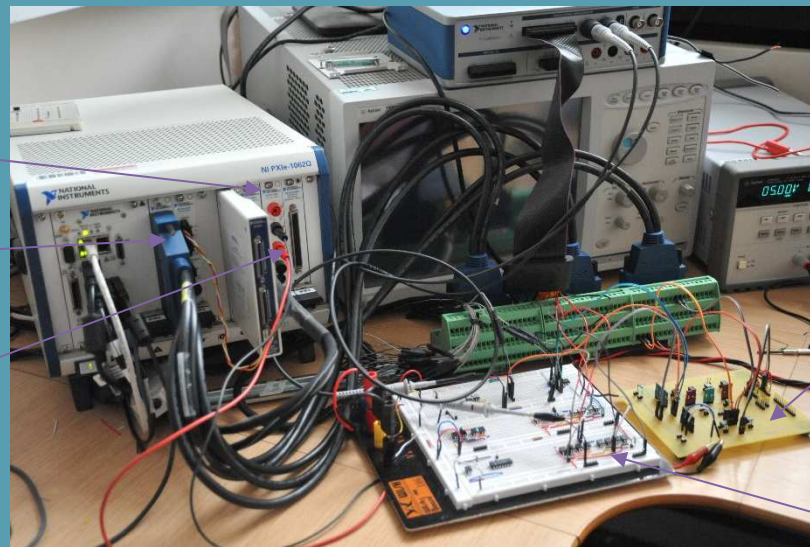
Initial outcomes:

- Initial failure analysis of most common degradations and their causal mechanisms performed based on public literature and industry interviews
- Identified thermal cycling as major cause of failure.
- **Construction of a test rig to carry out life analysis of air-to-air heat exchanger**

A fault injection rig



SAH Fault location	Input	Output	Current (mA)	Input	Output	Current (mA)	Input	Output	Current (mA)	Input	Output	Current (mA)
T1	'00'	H	0	'01'	H	0	'10'	H	0	'11'	H	59
T2	'00'	H	0	'01'	H	0	'10'	H	0	'11'	H	59
T3	'00'	H	0	'01'	H	0	'10'	H	0	'11'	H	59
T4	'00'	H	0	'01'	H	0	'10'	H	0	'11'	H	59
T5	'00'	H	0	'01'	H	0	'10'	L	43	'11'	L	0
T6	'00'	H	0	'01'	H	0	'10'	L	43	'11'	L	0
T7	'00'	H	0	'01'	L	49	'10'	H	0	'11'	L	0
T8	'00'	H	0	'01'	L	49	'10'	H	0	'11'	L	0



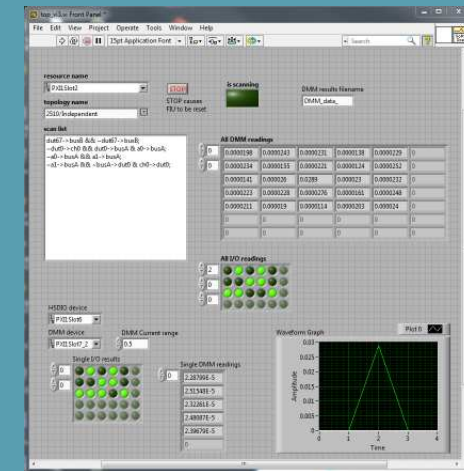
HSIO (digital)

FIU

DMM (analogue)

DUT

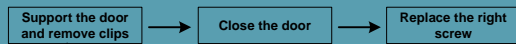
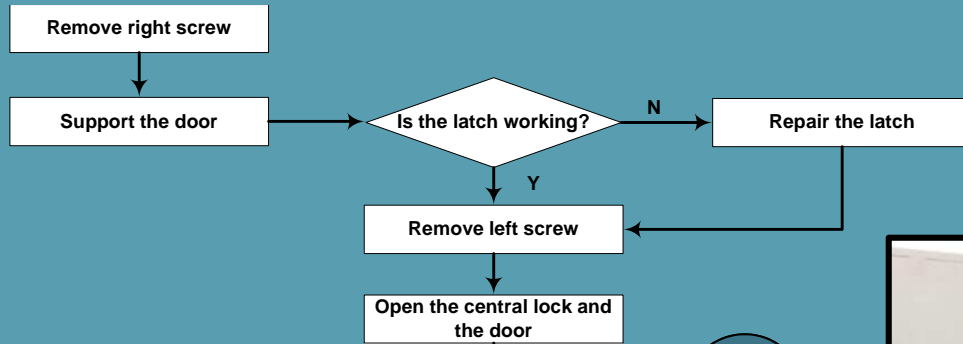
Reference circuits



Train Skirt Maintenance Example



1



- Search for the door
- Find the door
- Grasp the door

Force + Friction | Geometric Constraint | Suction | Magnetic Attraction
 Strength | Duration

2



3



(1)

(2)

(3)

(4)



Operations Excellence Institute

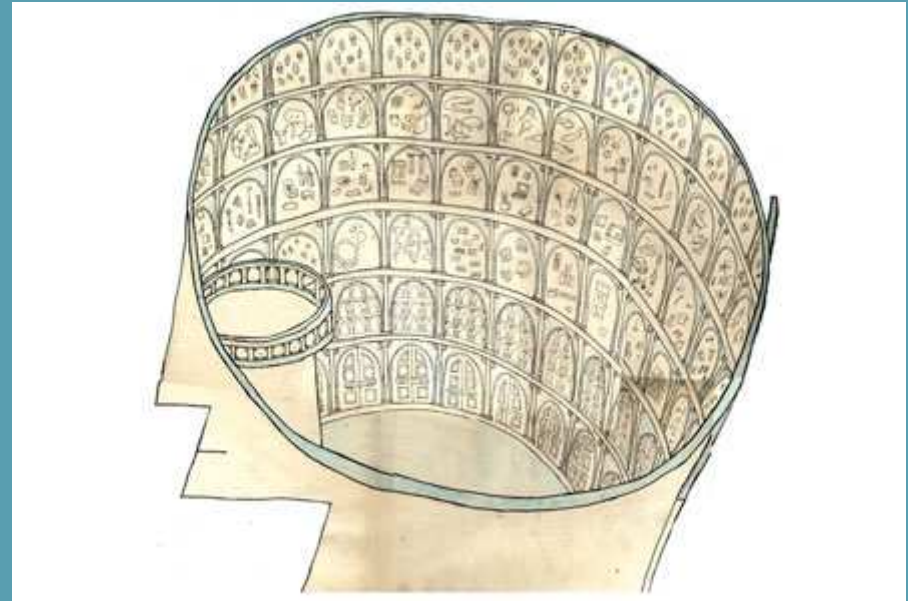


Through-life Operations
Simulation Lab – **Centre of
Excellence for Augmented
Reality – Maintenance Training**

**Blended learning to extend the
Through-life System
Sustainment MSc**

“Mind Palace” – Visualization and Data Analytics for Through- life Engineering

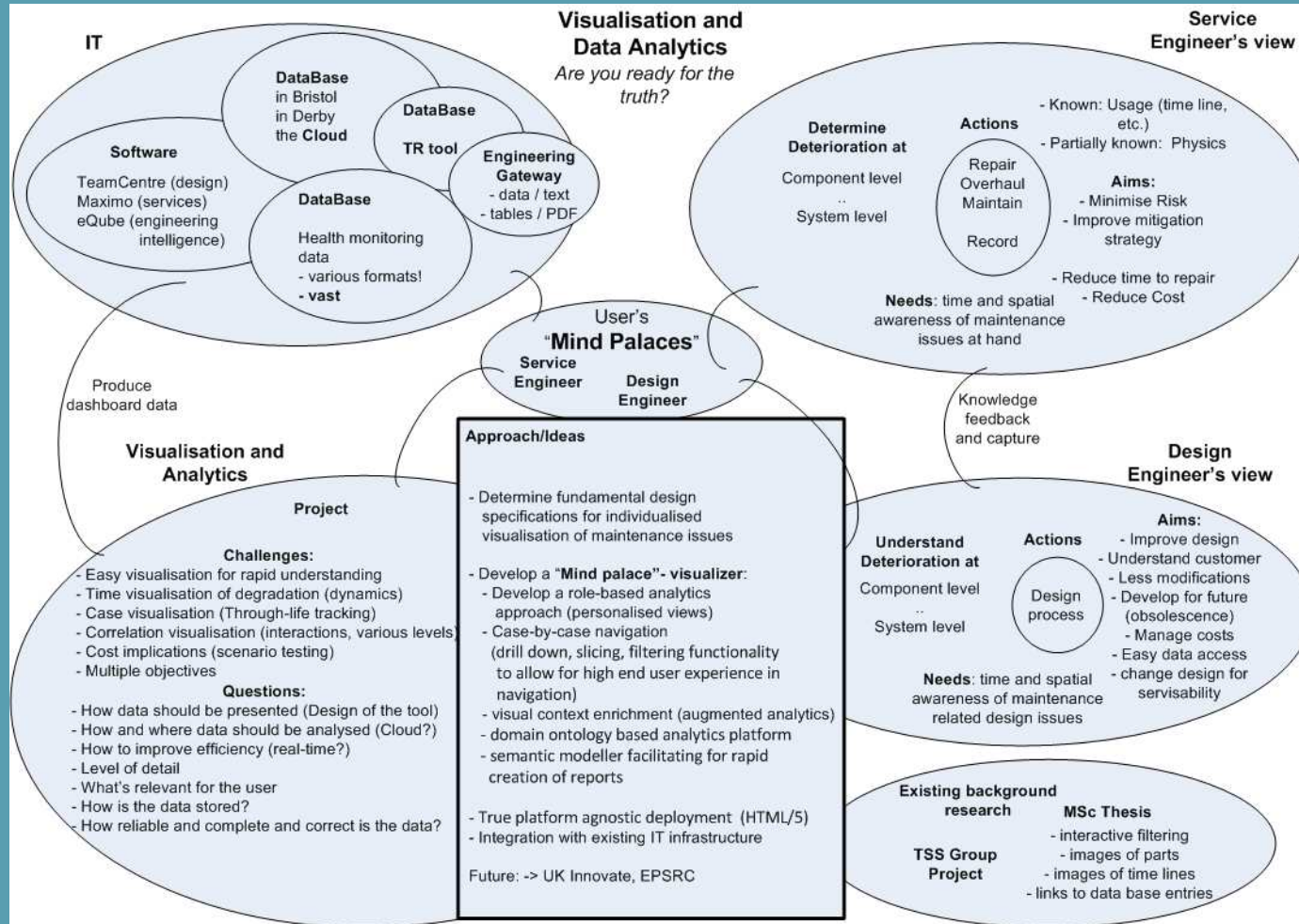
New EPSRC-TES Centre project



cr4.globalspec.com

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“Mind Palace” – future research direction



IoT Lab - TES applications

Remote maintenance

- Performance monitoring
- Predictions and warnings
- Visualisation
- Cost assessment
- Active repair



Process automation

Supply chain based spare parts planning

Flexible integration of various services (use and offer)

Embrace Industry 4.0



TES National Strategy Development

10th Sept 2015



TES National Strategy – Industry leadership

Rolls-Royce and HVM Catapult to co-chair



Concluding remarks

- **UK could further develop the TES market share through R&D capability and IP development**
- **We need both OEMs offering TES and multi-platform TES providers**
- **TES supply chain needs significant development: risks should be shared**
- **UK National Strategy for TES industries is timely and necessary**

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