Industrious Neutrons

ISIS Collaborative Research and Development Scheme



Christopher Frost
ISIS Facility, Rutherford Appleton Laboratory, UK

ISIS Collaborative Research and Development Scheme



Industrial access scheme…

…why have one?

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Industrial company approaches ISIS with a problem that neutrons (and/or X-rays) can help solve…

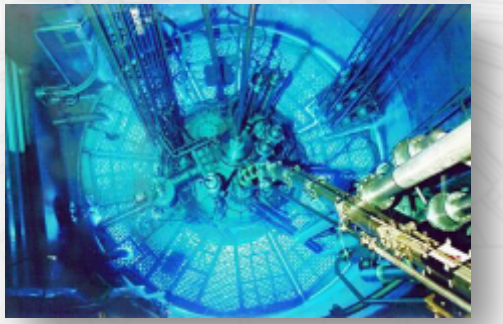
…UK has invested in Large Facilities over many years



Scientific & Technical

Facility Neutrons or X-rays







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ISIS

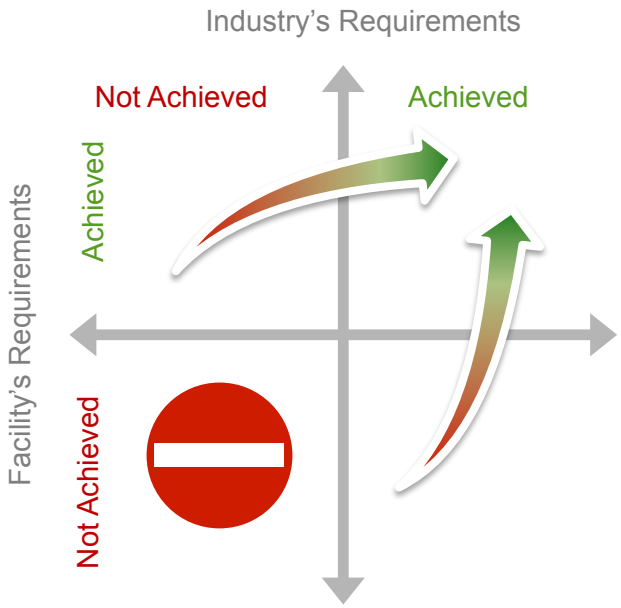
How do we work with Industrial companies to provide access to these facilities?







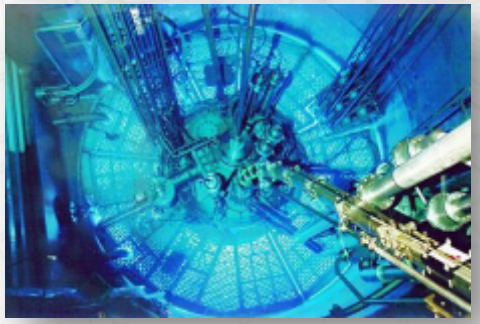
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Access

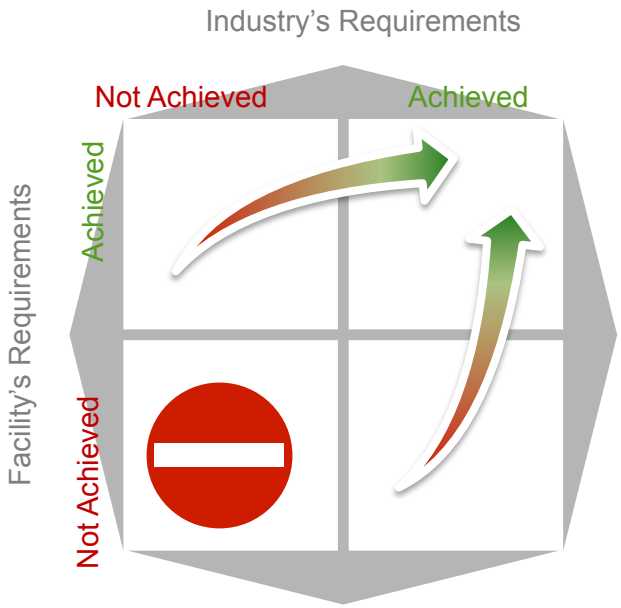
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Leading Edge vs Established

Esoteric & Unique

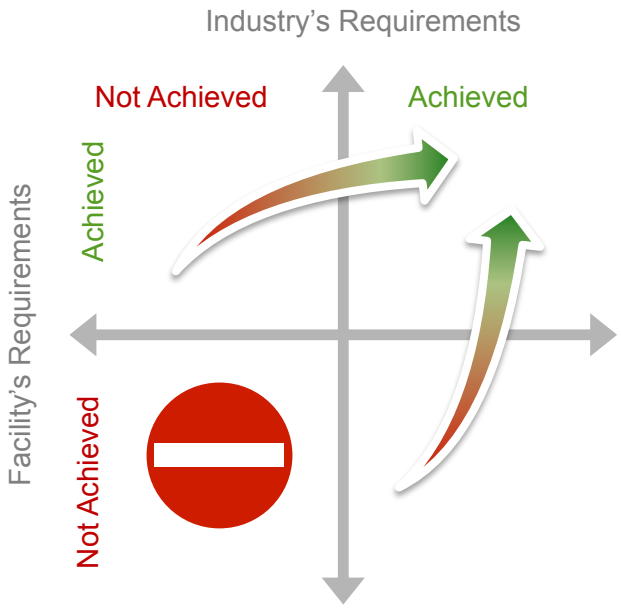
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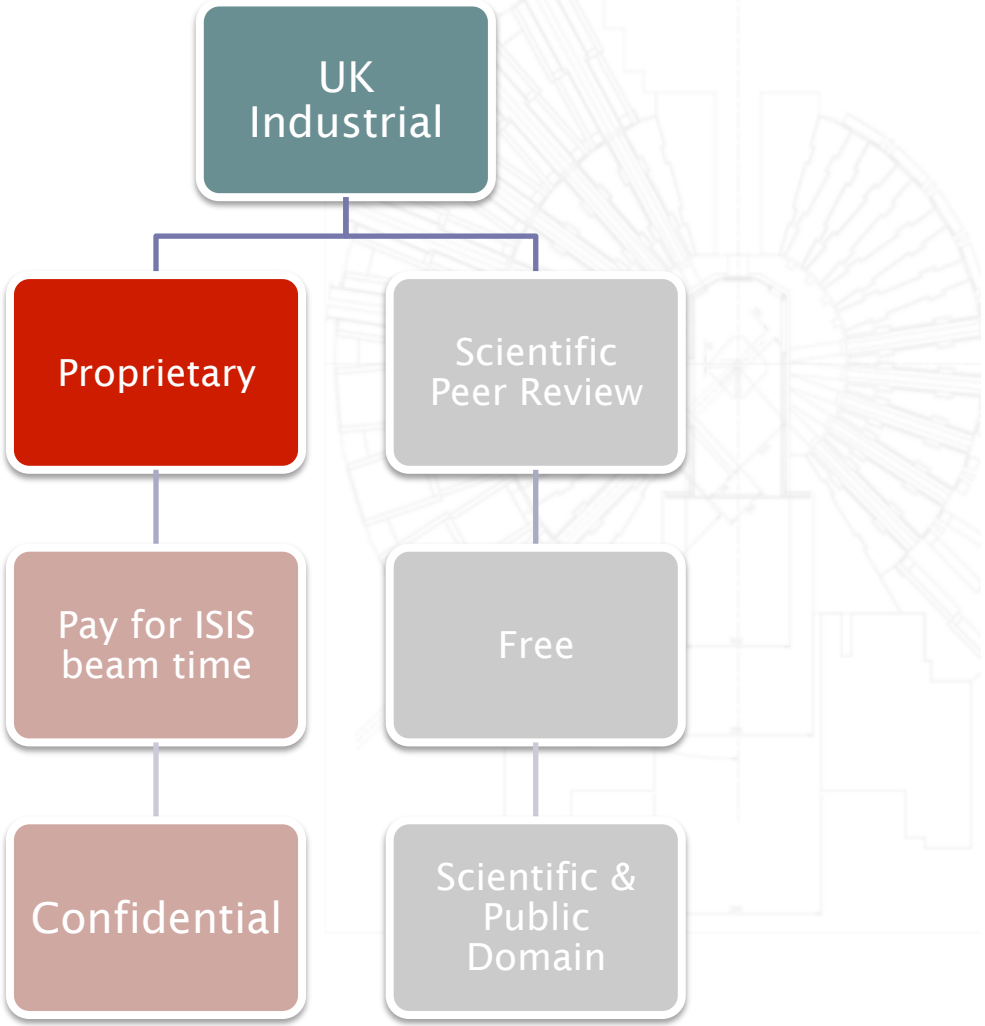
Public vs Proprietary

Offsite vs Onsite

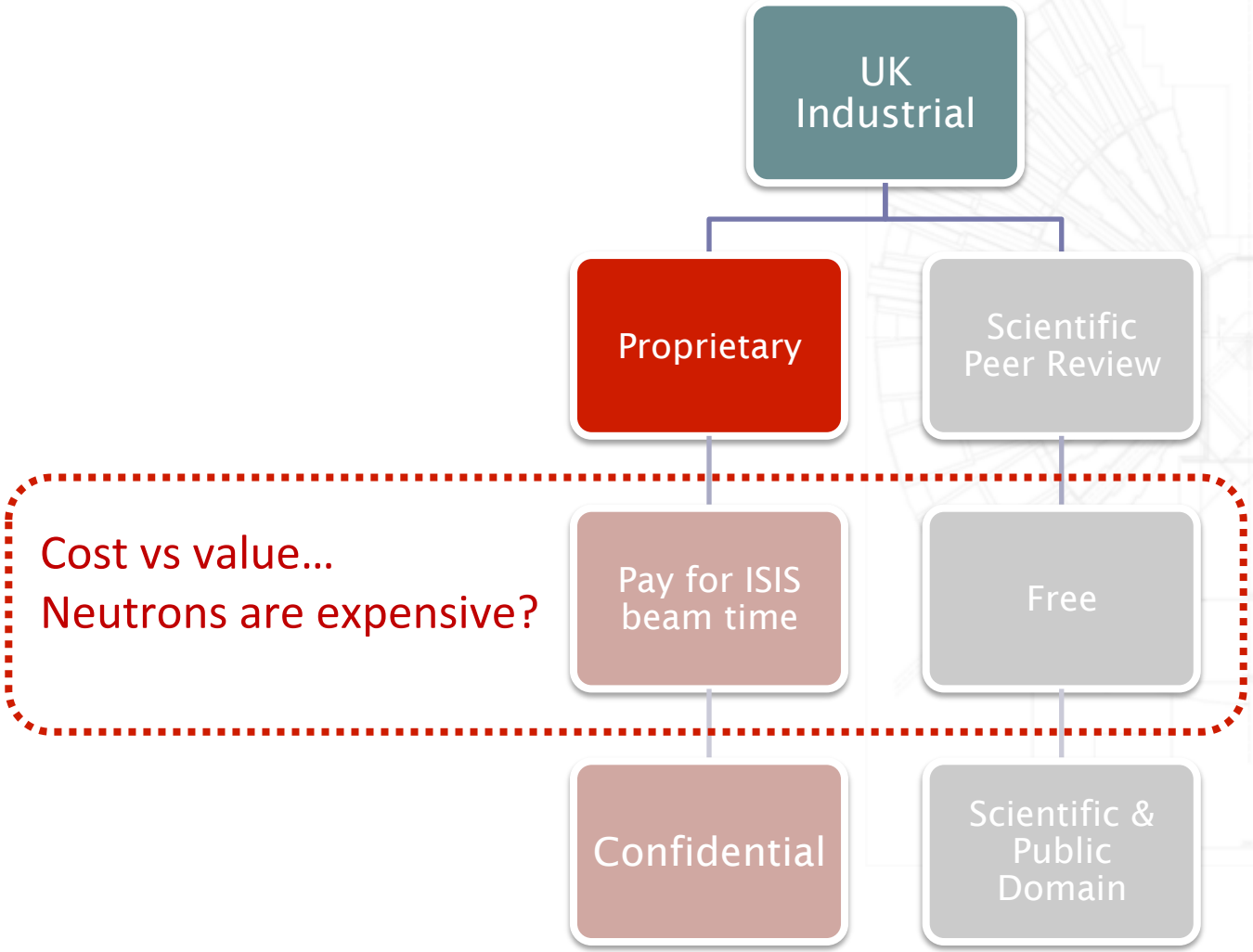
Cost vs Value

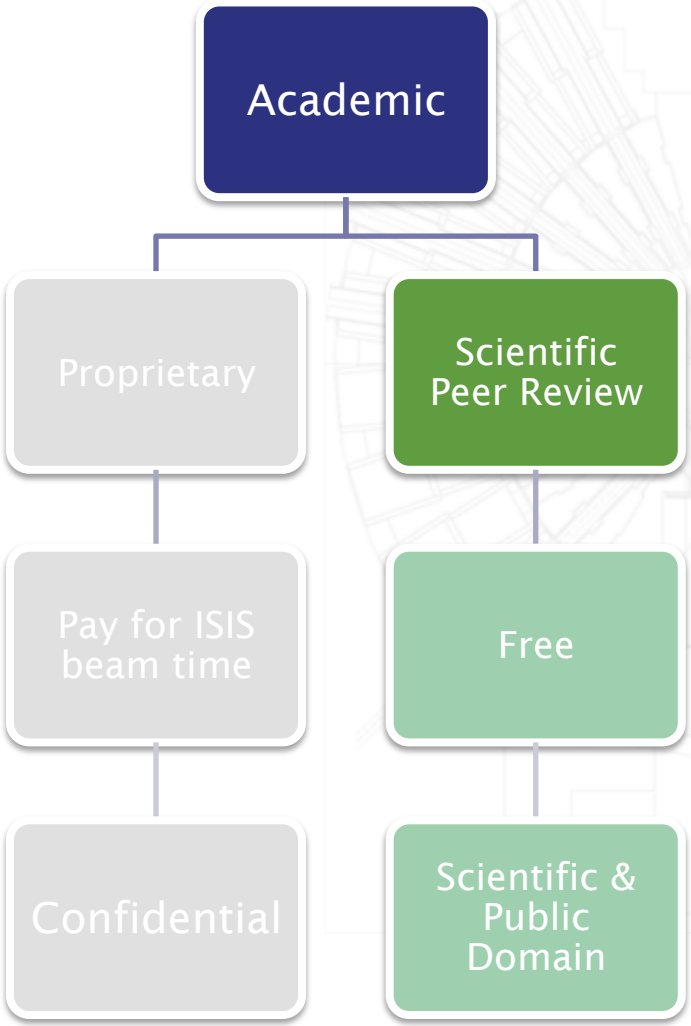
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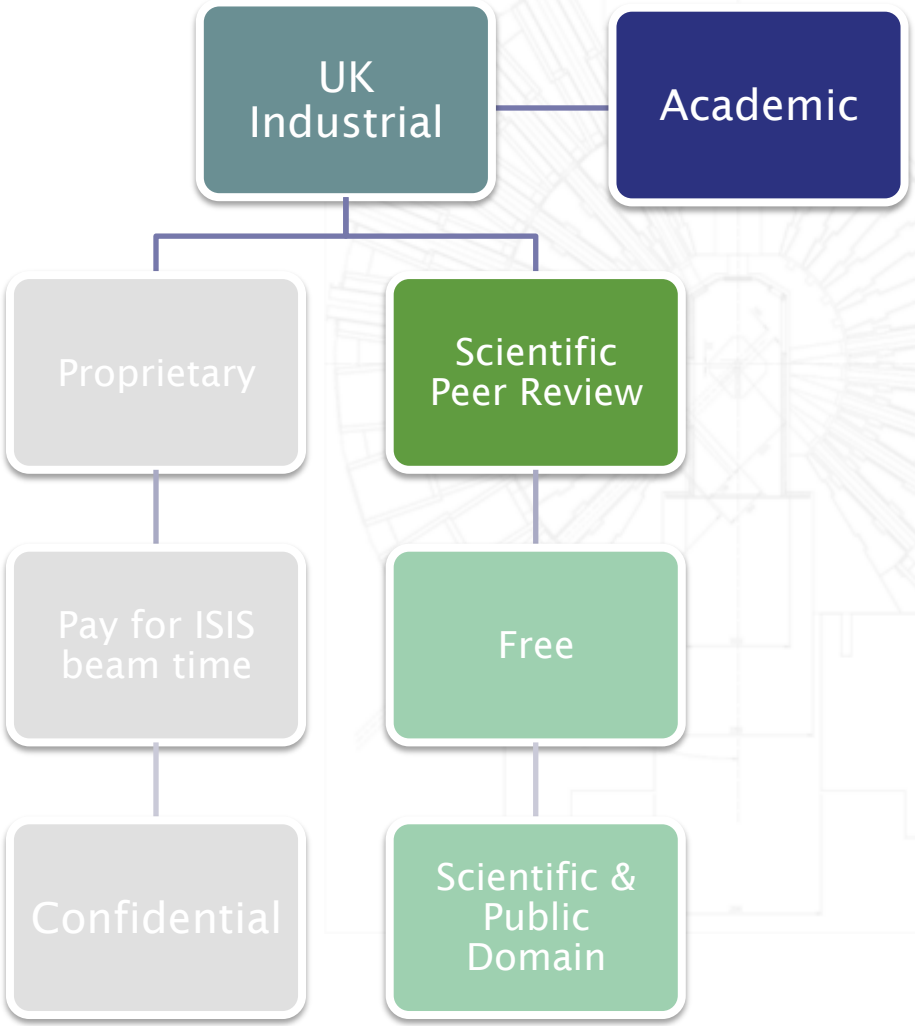


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UK Industrial
Proprietary
Scientific Peer Review
Cost vs value…
Neutrons are expensive?
Pay for ISIS beam time
Free
Confidential
Scientific & Public Domain



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Spectroscopy

MAPS
LET
MARI
MERLIN
HET

Molecular Spectroscopy

IRIS
OSIRIS
TOSCA
VESUVIO

Engineering

ENGIN-X

Large Scale Structures

SANS2D
OFFSPEC
POLREF
INTER
CRISP
SURF
LOQ

Diffraction

HRPD
SXD
POLARIS
GEM
WISH
PEARL
INES

15%

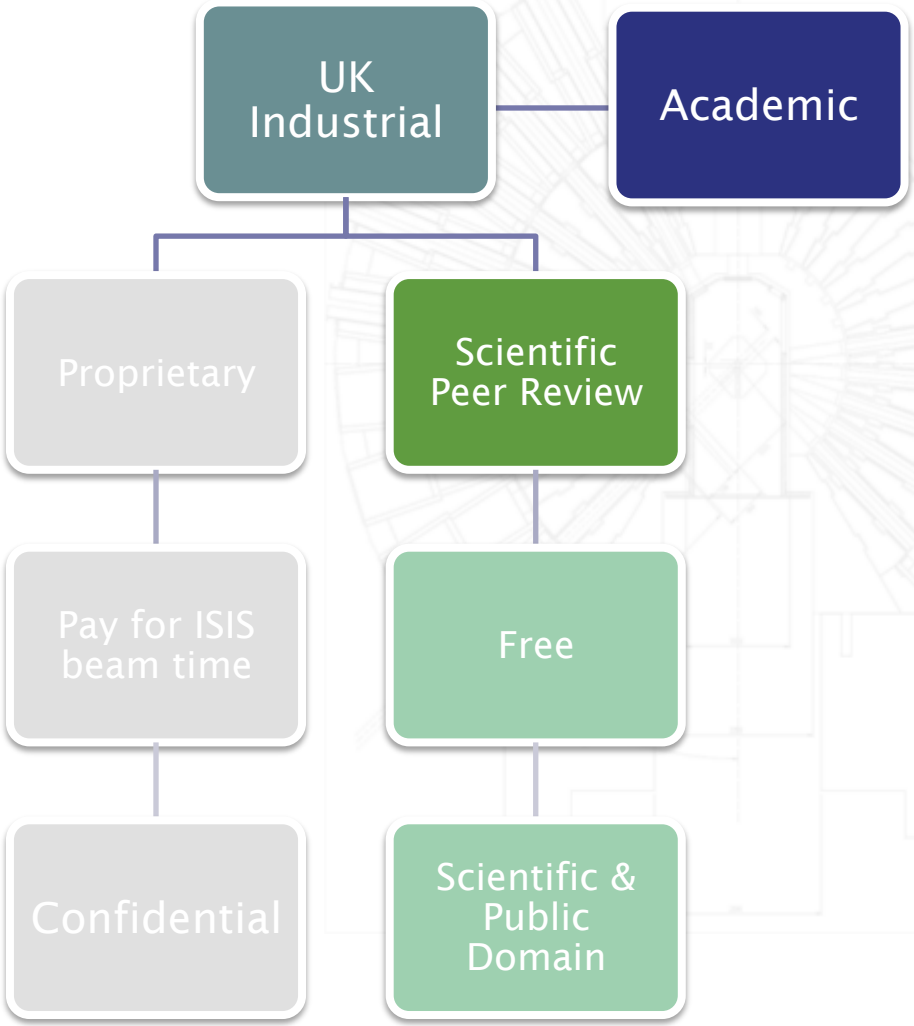
Peer-Review

Disordered Materials

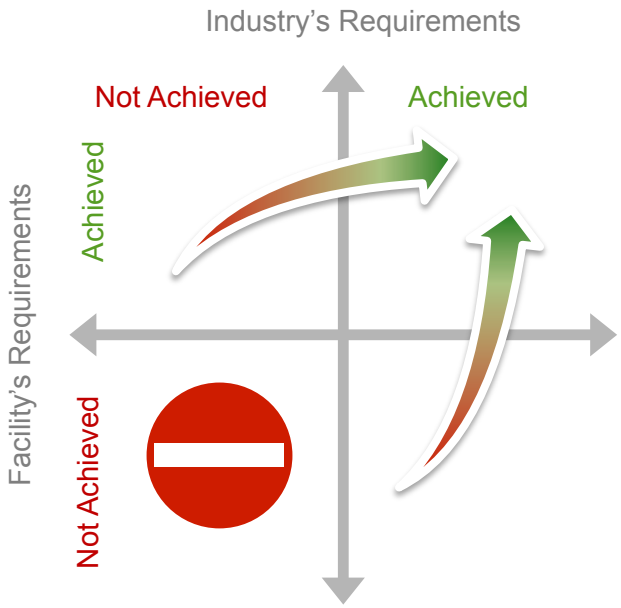
SANDALS
NIMROD

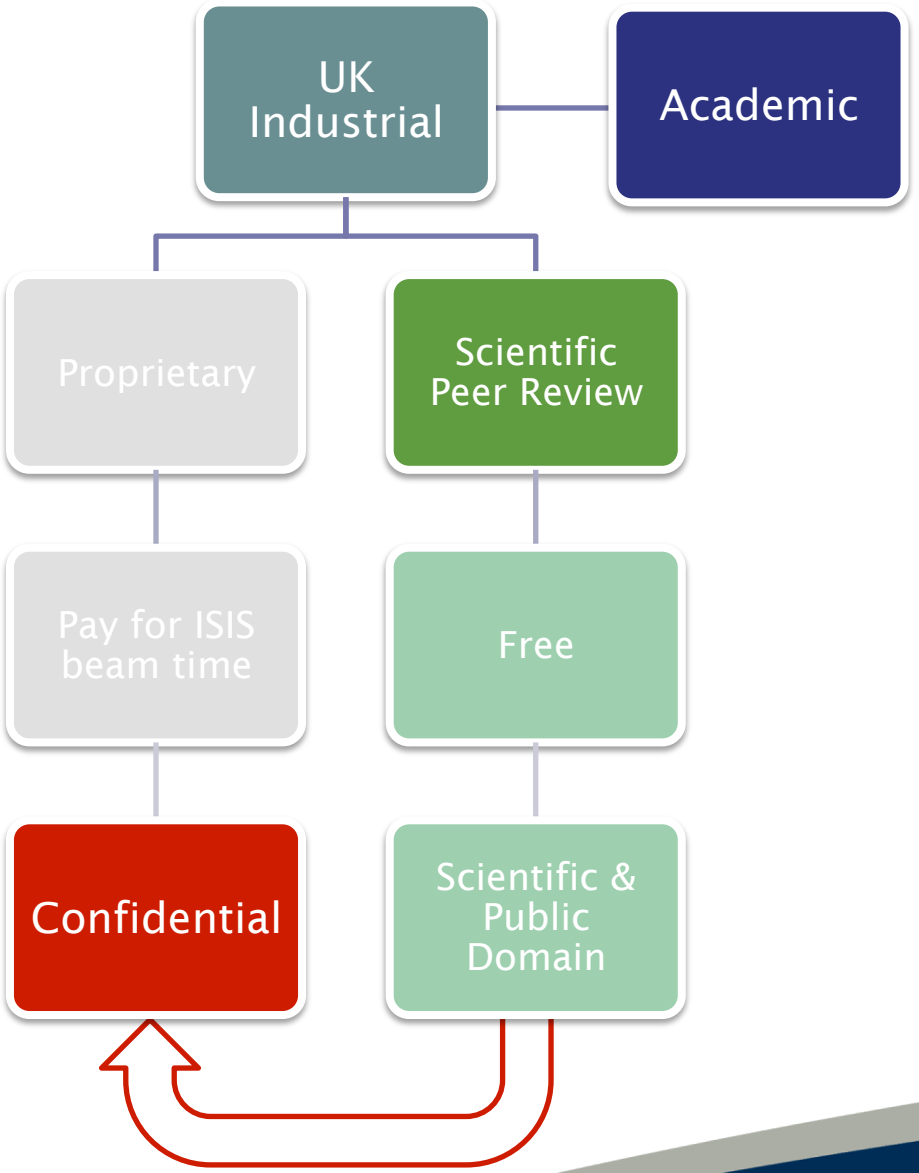
Muons

EMU
MuSR
HIFI
ARGUS

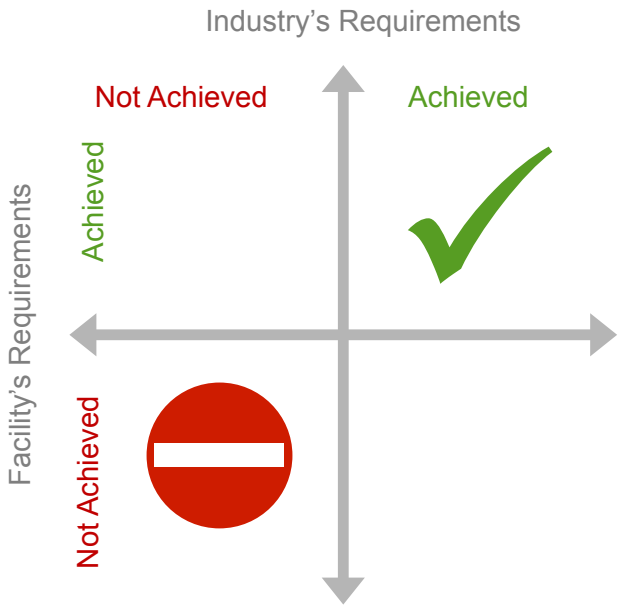


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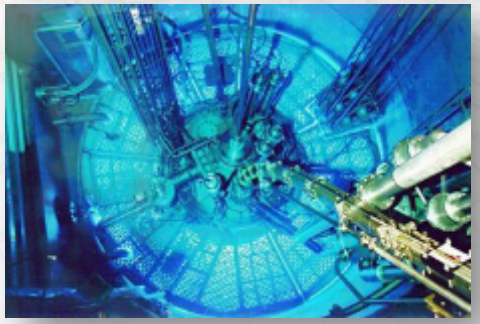
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Industrial Access

Scientific & Technical





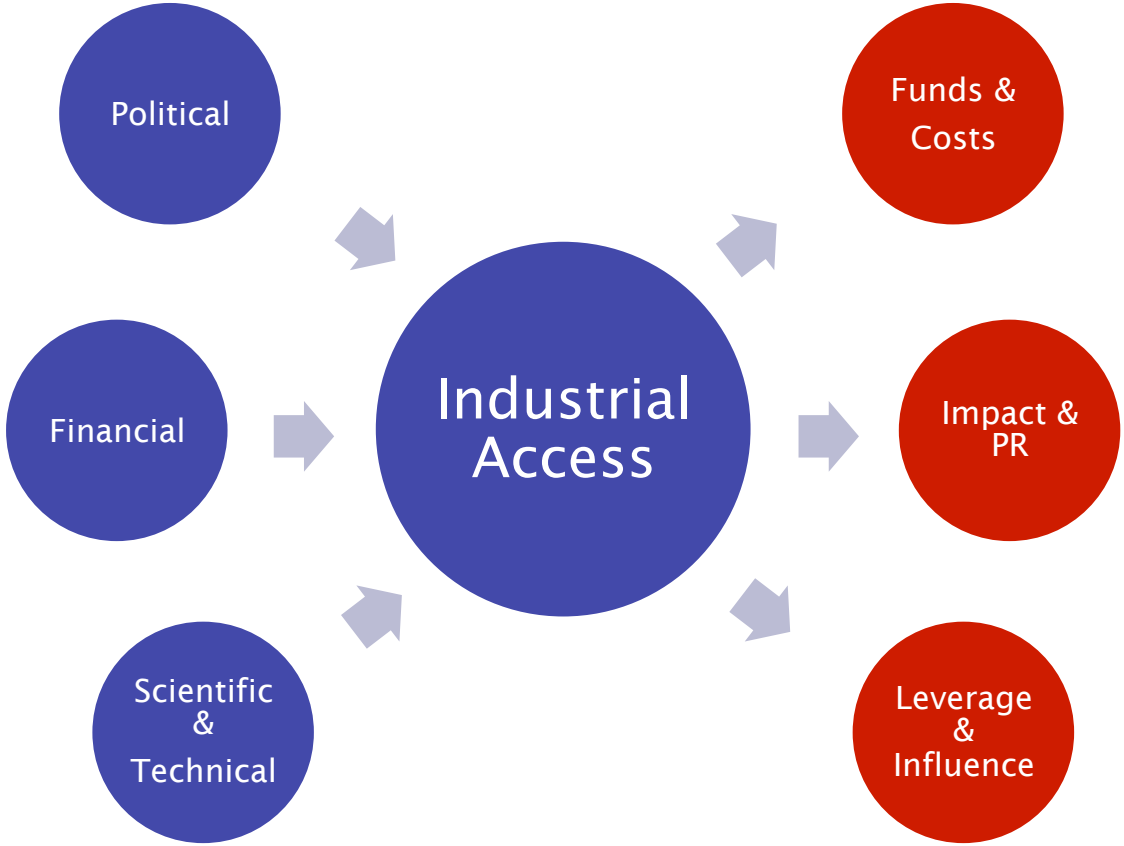


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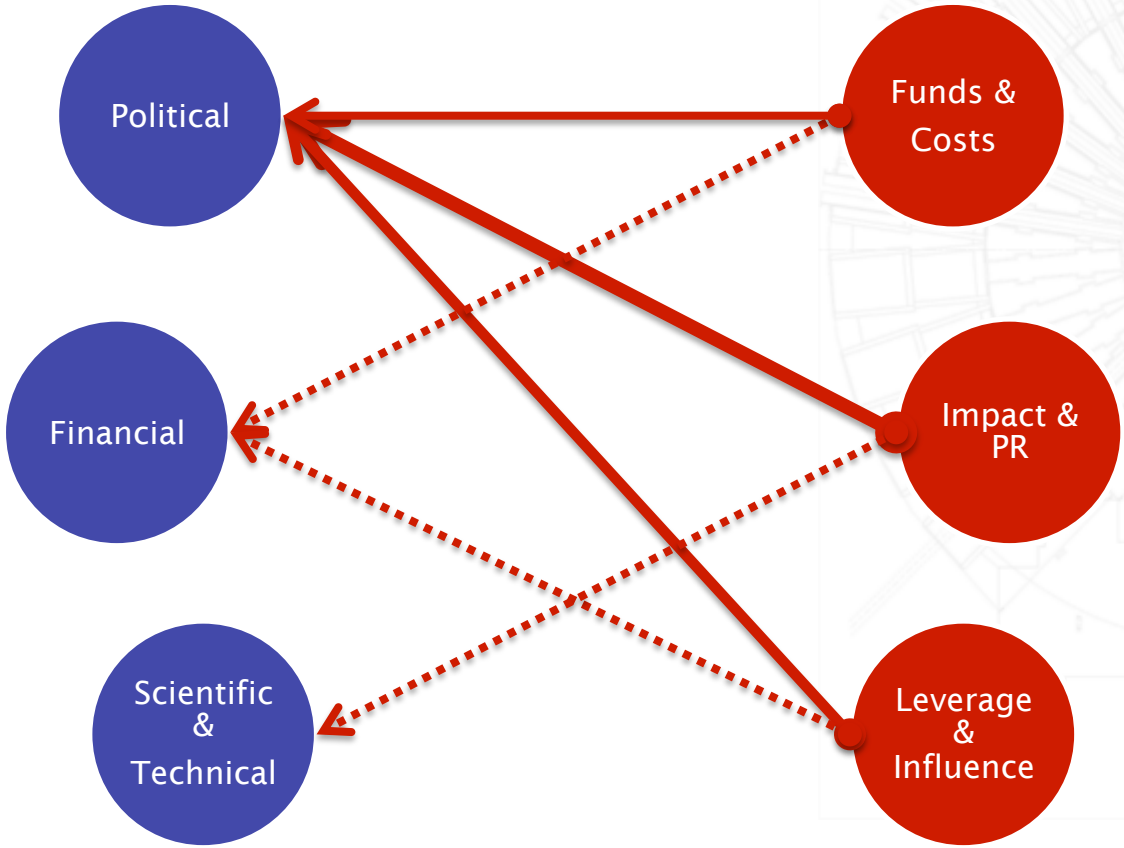


Drivers

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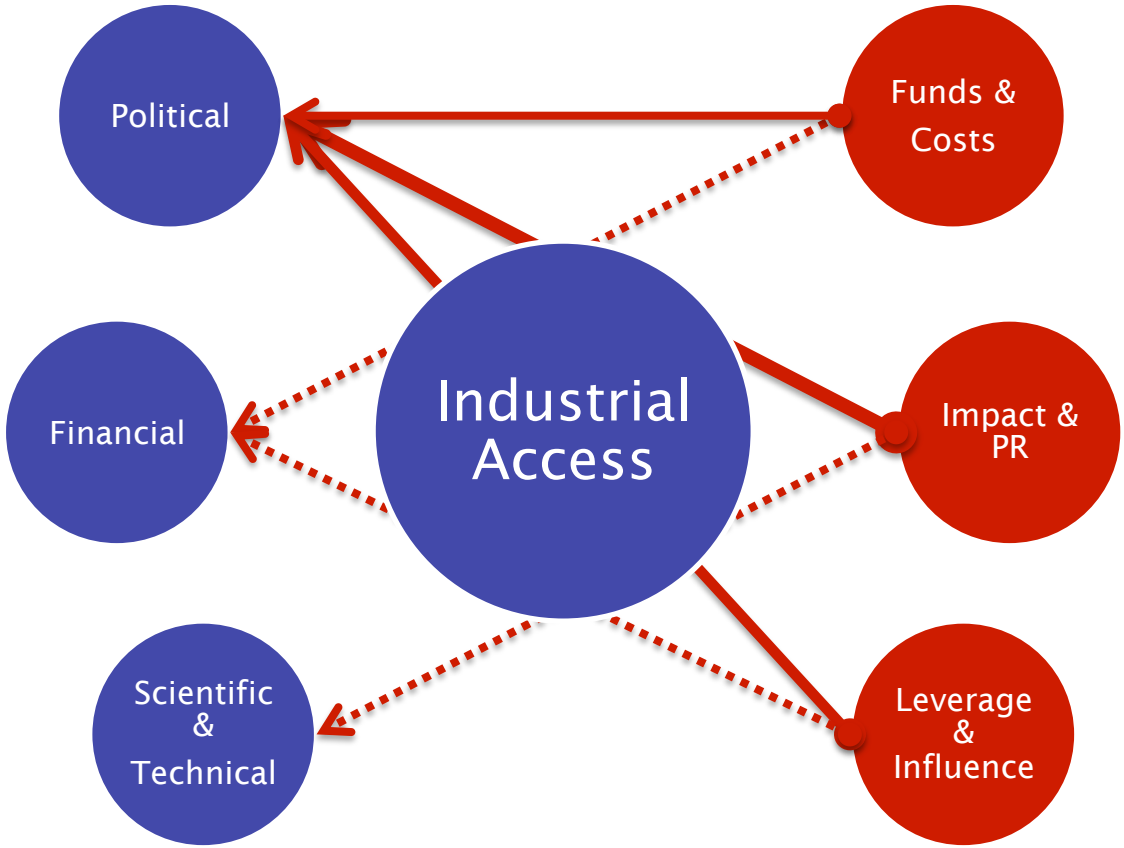
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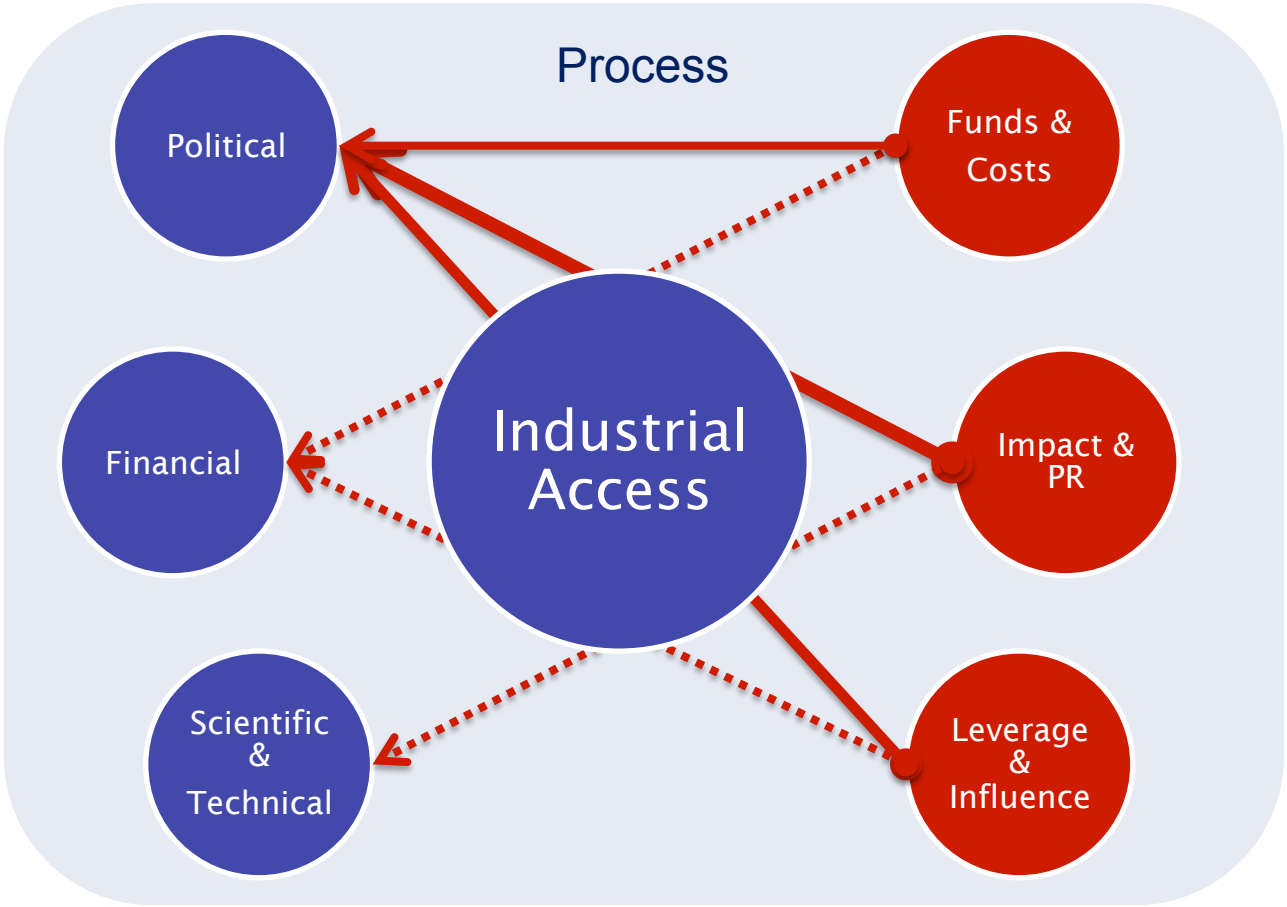


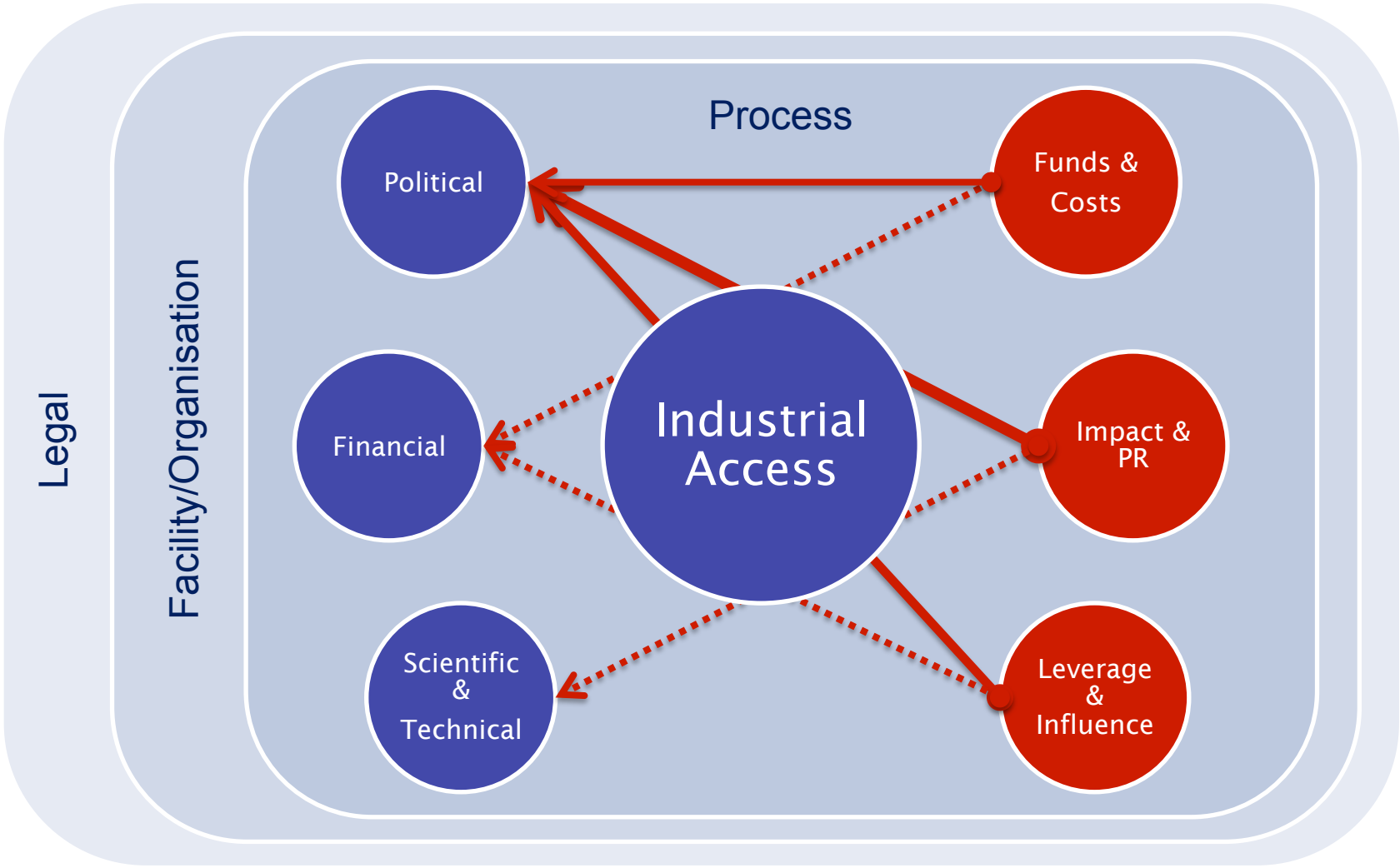
Drivers

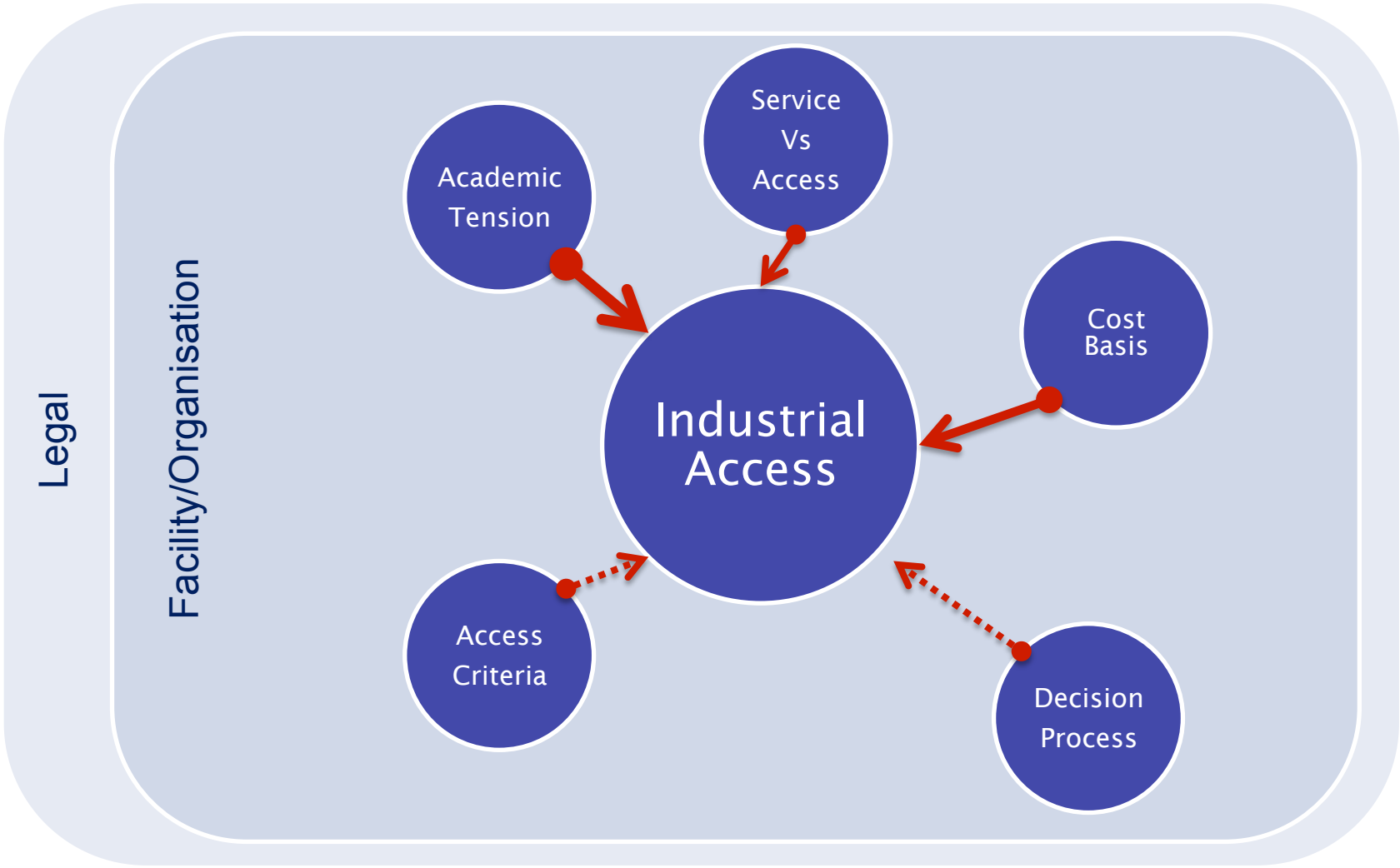
Outcomes

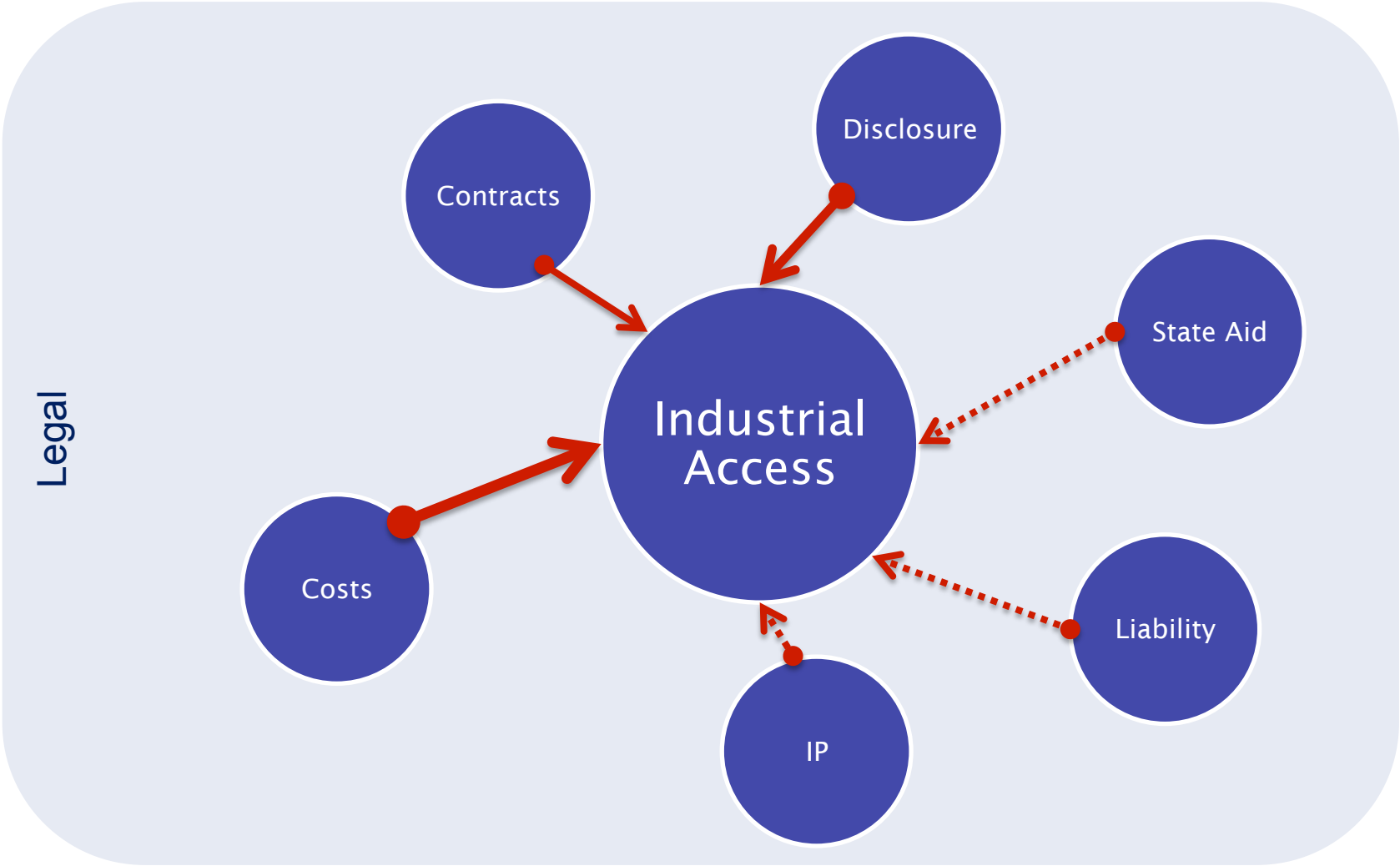
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Political
Funds & Costs
Financial
Industrial Access
Impact & PR
Scientific & Technical
Leverage & Influence


Process
Political
Funds & Costs
Financial
Industrial Access
Impact & PR
Scientific & Technical
Leverage & Influence


Legal
Facility/Organisation
Process
Political
Funds & Costs
Financial
Industrial Access
Impact & PR
Scientific & Technical
Leverage & Influence


Legal
Facility/Organisation
Academic Tension
Service Vs Access
Cost Basis
Industrial Access
Access Criteria
Decision Process


Legal
Contracts
Disclosure
State Aid
Industrial Access
Costs
Liability
IP

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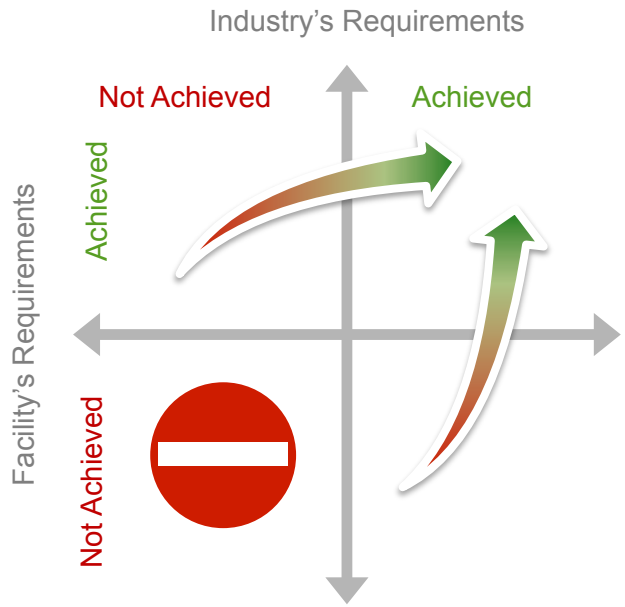
ISIS Collaborative Research and Development Scheme

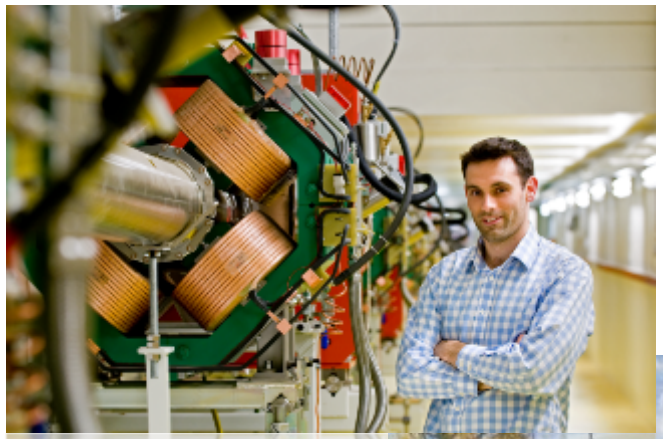


Remit:-

- Focus on delivering economic impact
- Build long-term partnerships with industry
- Engage with diverse industrial base

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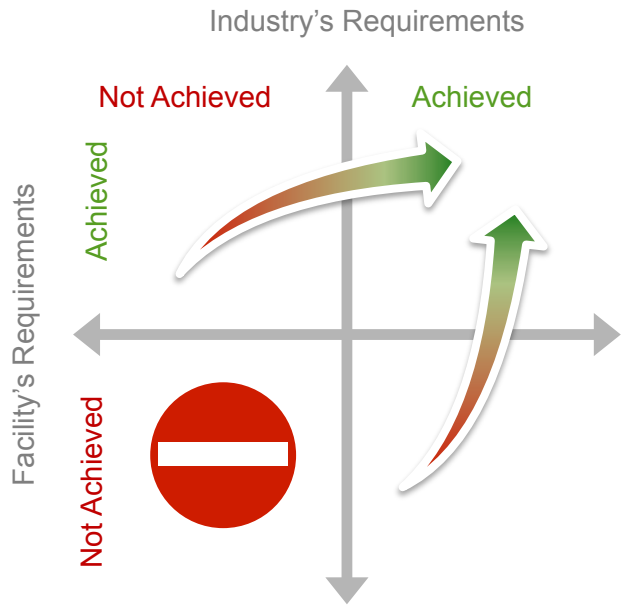




New access mechanism's objectives:-

- Demonstrate the economic impact of neutrons to key stakeholders
- Widen and progress industrial use of ISIS

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New access mechanism should:-

- Allow industry to asses the value of neutrons for their business
- Use economic impact as an major assessment criteria
- Build-in impact reporting

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UK Industrial

Academic

ICRD Route

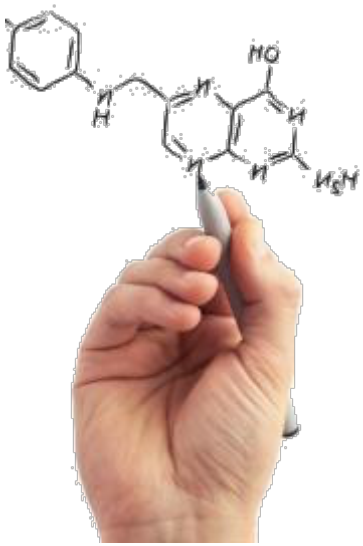
Scientific Peer Review

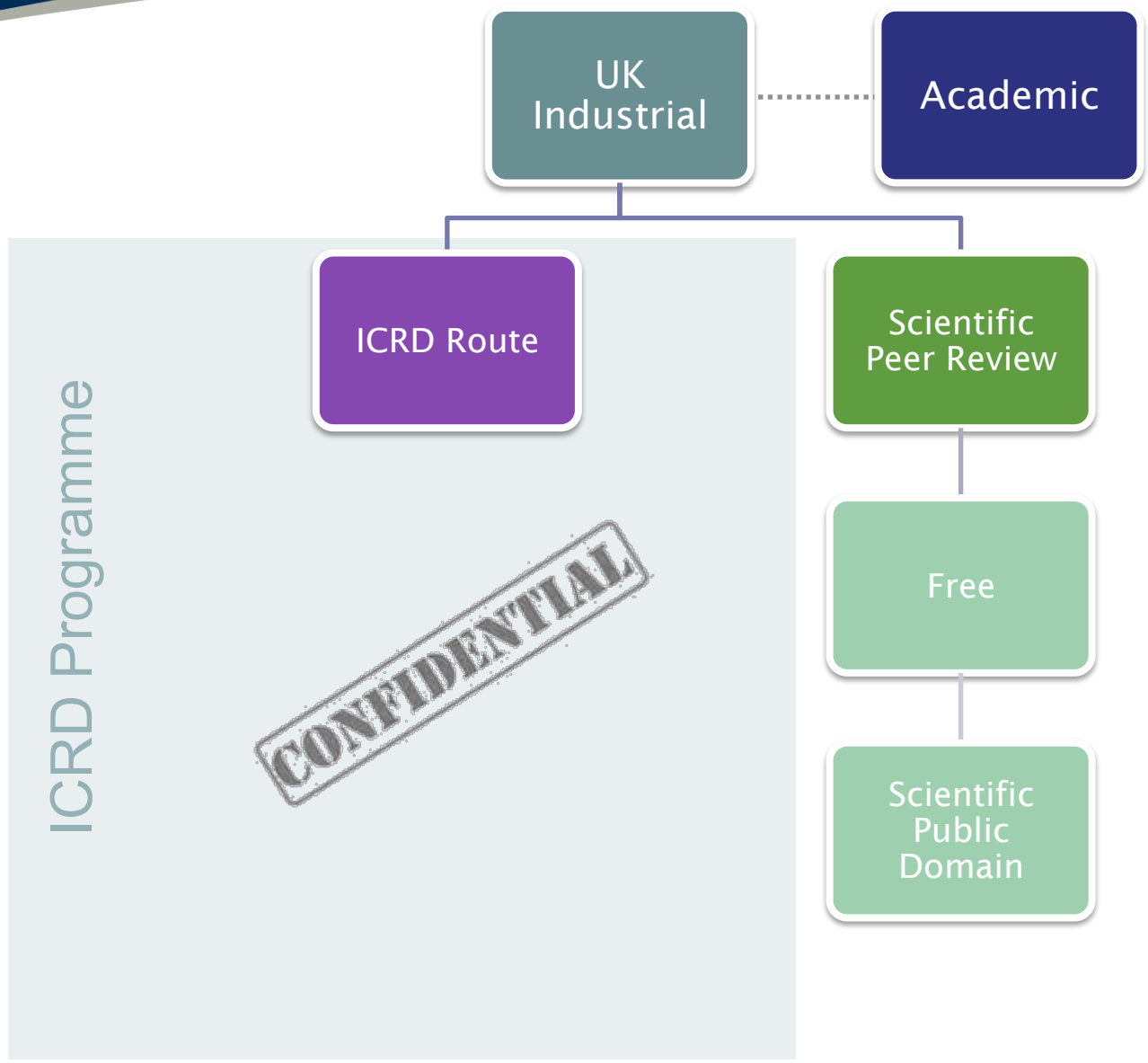
Free

Scientific Public Domain

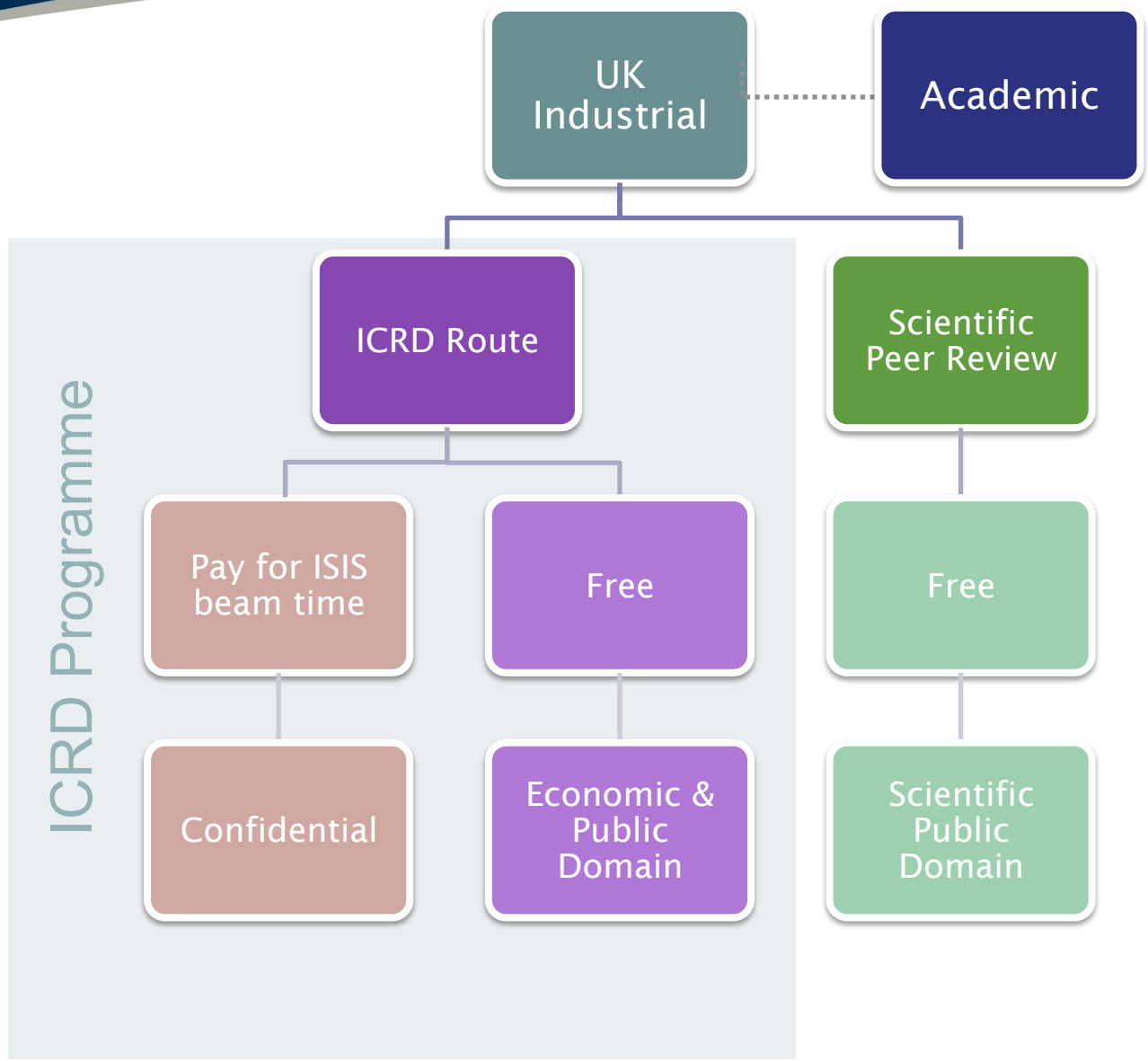
ICRD Programme



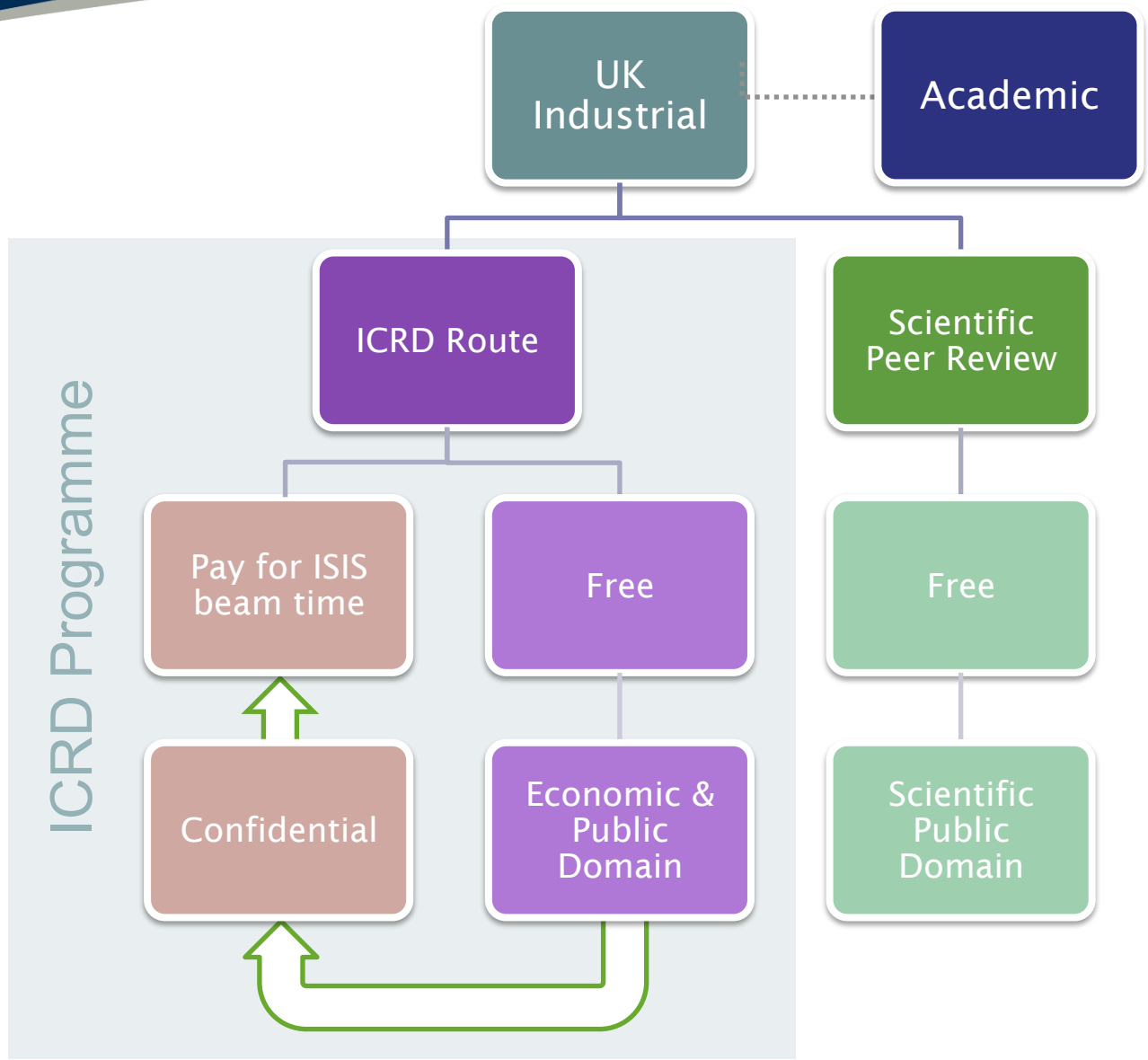



UK Industrial
Academic
ICRD Route
Scientific Peer Review
ICRD Programme
CONFIDENTIAL
Free
Scientific Public Domain

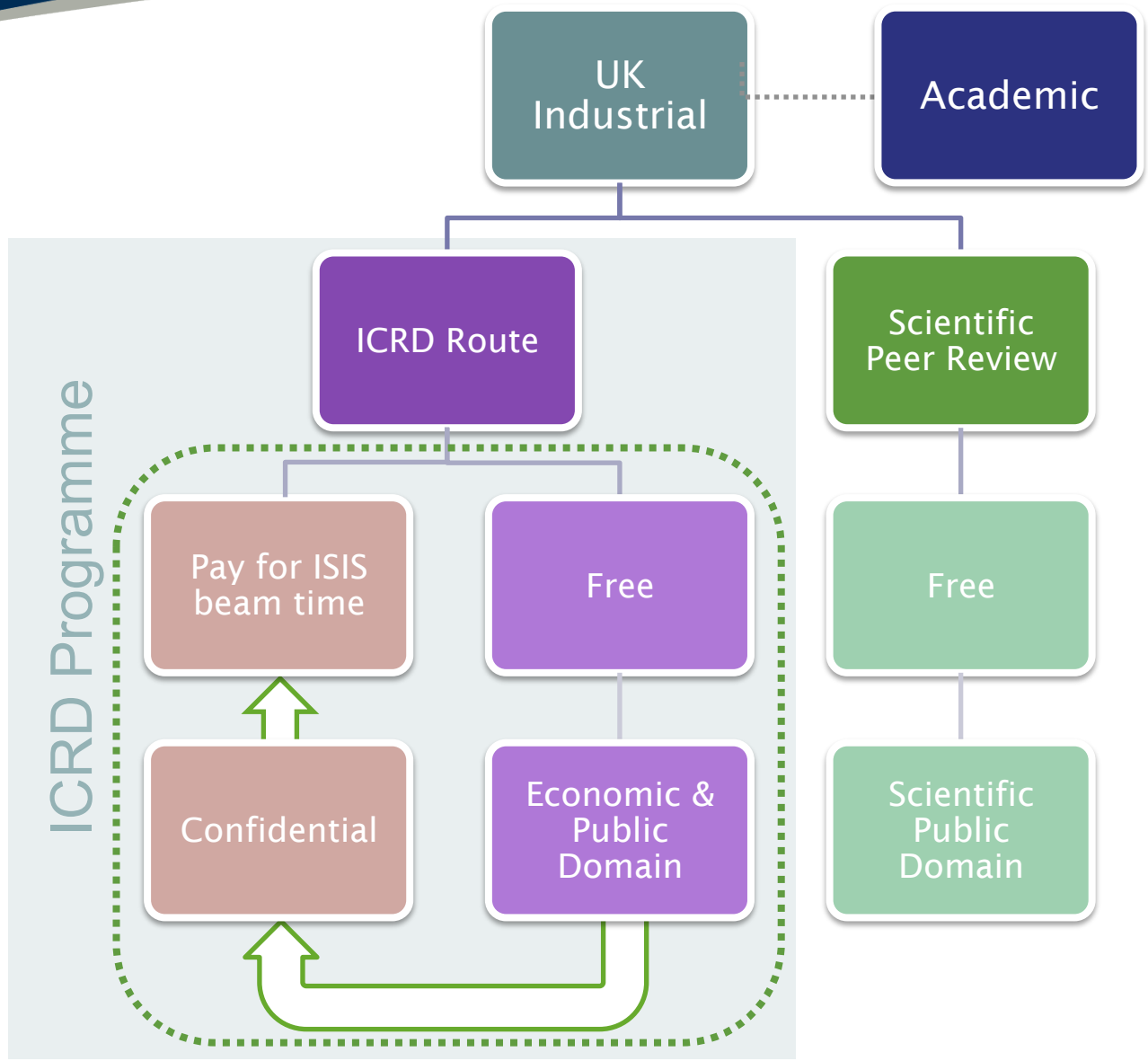
Science & Technology Facilities Council
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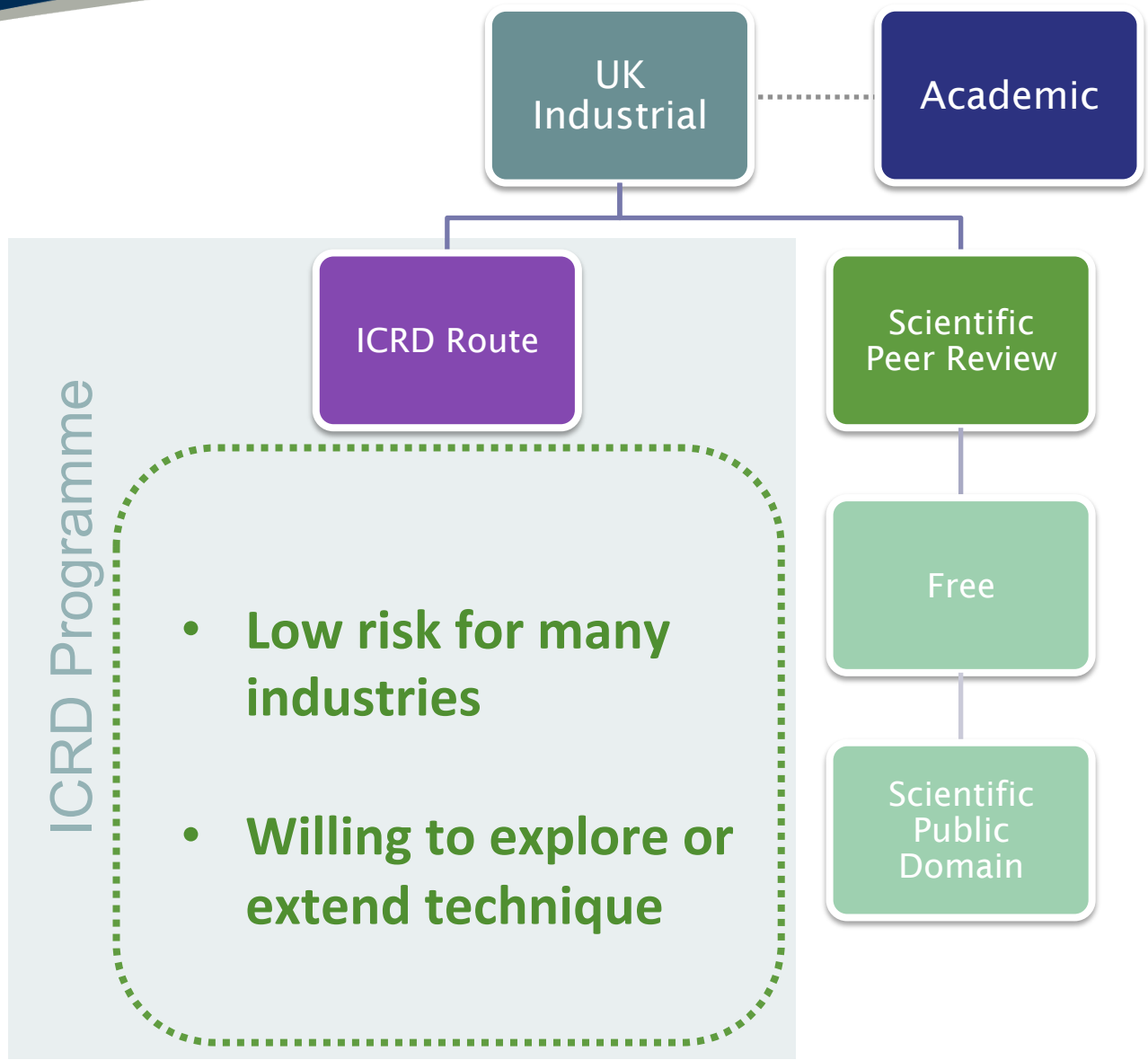
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Economic Impact is the main assessment criteria

ICRD Programme



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Confidentiality intrinsic to process

ICRD Programme

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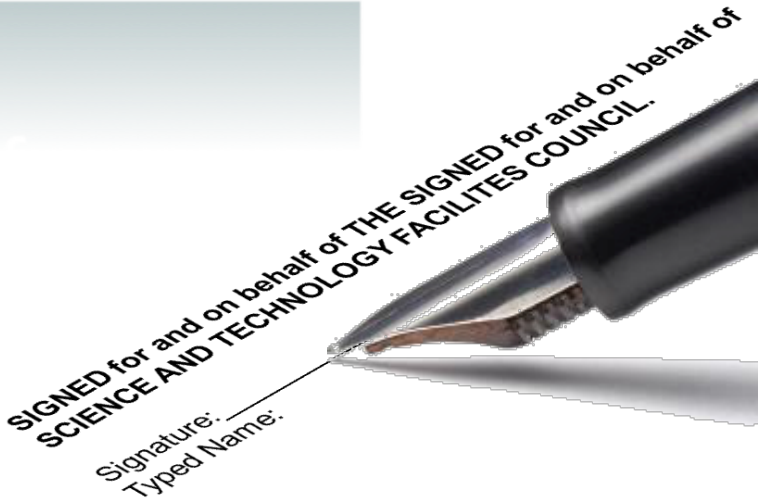
Beam-time is free at point of access through collaboration agreement

ICRD Programme

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Option to buy data confidentiality after the experiment

ICRD Programme



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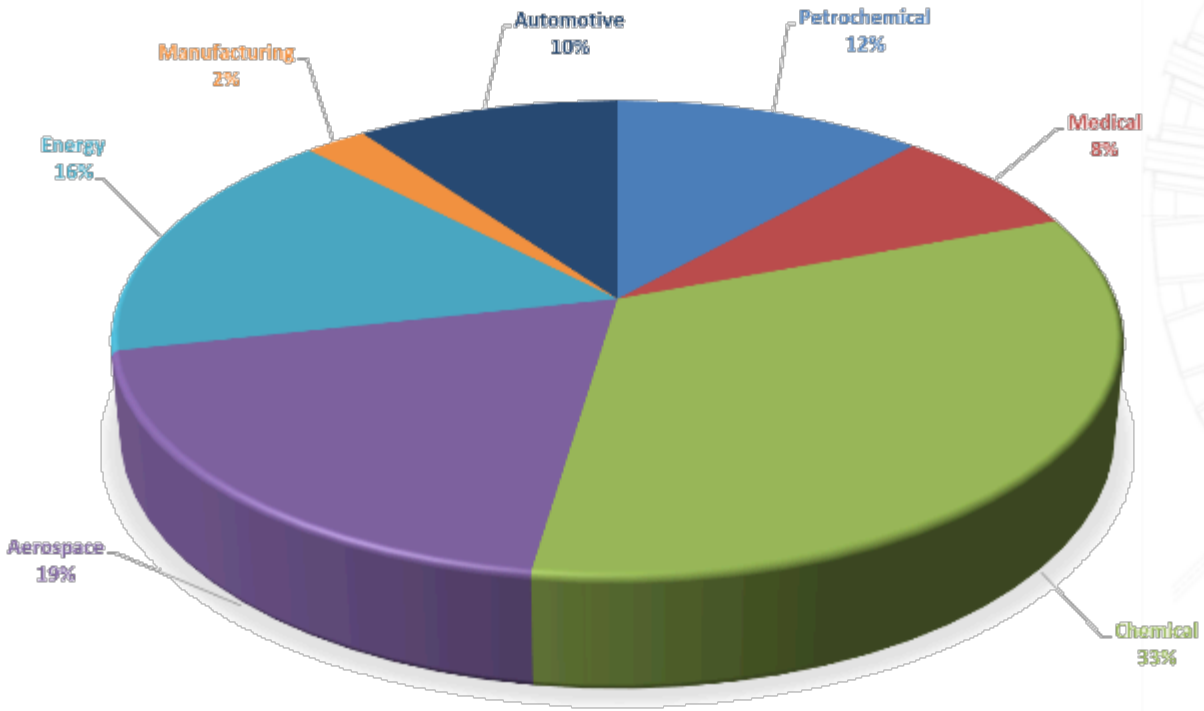
ISIS Collaborative Research and Development Scheme



outcomes…

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38 companies involved in the scheme…



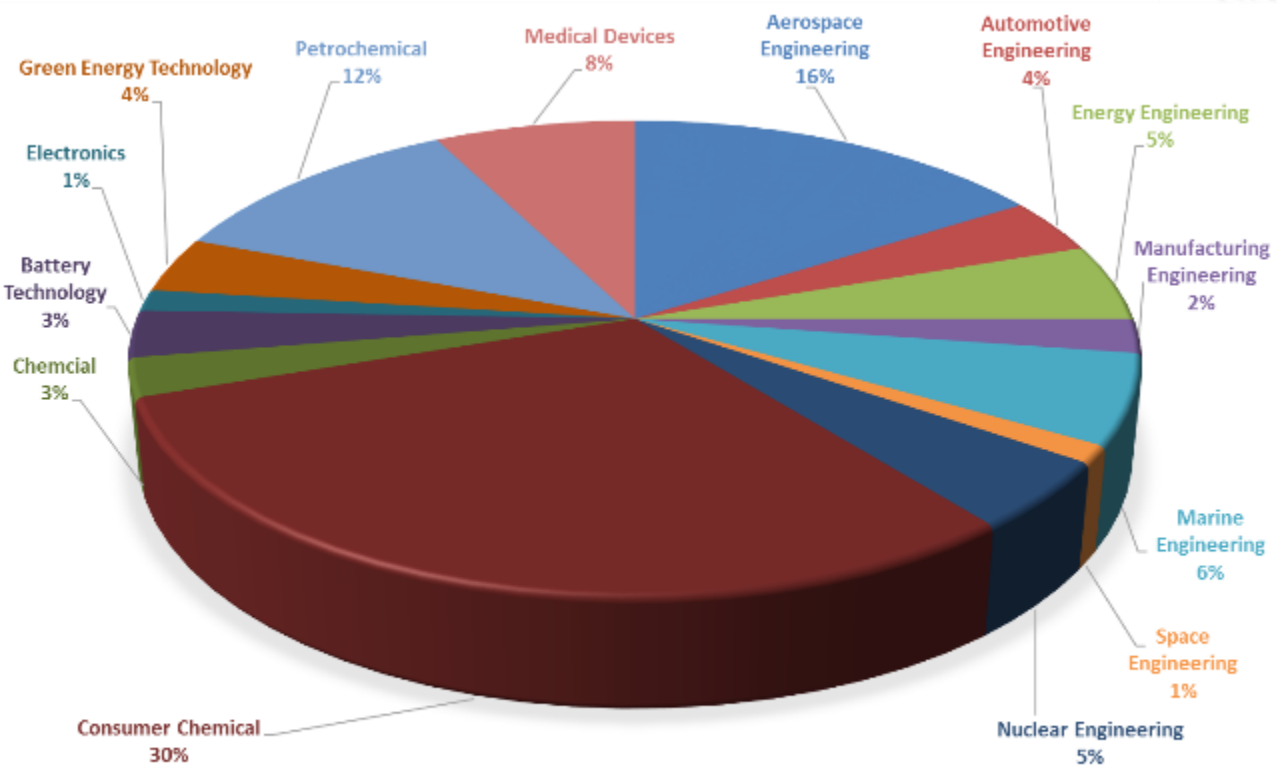


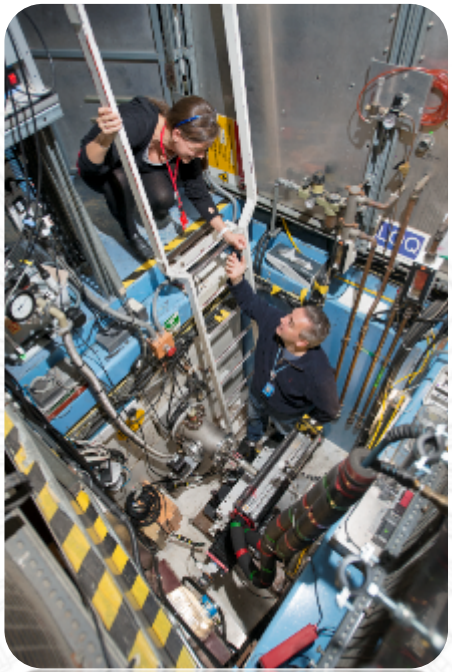
…from across the industrial sector

In addition to the normal 15% through peer review

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38 companies involved in the scheme…



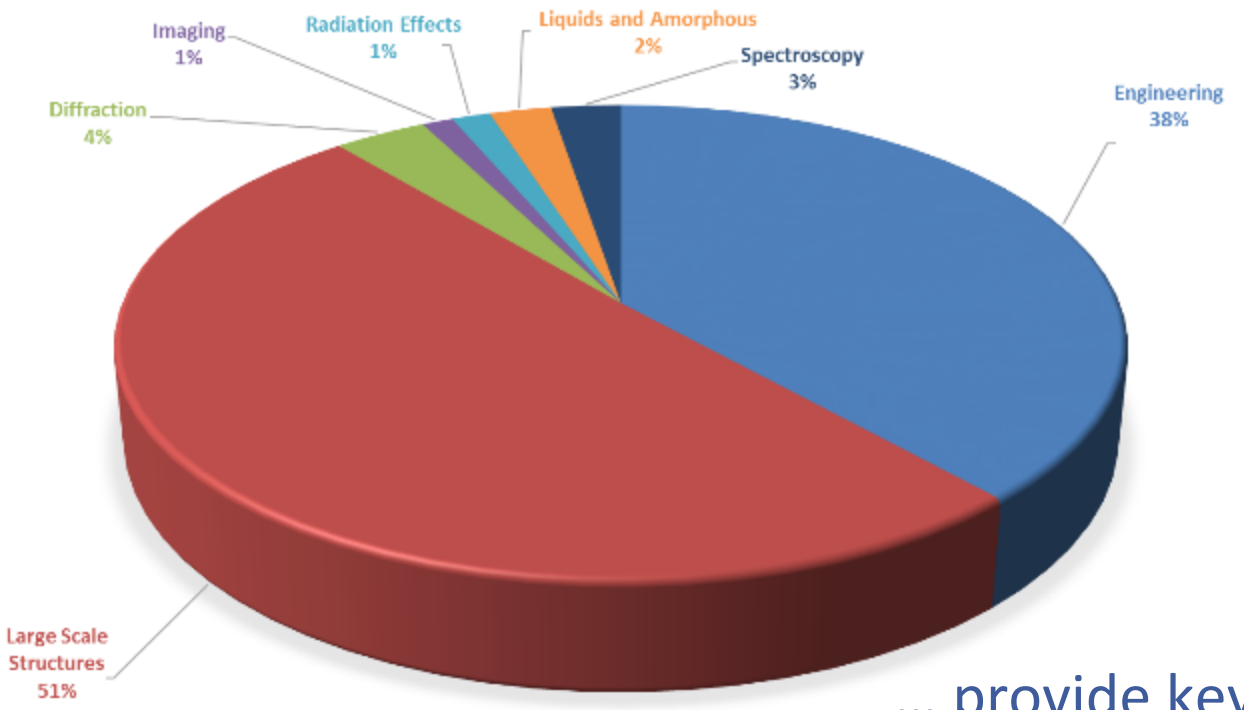


…from across the industrial sector

In addition to the normal 15% through peer review

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Engineering and Large Scale Structures ...



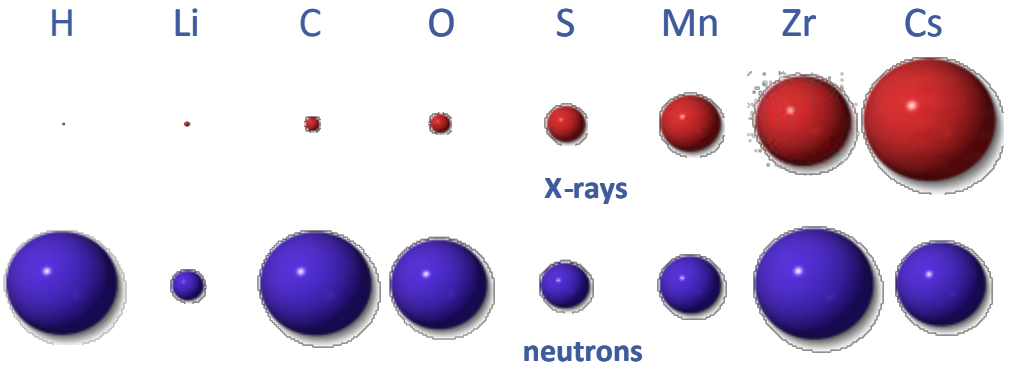


… provide key ‘value’ to industry

- Non-destructive in-situ stress analysis
- High sensitivity to hydrogen/light atoms

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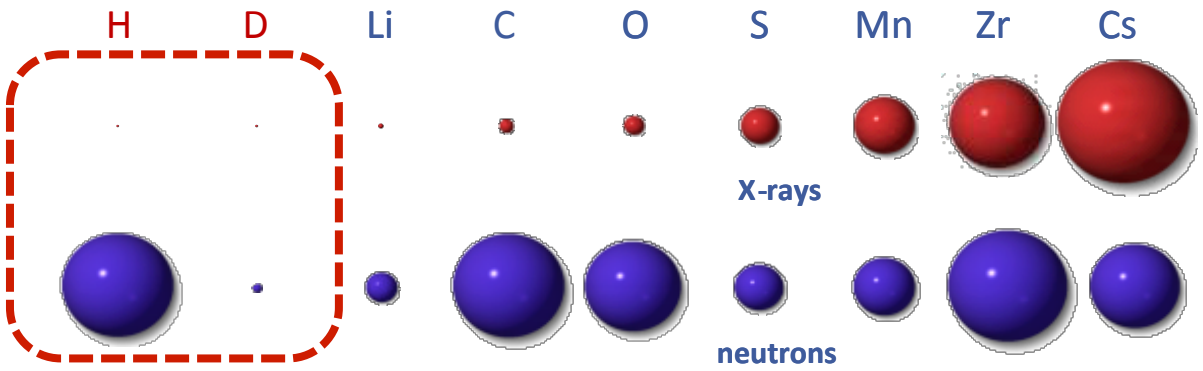




… provide key ‘value’ to industry

- Non-destructive in-situ stress analysis
- High sensitivity to hydrogen/light atoms

Nuclear Interaction Changes



Chemistry Remains the Same

… provide key 'value' to industry

- Non-destructive in-situ stress analysis
- High sensitivity to hydrogen/light atoms

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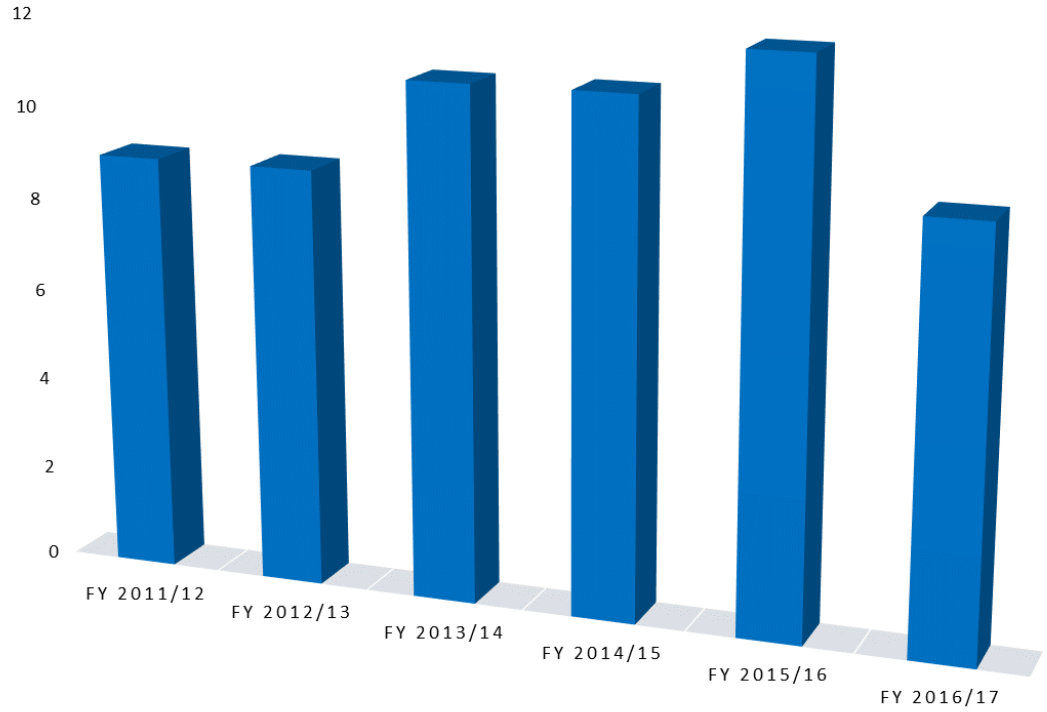
Expertise in application of neutrons …

… provide key ‘value’ to industry

- Non-destructive in-situ stress analysis
- High sensitivity to hydrogen/light atoms

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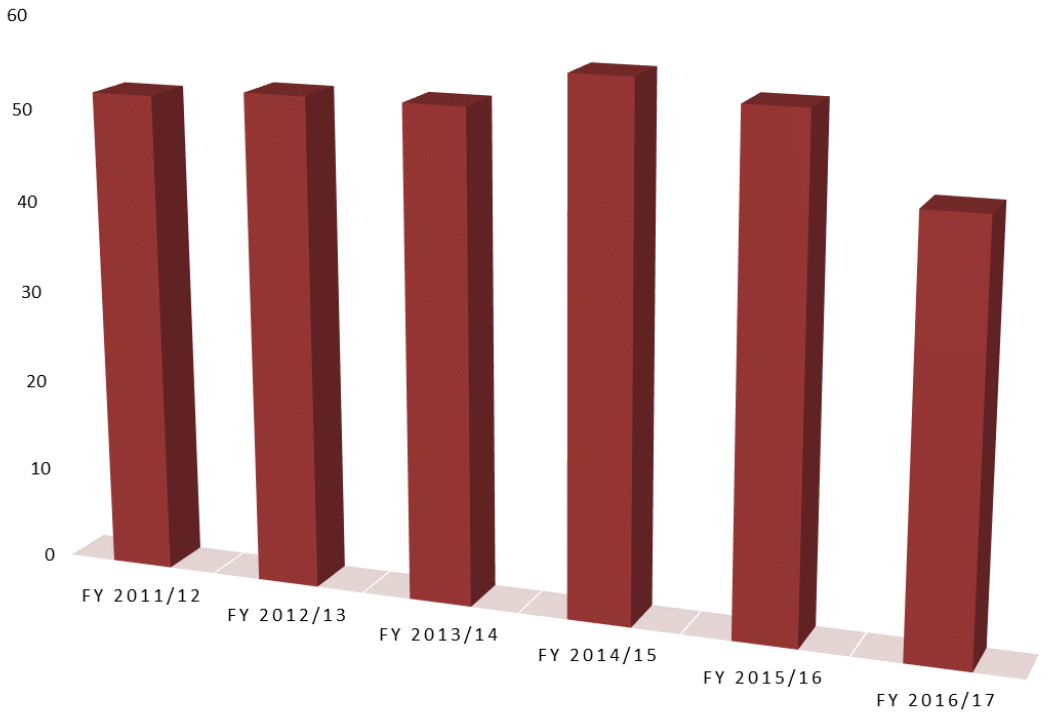
Typical 10 proposals per year…





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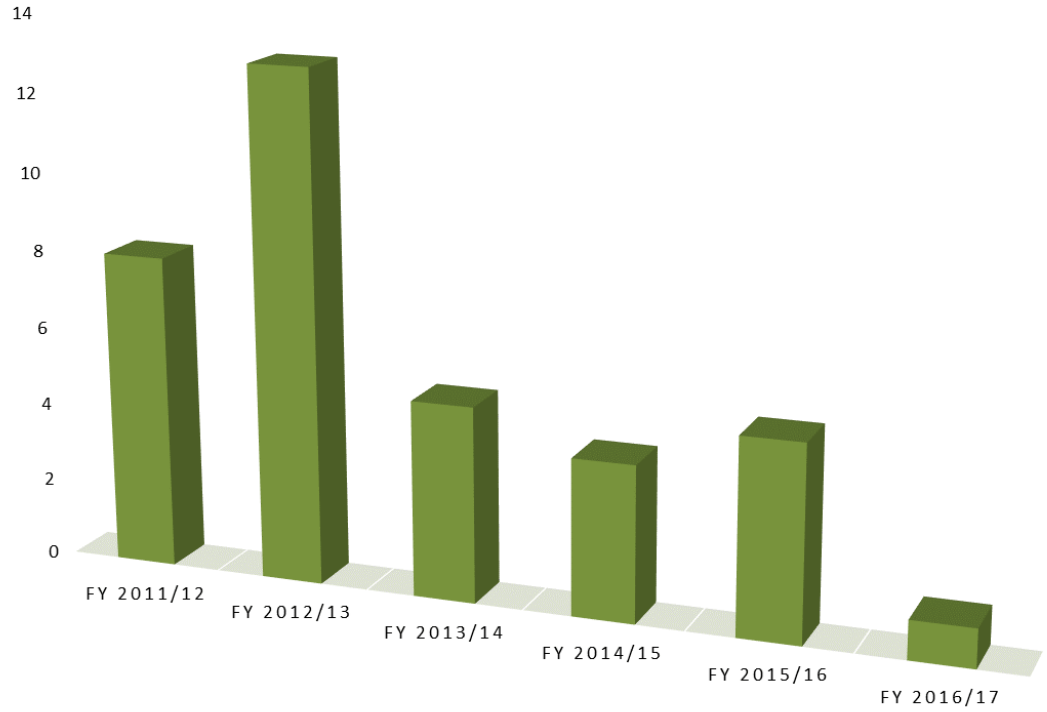
…using about 50+ days per year across ISIS





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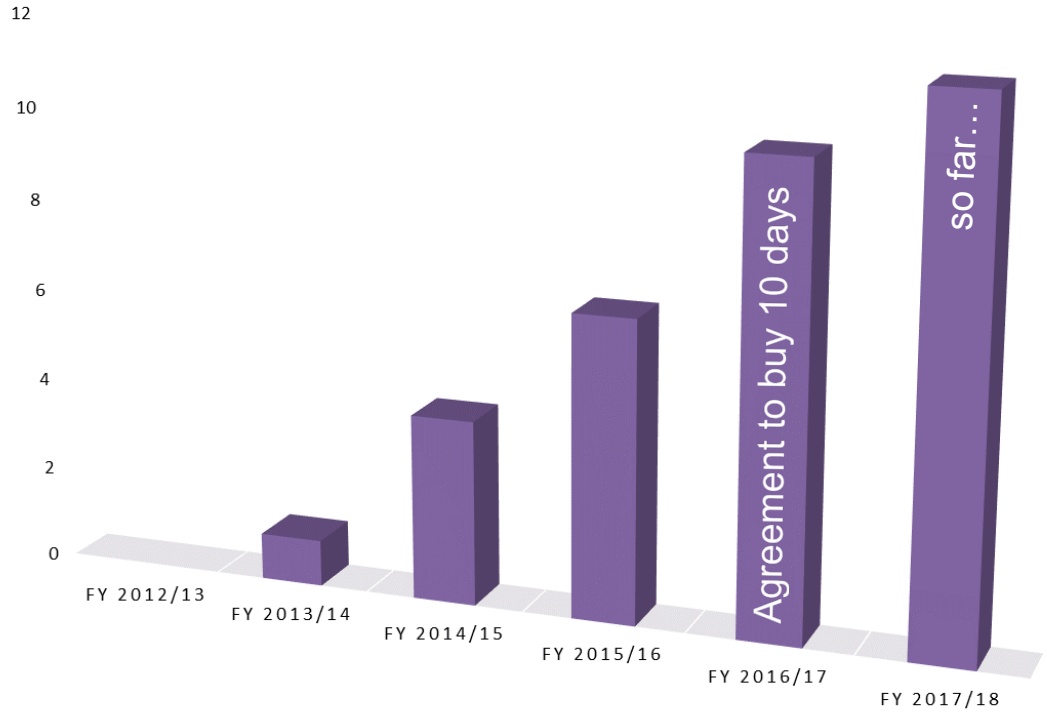
ICRD attracts new companies to the scheme each year…





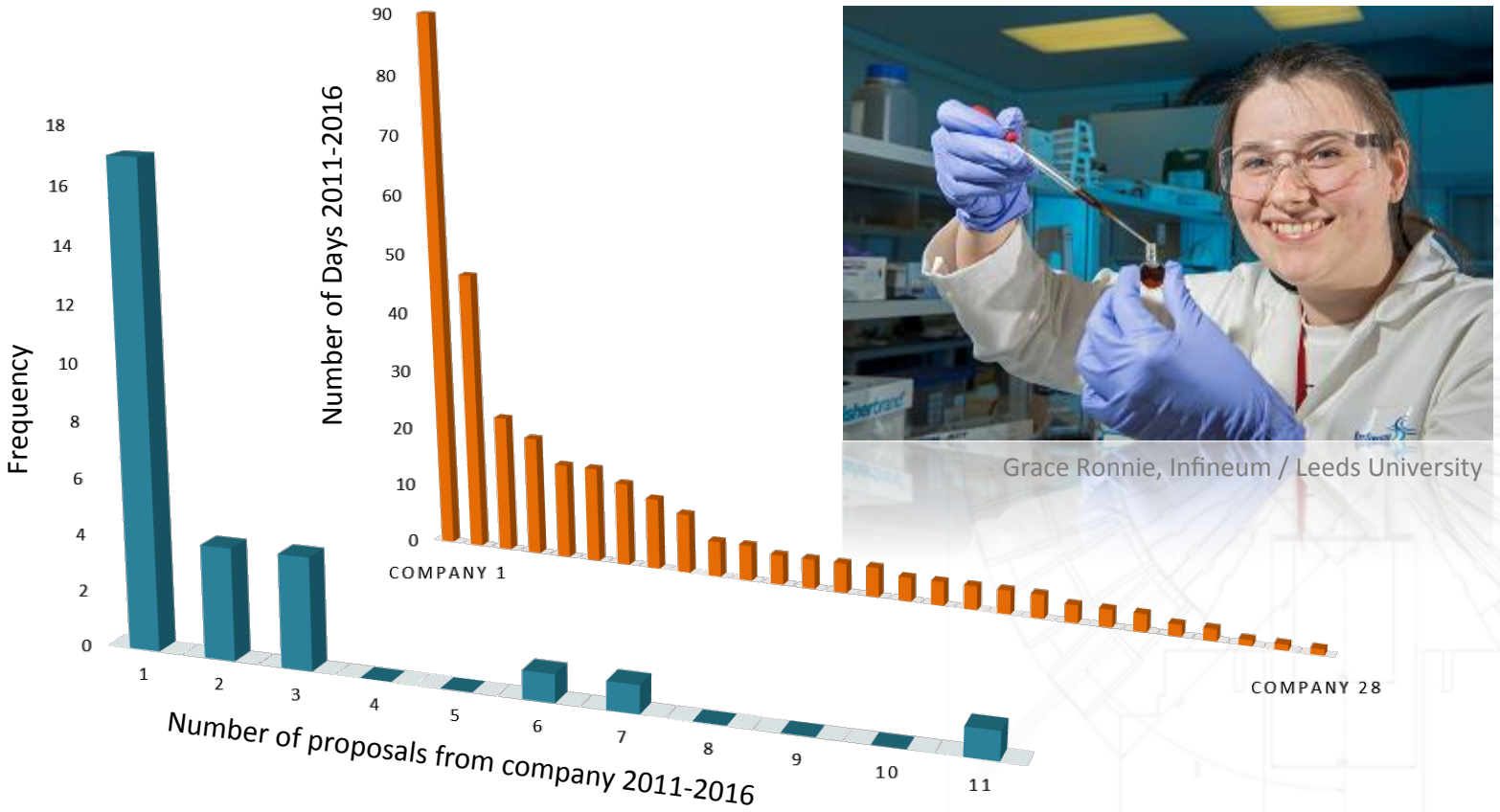
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… and led to a growth in demand for proprietary purchase of beamtime





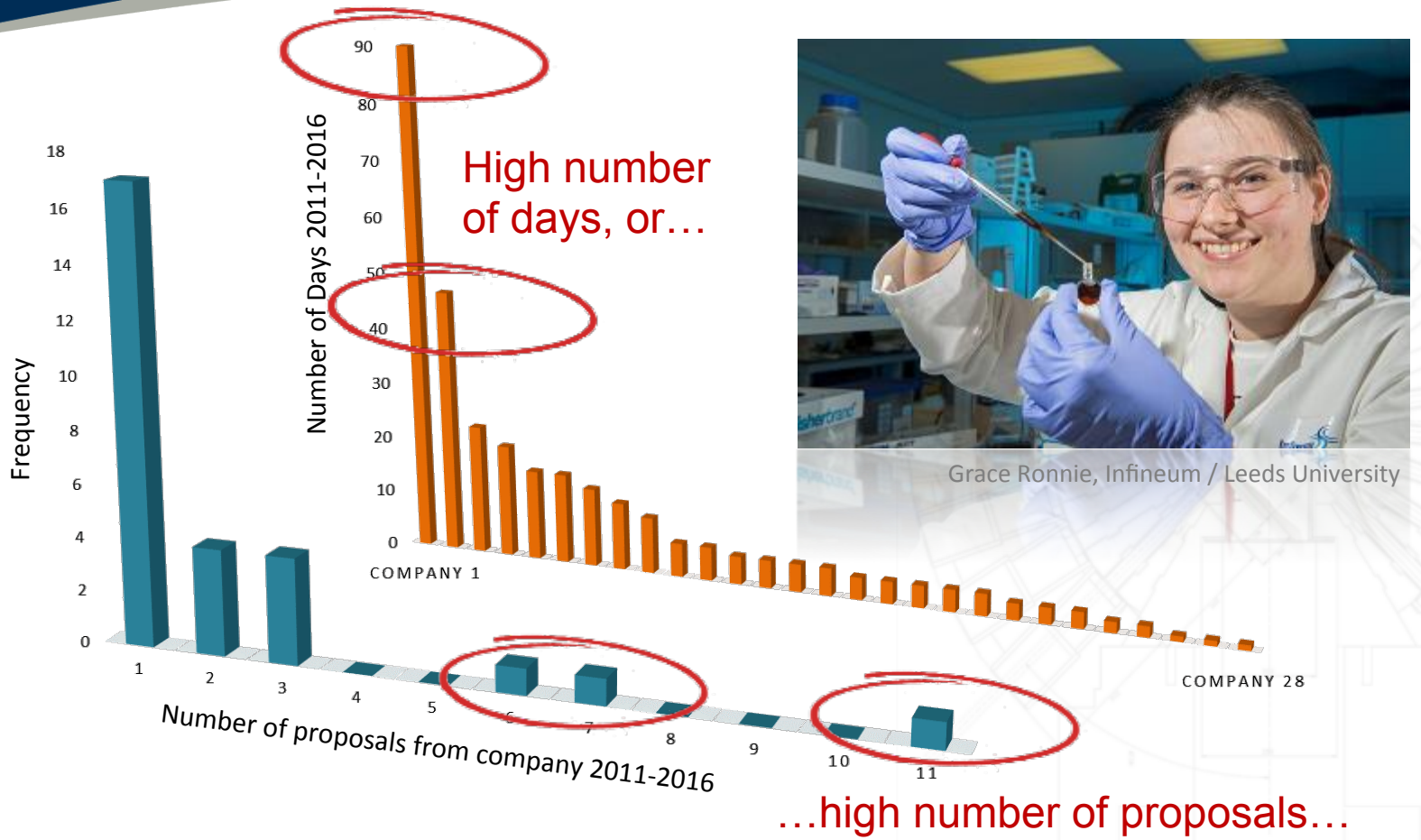
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Grace Ronnie, Infineum / Leeds University

Look at frequency of proposals and total days used by companies…

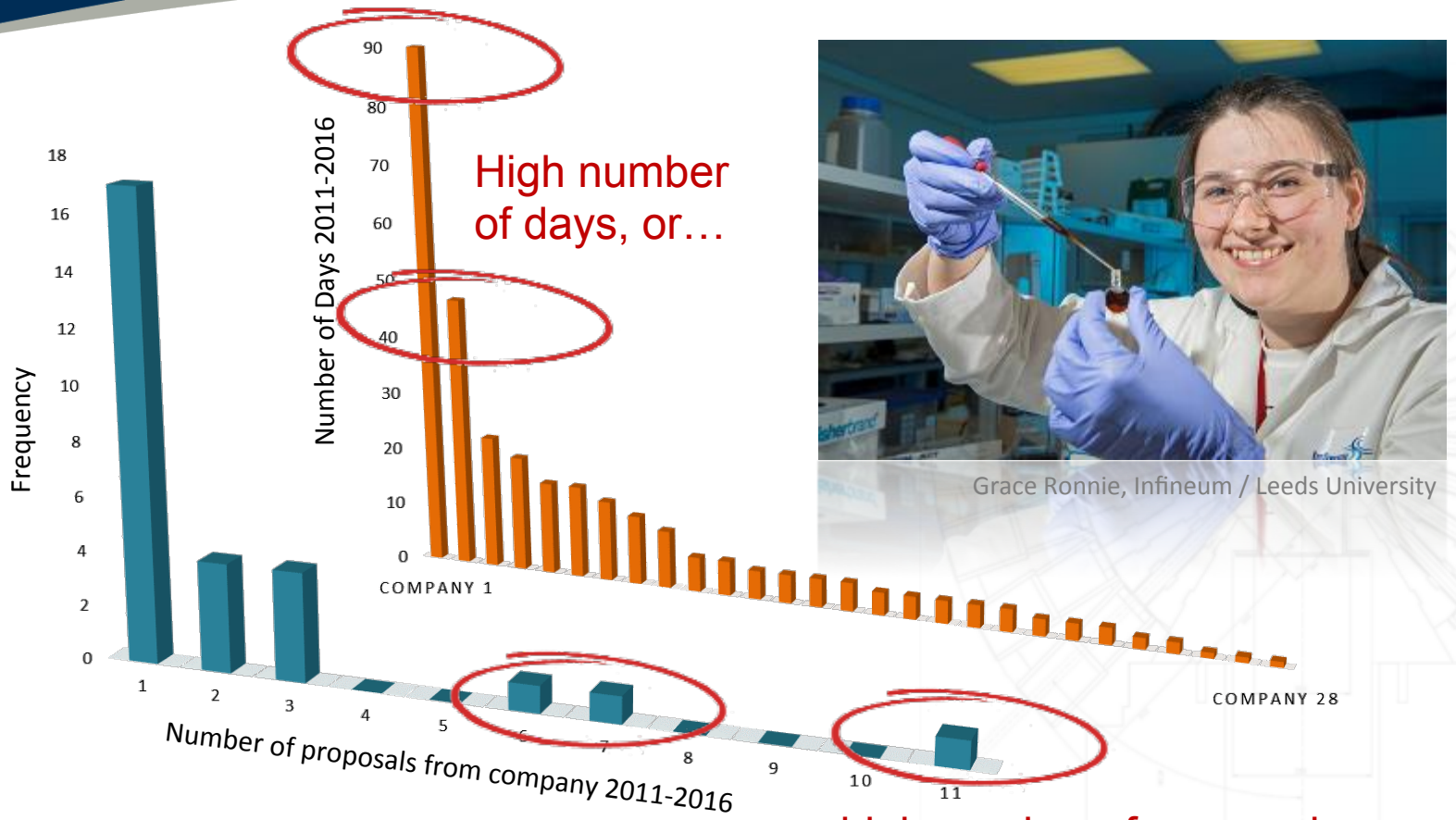
Science & Technology Facilities Council
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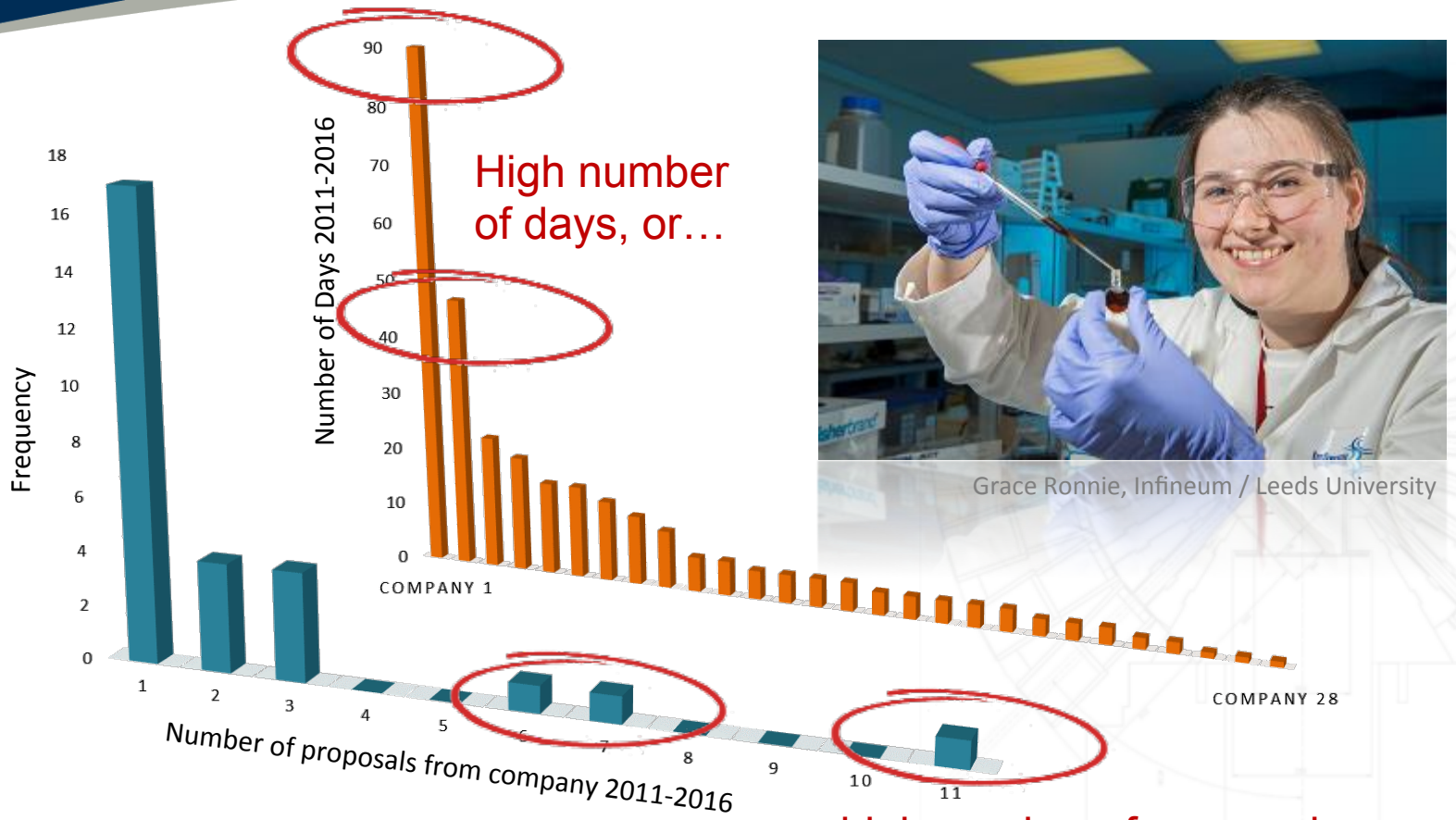
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Create ‘Framework Agreement’ to manage access over a number of years

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3 ‘Framework Agreements’ in place with 2 more expected soon…

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Impact





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Companies publishing articles on neutron measurements

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Impact





Material for Case Studies and Annual Reviews

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"The **ICRD programme** is a reasonable approximation to the close working relationship that the facility has had with a core group of industrial users across its 30-year life, and we have used these detailed financial projections as the basis for estimating historical benefits to industry users."

Data and Case Studies for Key Stakeholders

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"**The industrial use of ISIS has and will continue to be of direct benefit to the UK economy.** Companies who use ISIS report increased productivity, competitiveness and share value. We conservatively attribute around £200 million of net economic impact directly to ISIS over the lifetime of the facility, and a future net economic impact of £200 million (up to 2025)"

Data and Case Studies for Key Stakeholders

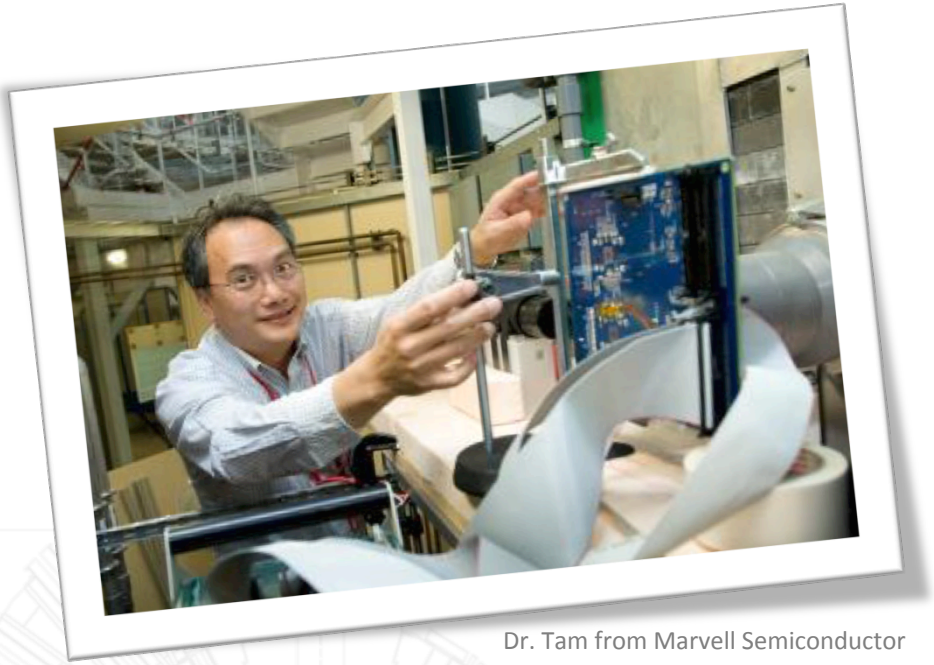
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Case Studies



Cosmic Ray muons and micro-electronics

MARVELL



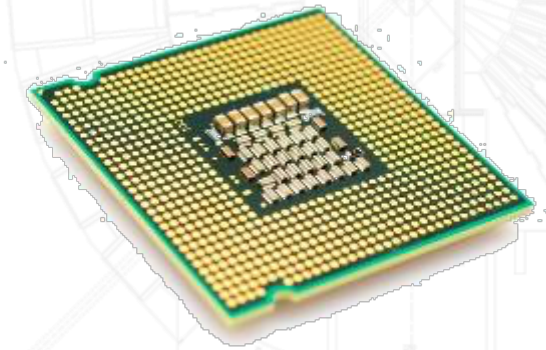
Dr. Tam from Marvell Semiconductor

Notes:-

"The micro-electronics industry is on the verge of architectural shift as devices get to below 20 nm. It was predicted in 1979 that there will be a watershed moment when such devices become susceptible to muon ionisation, and we believe current technologies are approaching this threshold."

"Our experiments today are about understanding the probability of these events, which represents an important contribution to the semiconductor industry. This will inform future design decisions, enabling manufacturers to develop devices that are less susceptible to muon SEUs."

Prof. Bhuva, Vanderbilt University



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Building safer ships with Lloyd's Register



Notes:-

Ultrasonic peening is a technique for improving the fatigue performance of welded joints. Little research has been done on how UP-treated welds behave when they are subjected to real world conditions such as compressive overload or variable amplitude loading.

Lloyd's Register provides quality assurance to the marine industry, and they have been using ENGIN-X to investigate UP welded joints in these conditions.

"For many years the advantages of adding a compressive stress in the area of the weld toe have been known but could not be practically applied to large ship structures….

…The ability to understand how residual stresses perform under realistic conditions has been a great help to the industry in pushing the process forward."

David Howarth, Lloyd's Register

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Optimising machining strategies for Boeing



Image Source: Boeing

Notes:-

The Advanced Manufacturing Research Centre (AMRC), with Boeing, at the University of Sheffield have been using Engin-X at ISIS to study the evolution of residual stresses in AA7050 – an aluminium alloy commonly used in aerospace structures - as it is heated and then machined. This understanding will enable them to reduce non-conformance in the manufacturing process, and significantly reduce costs.

Engin-X allowed the team to map residual stresses in three dimensions and build up residual stress profiles resulting from quenching and machining processes. This capability allowed the team to see the hidden residual stresses prior to releasing them during the machining process which is unachievable by other means.

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Testing new welding techniques for the nuclear industry



Image Source: EDF Energy

Notes:-

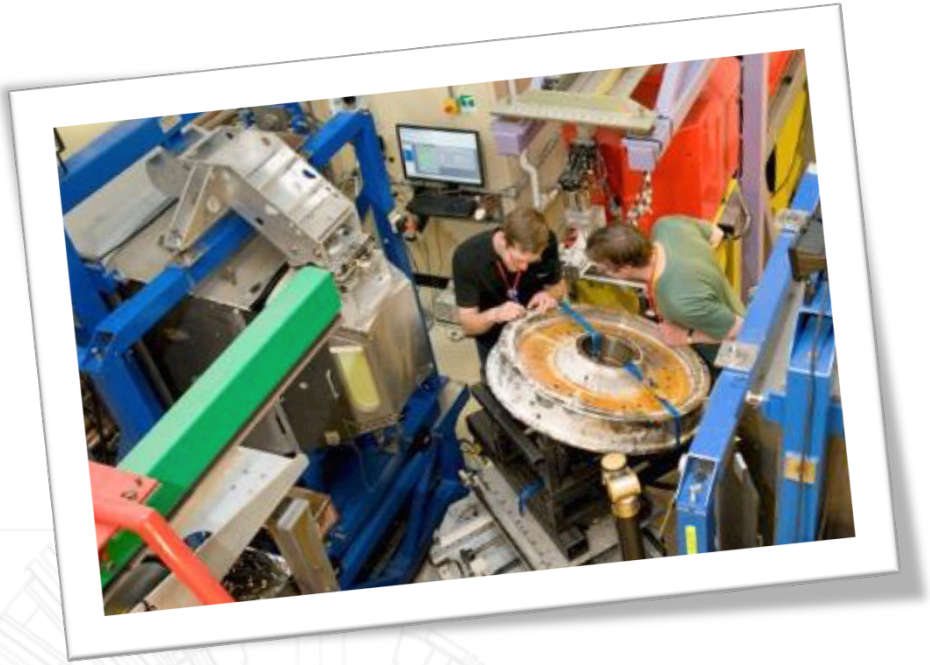
AREVA has developed new welding procedures, but before deploying them, the very high levels of qualification and validation required by the nuclear industry and regulators must be met. Together with the Open University, AREVA has been using ENGIN-X to map residual stress in mock-ups of welded nuclear components for the purpose of validating models for over five years.

"This was a challenging experiment as we were working close to the operational limit of ENGIN-X. However the results were in good agreement with earlier measurements and validated the advanced weld prediction model developed by AREVA. We are confident that the knowledge we've gained will support implementation of this new welding process".

Professor John Bouchard, Open University

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Letting the train take the strain



Notes:-

The University of Huddersfield and an industrial consortium of the Rail Safety and Standards Board, the Association of Train Operating Companies, Siemens and Lucchini, has been using Engin-X at ISIS understand how cracks begin and spread in train wheels.

Every five years or so, every wheel on every train in the UK has to be replaced. Maintenance and renewal of train wheels make up a significant proportion of the cost of our rolling stock.



"We have extensive facilities in Italy but we don't have anything like ENGIN-X at ISIS. Collaboration between industry and academia can be beneficial and lead to improvements in safety and processes."

Sean Barson, Technical Services Manager at Lucchini UK

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TWI examines flaws in pipelines under high plastic strain



Notes:-

The outcome of a study carried out by engineering consultancy TWI have been using ENGIN-X at ISIS to assess how pipes used in the offshore oil and gas industry are affected by installation processes introducing high plastic strain. The results give an insight into how residual stresses introduced by pipeline welding change after strains imposed during installation, and what this means for the structural integrity of the pipe.

"This study has important implications for the oil and gas industry and our findings have been submitted to the R6 panel, a group of industrialists interested in residual stress and fracture mechanics in structural steel. Ultimately the work may influence the standards on fracture mechanics used by the oil and gas industry."

Dr Elvin Eren, TWI

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Neutrons could reveal how pesticides protect crops



Elias Pambou, University of Manchester

Notes:-

Scientists have created a model of a leaf's waxy surface, similar to those found in wheat crops, in a project supported by the agrochemical company, Syngenta. They are now using the model at ISIS to study how surfactants, a key component in pesticide formulations, interact with the leaf surface to get into the plant and take effect. The results could lead to the fine-tuning of pesticide formulations to further increase crop yields in an attempt to meet the demand of feeding an ever growing global population.

"This research has furthered our understanding of the kinetics of plant uptake. It has shown that water can penetrate into leaf wax. This simple observation explains a lot of the basic science behind pesticide uptake into plants."

Dr Gordon Bell, Senior Scientist at Syngenta



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Helping make hydrogen cars a reality

TOYOTA

Image Source: Toyota



Notes:-

Toyota, who will release a hydrogen fuel cell vehicle in Japan in 2015, have been working with ISIS scientists to address a key challenge: hydrogen loss during cycling.

With the depletion of fossil fuels an alternative is needed, and hydrogen, provided it can be produced without using fossil fuels, is a promising option. But there are challenges in both producing and storing hydrogen that must be overcome before commercial hydrogen cars become reality.

"Our work with ISIS has allowed us to develop in operando neutron powder diffraction techniques that has provided important insights into the nature and location of hydrogen in Ti-V-Cr-Mo alloy for hydrogen storage systems. This in turn provides new opportunities for the rational improvement of these materials for use as storage for future hydrogen cars."

Shin-ichi Towata
Toyota Central Research and Development Laboratories Inc

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Fuelling efficiency with Infineum



Image Source STFC

Notes:-

Infineum is one of the world's leading formulators, manufacturers and marketers of fuel and lubricant additives. Their work is driven by reducing emissions into the environment, improving engine performance and responsible, more efficient use of chemicals.

Infineum have been using ISIS instrument, LOQ to understand at the atomic scale how calcium carbonate particles in their additives form.

"Our work at ISIS allows us to not only use the products we make more efficiently but to improve fuel economy in the future, as we can look at which molecules influence friction at the molecular level."

Infineum's Lead Scientist Prof Peter Dowding



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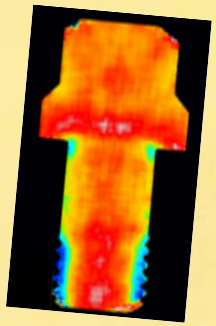
Taking the Stress out of Engine Manufacture #1

Rolls-Royce



Notes:-

Rolls Royce aircraft engines relies heavily on the use of small bolts made out of a superalloy. However the bolts can often fail due to the appearance of fatigue crack at an area of high stress concentration.



ENGIN-X has showed that a process called 'fillet rolling' can be used to manufacture safer bolts. This will save a substantial amount of money as well as reducing the time and energy used both in the creation of new bolts and the replacement of those that have worn out.

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Wei Li et al., 2014, Advanced Materials Research, 996, 670

Taking the Stress out of Engine Manufacture #2

Rolls-Royce



Notes:-

Nickel based superalloys are a class of material designed for high-temperature applications, such as turbine blades for jet engines. During the manufacturing process single crystal turbine blades are subject to a series of heat treatments. Scientists at Rolls Royce identified a mechanism they believed led to the formation of surface defects in the blades, potentially limiting their performance and leading to costly reworking of the blades.

"The experiments on Engin-X provided the evidence we needed to support an existing patent. We've now been able to use this patent in the foundry, and also read the technique across to other turbine components, leading to significant cost savings."

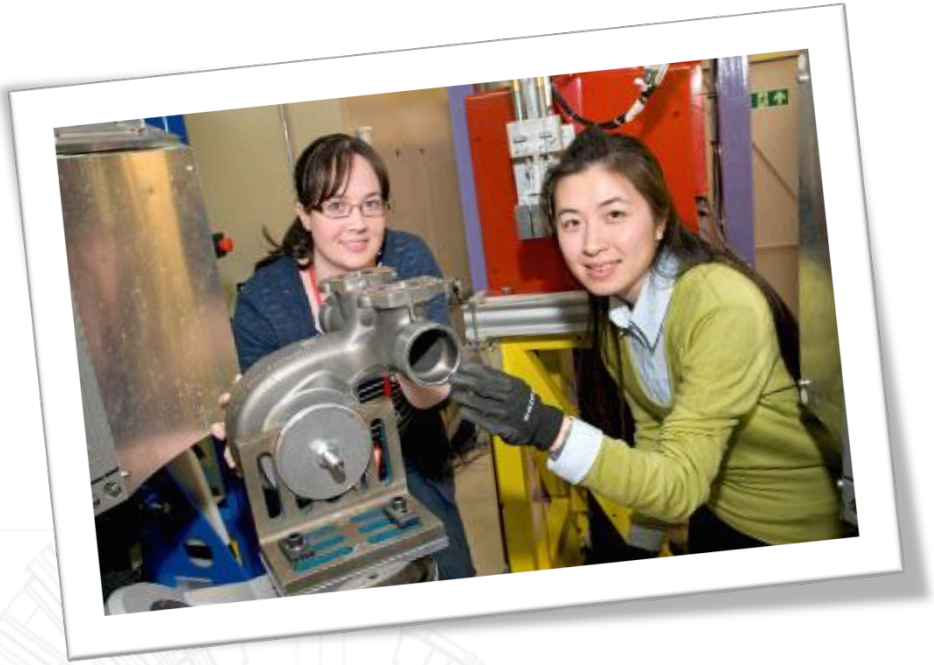
Neil D'Souza, Rolls Royce



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Wei Li et al., 2014, Advanced Materials Research, 996, 670

Testing Turbochargers with BorgWarner



Notes:-

Turbine housing has to be able to operate in areas of high vibration, and temperatures of up to 800°C. Current turbochargers are at the operational limit in terms of strength and usability, and failures have been recorded during accelerated testing. Understanding the fatigue performance and the conditions that determine it will enable the company to identify how cracks form and what they can do to mitigate this.

"Our current methods of analysis have been unable to predict failures or identify the root causes of failure. Engin-X allowed us to gain a detailed analysis of the structure of current components and greatly improved our understanding of component failure."

Katy Gannon from BorgWarner



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