AVALON CONSULTANCY SERVICES LTD

R&D in Advanced Engineering in the UK – Support and Examples

Dr Faye Smith CEng, FIMMM, 2010

Contents

- R&D in the UK
- R&D Funding
  1. Tax Credits and Allowances
  2. RDA/DA Funding
  3. EU Framework 7 Programme
  4. Research Councils
  5. Centre for Defence Enterprise
  6. The Technology Strategy Board
- Examples of R&D
  - Aerospace
  - Automotive

Research and Development

- R&D has never been more important.
- It underpins innovation, on which wealth creation in modern economies increasingly depends.
- Only companies that constantly seek to improve and innovate will grasp the opportunities that globalisation offers.
- Technological innovation provides potential solutions to some of the great challenges that governments and societies face, such as healthcare in an ageing society, developing a more secure environment, and tackling the problems of sustainability and climate change.

R&D in the UK

- The UK is renowned for the quality of its R&D
- Expenditure on R&D in the UK was £25.6 billion in 2008 (ONS, 2010)
  - 62% private sector - 5% Govt
  - 26% higher education - 7% other
- UK is ranked as the second strongest research base in the world behind only the US (Evidence, 2009)
- UK produces 8 per cent of the world's scientific papers and has a citation share of 12%, second only to the US (Evidence, 2009).
- Overseas-funded R&D in the UK reached £3.7bn in 2008.
- Overseas entities own 35.3% of patents in the UK, compared to 13.5% across the EU, 11.1% in the US and 3.9% in Japan (OECD, 2009).
- For companies like Ford, Boeing, Tata, Pfizer, Airbus, Eli Lilly, Nokia and Syngenta, the UK is the natural choice for large-scale R&D investment.

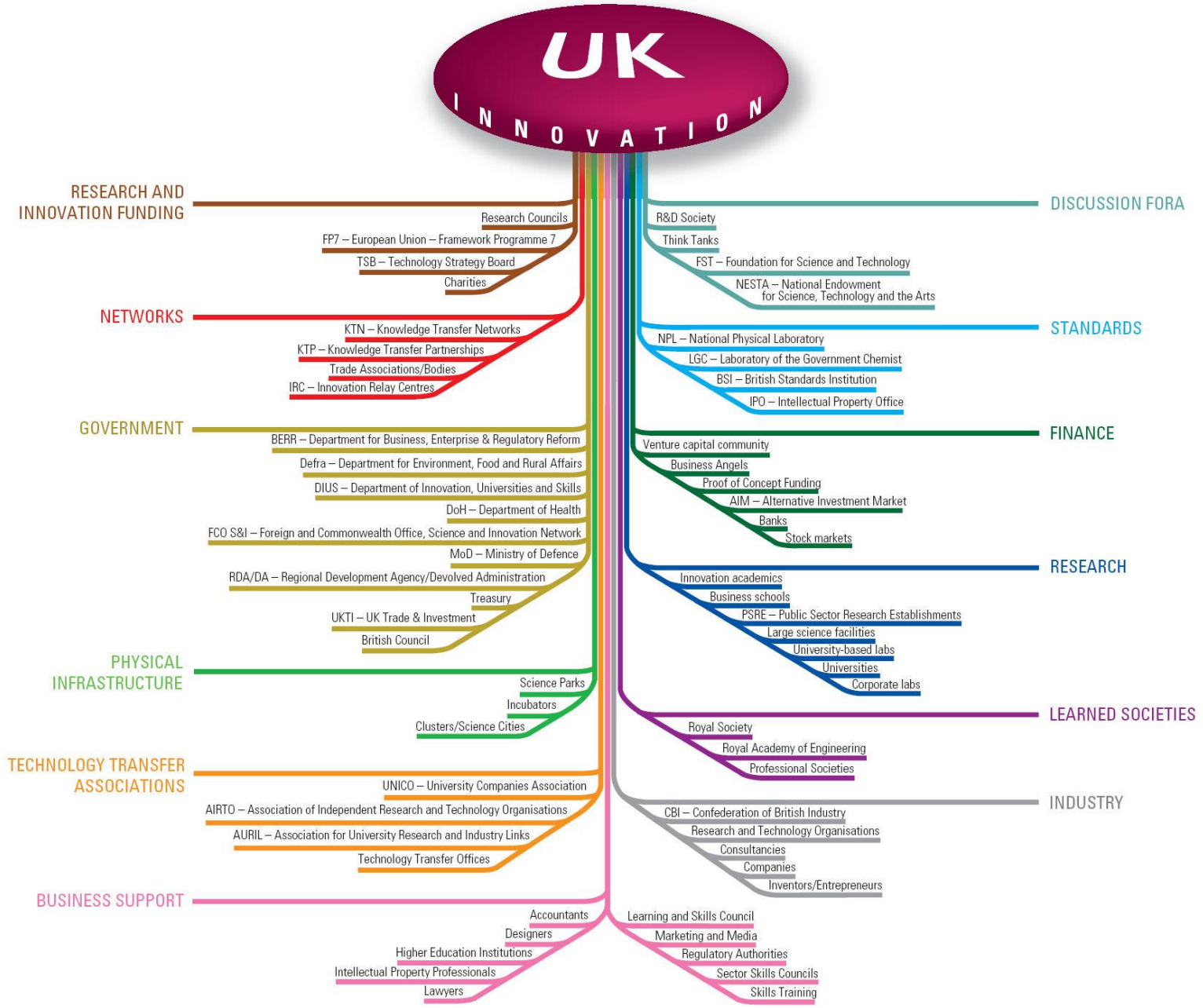
R&D in the UK

The benefits of undertaking R&D in the UK are well attested:

- The expertise of world-renowned scientists
- Immediate access to leading research institutions with cutting-edge technology
- A robust system of protecting intellectual property
- A highly cost effective environment for R&D investment
- A wide range of tax and incentives support – an overall package that makes undertaking R&D in the UK a world-class proposition
- A proven business and investment environment.

UK R&D Landscape

A comprehensive range of interlocking R&D resources providing companies with the strongest R&D network in Europe:



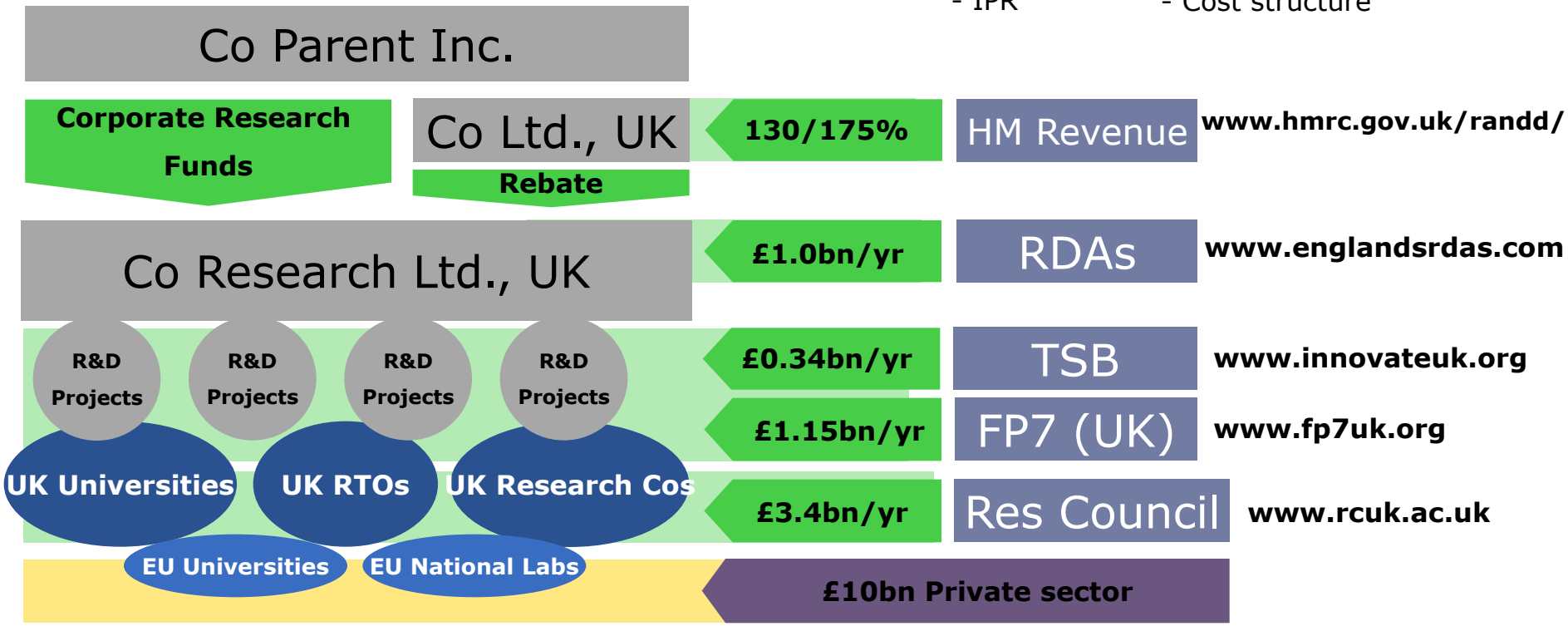
http://www.ukinvest.gov.uk/UKTI-publications/4018023/en-GB.pdf

R&D Funding

National funding support in UK will reach £6bn in 2008

Funding criteria:

- R&D topic
- Region
- IPR
- Type of collaboration
- National fit (eg NATS)
- Cost structure



1. R&D Tax Credits and Allowances

R&D tax credits are available for both large corporations and for small and medium-sized companies (SMEs) investing in R&D:

- *Large corporations R&D:* In addition to the normal 100 per cent deduction, large companies are entitled to a further deduction from their taxable income of 30 per cent of their current spending on qualifying R&D.

  For example, if a company spends £100,000 on qualifying R&D, it will be able to deduct £100,000 from its taxable income under ordinary tax rules and an additional £30,000 under the R&D tax credit.

- *SMEs R&D:* In addition to the normal 100 per cent deduction, SMEs (companies employing up to 500 people) are entitled to a further deduction from their taxable income of 75 per cent of their current spending on qualifying R&D.

www.hmrc.gov.uk/randd/

www.berr.gov.uk/dius/innovation/randd/randd-tax-credits/RandD-Tax-Guidelines/page14094.html

2. RDA/DAs

- Regional Development Agencies
  - South West
  - South East
  - London
  - East of England
  - West Midlands
  - East Midlands
  - North West
  - Yorkshire & the Humber
  - North East
- Devolved Administrations
  - Wales
  - Scotland
  - Northern Ireland

2. RDA/DA Funding

The Grant for Research and Development is an initiative that provides funding to help individuals and SMEs to research and develop technologically innovative products and processes.

- ***Micro projects****:* low-cost development projects, <12 months. Output is simple prototype of a novel or innovative product or process. Grant up to £20,000 for businesses <10 employees.
- ***Research projects****:* planned research or critical investigations, 6-18 months. Result is new scientific or technical knowledge useful in developing a new product or process. Grant up to £100,000 for businesses <50 employees.
- ***Development projects****:* shaping industrial research into a pre-production prototype of a technologically innovative product or process. Grant up to £250,000 for businesses <250 employees.
- ***Exceptional projects****:* technology developments which have higher costsand will be of "strategic importance" for a technology or industrial sector. Grant up to £500,000 available for businesses <250 employees.

England: http://www.businesslink.gov.uk/bdotg/action/detail?r.l3=1074463677&r.l2=1073866776&r.t=RESOURCES&r.i=1075065254&r.l1=1073858790&r.s=m&type=RESOURCES&itemId=1074469930

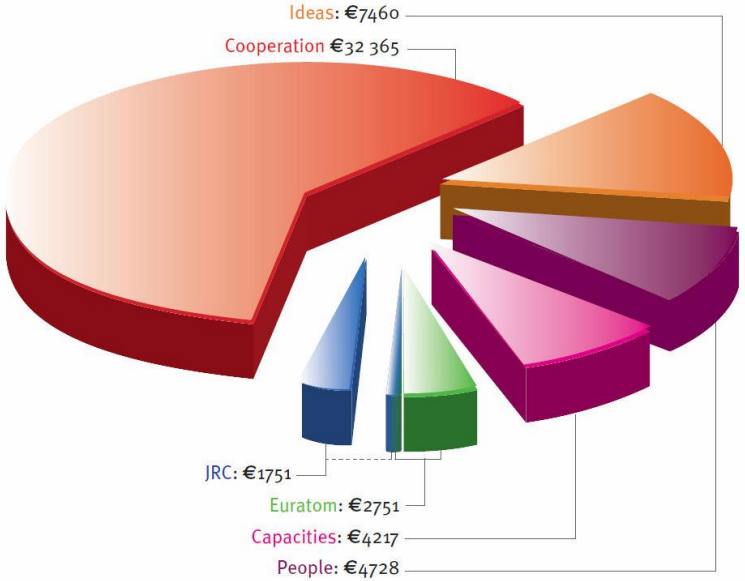
Scotland: www.scottishbusinessgrants.gov.uk/rsa/1000.html

Wales: www.business-support-wales.gov.uk

Northern Ireland: www.investni.com/invest/

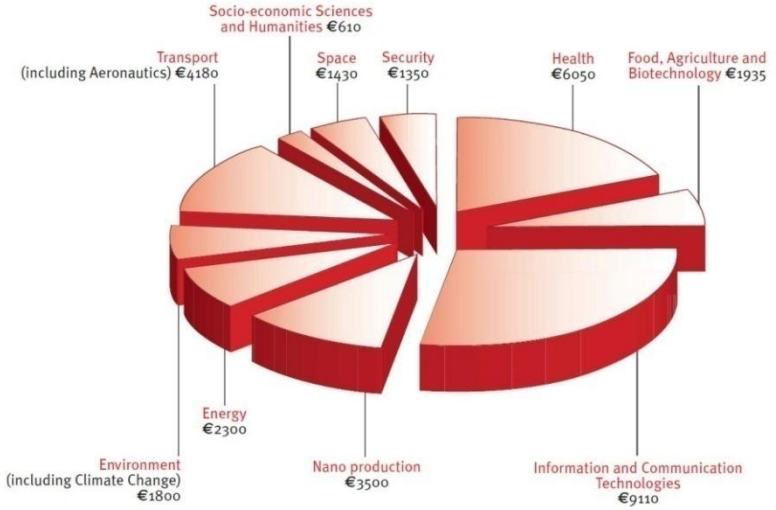
3. EU 7th Framework Programme

- FP7 - Total budget over €50 billion, for seven years, 2007-2013.
- “European added value” – e.g. transnationality – consortia include participants from different European (& other) countries.
- While FP7 participants can in principle be based anywhere, there are different categories of country which may have varying eligibility for different specific work programmes:
  - MEMBER STATES - The EU-27;
  - ASSOCIATED COUNTRIES – with science and technology cooperation agreements that involved contributing to the framework programme budget;
  - CANDIDATE COUNTRIES – currently recognised as candidates for future accession;
  - THIRD COUNTRIES - the participation of organisations or individuals established in countries that are not Member States, candidates or associated should also be justified in terms of the enhanced contribution to the objectives of FP7.



FP7 Programmes

- **Cooperation -** Collaborative research, 10 areas:
  - Health
  - Food, agriculture and fisheries, and biotechnology
  - Information and communication technologies
  - Nanosciences, nanotechnologies, materials and new production technologies
  - Energy
  - Environment (including climate change)
  - Transport (including aeronautics)
  - Socio-economic sciences and the humanities
  - Space
  - Security
- **ERA-NET/+** - framework/funding for collaboration
- **Capacities** – Strengthens research capacities:
  - Research infrastructures
  - Research for the benefit of SMEs
  - Regions of Knowledge
  - Research Potential
  - Science in Society
  - Specific activities of international cooperation
- **Ideas -** "Frontier research" in any area. No cross-border obligation.
- **People -** Support for researcher mobility and career development, both for researchers inside the European Union and internationally.
- **Nuclear** – Two specific programmes; fusion (ITER) and Joint Research Centre (JRC).



FP7 Funding and Support

- Funding rates depend on scheme, participant and activity.
- Standard for R&T development is 50%.
- Certain orgs can receive up to 75% (non-profit, SMEs, research orgs, HEIs).
- For other activities (consortium management, networking, training, coordination, dissemination etc.), the reimbursement can be up to 100% of the eligible costs.

- Enterprise Europe Network http://www.enterprise-europe-network.ec.europa.eu/index_en.htm
- National Contact Point (NCP) http://cordis.europa.eu/fp7/ncp_en.html
  - UK Aerospace NCP is Gill Richards.
  - UK Transport is Cliff Funnel
  - UK NMP is Alastair McGibbon

4. Research Councils

- Research Councils are public bodies charged with investing in science and research in the UK in order advance knowledge and generate new ideas to create wealth and drive improvements in quality of life.
- Eligible for funding:
  - UK higher education institutions (HEIs);
  - Research Council institutes;
  - Independent research organisations (IROs).
- Each Research Council funds research and training activities in a different area of research. There are currently seven Research Councils:

  Arts and Humanities Research Council (AHRC)
  Biotechnology and Biological Sciences Research Council (BBSRC)
  Engineering and Physical Sciences Research Council (EPSRC)
  Economic and Social Research Council (ESRC)
  Medical Research Council (MRC)
  Natural Environment Research Council (NERC)
  Science and Technology Facilities Council (STFC)
- The Councils employ around 12,000 staff, supports around 30,000 researchers, including 15,500 doctoral students in UK universities and in their own Research Institutes.

Research Councils (RCs)

Research Councils support research through three principal mechanisms:

- By providing project or programme funding to higher education institutions, as part of the dual support system.
- By funding research in their own research facilities – some are located in universities, some are wholly owned and administered, while others are more independent, “sponsored” institutes.
- By providing access to large facilities for UK researchers. This can be through international subscriptions or the funding of national facilities.

Funding for interaction with business is in 4 forms:

- Collaborative R&D
- Commercialising research
- Secondments & training
- Strategic partnerships

RCs - R&D Funding

R&D

- **Responsive Mode** – University researchers. Any amount and length of funding, in any area of RC's remit. Collaborations encouraged. Open call.
- **Calls for Proposals** specific research areas, on website, as a weekly email alert and as an RSS feed. (Includes Joint Academic Research programme – Defence, which MoD jointly funds)
- **IDEAS Factory** - intensive interactive workshops to stimulate highly-innovative and risk-accepting research activities. Proposals from industry for topics welcomed. Calls for participants are issued.
- **Network grants** - available to create new interdisciplinary research communities and topics, by developing interaction between the research community and appropriate science, technology and industrial groups.

Flexible Funding for Collaboration

Selected universities receive substantial long-term, flexible funding for collaborative training. Can be used on KTPs, Engineering Doctorates etc.

Industrial Case Studentships

- Students receive EPSRC funding for 3.5 years.
- Companies provide extra funding to the student, a minimum of a third of the EPSRC funding. (£22,000 over the course of the project.)
- The student spends at least three months at the company, and the company pays any travel and subsistence costs.
- Projects should be in the area of engineering and the physical sciences.
- Awarded:
  - To large businesses based on financial collaboration on EPSRC-funded research and collaboration on studentships.
  - Through Industrial CASE agents (knowledge transfer networks and regional developments agencies).
  - Through an Industrial CASE pool competition where companies can bid for awards. 40 studentships for companies with a UK research and/or manufacturing base.

RCs - Strategic Partnerships

- A formal arrangement between RC and other organisations where RCs agree to jointly support research, training and other activities in UK universities.
- A partnership can involve one or several organisations.
- Activities can include things like research chairs, research grants and consortia and studentships.
- Ground rules:
  - Partners can't pre-select research groups or researchers to take part – opportunities must include an element of openness to all
  - Summary details of the activities funded are placed in the public domain
  - RCs stick to the principles of peer review
  - No exclusive deals - are open to partnerships with all stakeholders, including possible competitors
  - Grants awarded to universities, not to the partner organisations
- Examples of companies using this scheme are Rolls Royce, BAE Systems.

5. Centre for Defence Enterprise

- First point of contact for anyone with a disruptive technology, new process or innovation that has a potential defence application.
- ‘Gateway’ between MoD and outside world.
- Online proposal submission (assessed in as little 15 days).
- Successful applicants benefit from :
  - Proof-of-concept funding in the form of a research contract
  - Support from our military scientists and engineers
  - MOD trials and testing facilities
  - A mentoring service ensuring a single point of contact within the MoD
  - A unique customer insight into both UK and non-domestic defence markets

http://www.science.mod.uk/Engagement/enterprise.aspx

6. Technology Strategy Board

Technology Strategy Board

Provides support and funding to stimulate innovation in those areas which offer the greatest scope for boosting UK growth and productivity.

"Connect and Catalyse - a strategy for business innovation"

2008-2011, three main themes:

- Innovation in response to societal and economic challenges – Challenge-led innovation in Key Application Areas
- Innovation inspired by existing and emerging technology, where the UK leads or could lead – Technology-inspired innovation
- The "innovation climate", or the culture in which innovation can grow.

Underpinning Technologies

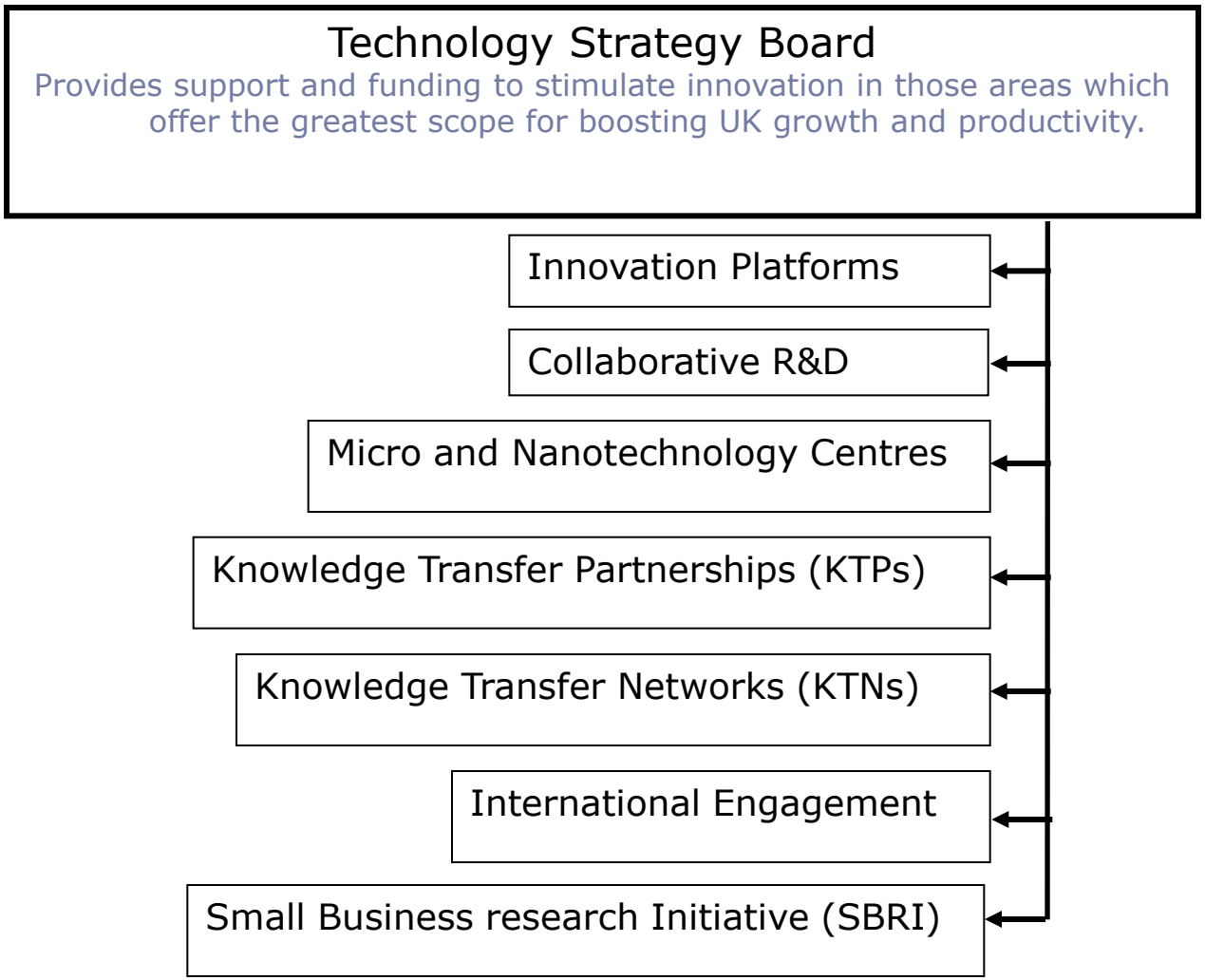
- High Value Manufacturing
- Advanced Materials
- Bioscience
- Electronics, Photonics & Electrical
- Information and Communication
- Nanotechnology

Application Areas

- Environmental Sustainability
- Energy Generation and Supply
- Medicines & Healthcare
- Transport (focus on aerospace & automotive)
- Creative Industries
- High Value Services
- Built Environment

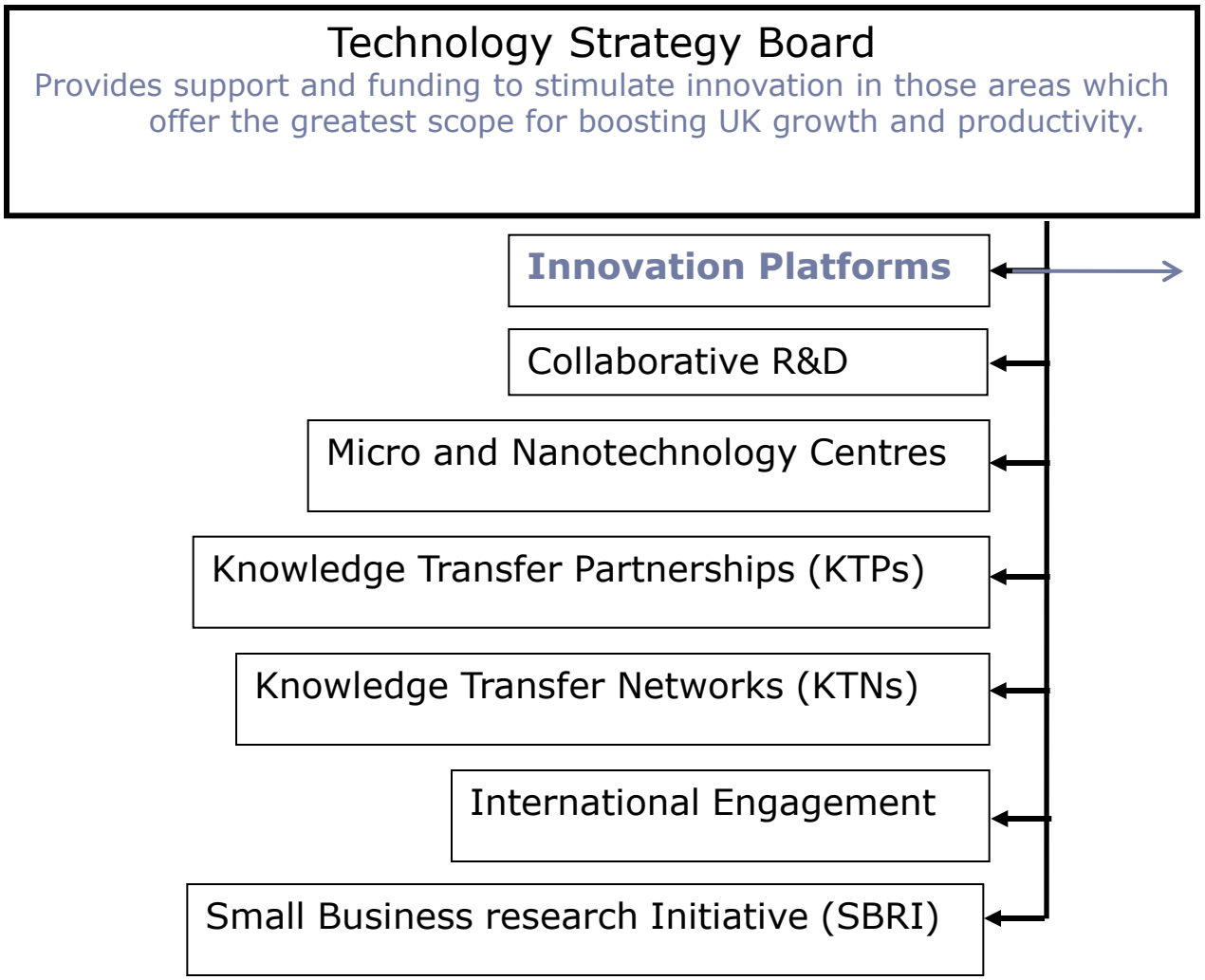
www.innovateuk.org

Technology Strategy Board



www.innovateuk.org

Technology Strategy Board



Concept:

- To pull together policy, business, government procurement and research perspectives and resources to generate innovative solutions to societal problems and make a real difference.

- Intelligent Transport Systems
- Network Security
- Low Carbon Vehicles
- Assisted Living
- Low Impact Buildings
- Detection and Identification of Infectious Agents (DIIA)

www.innovateuk.org/ourstrategy/innovationplatforms.ashx

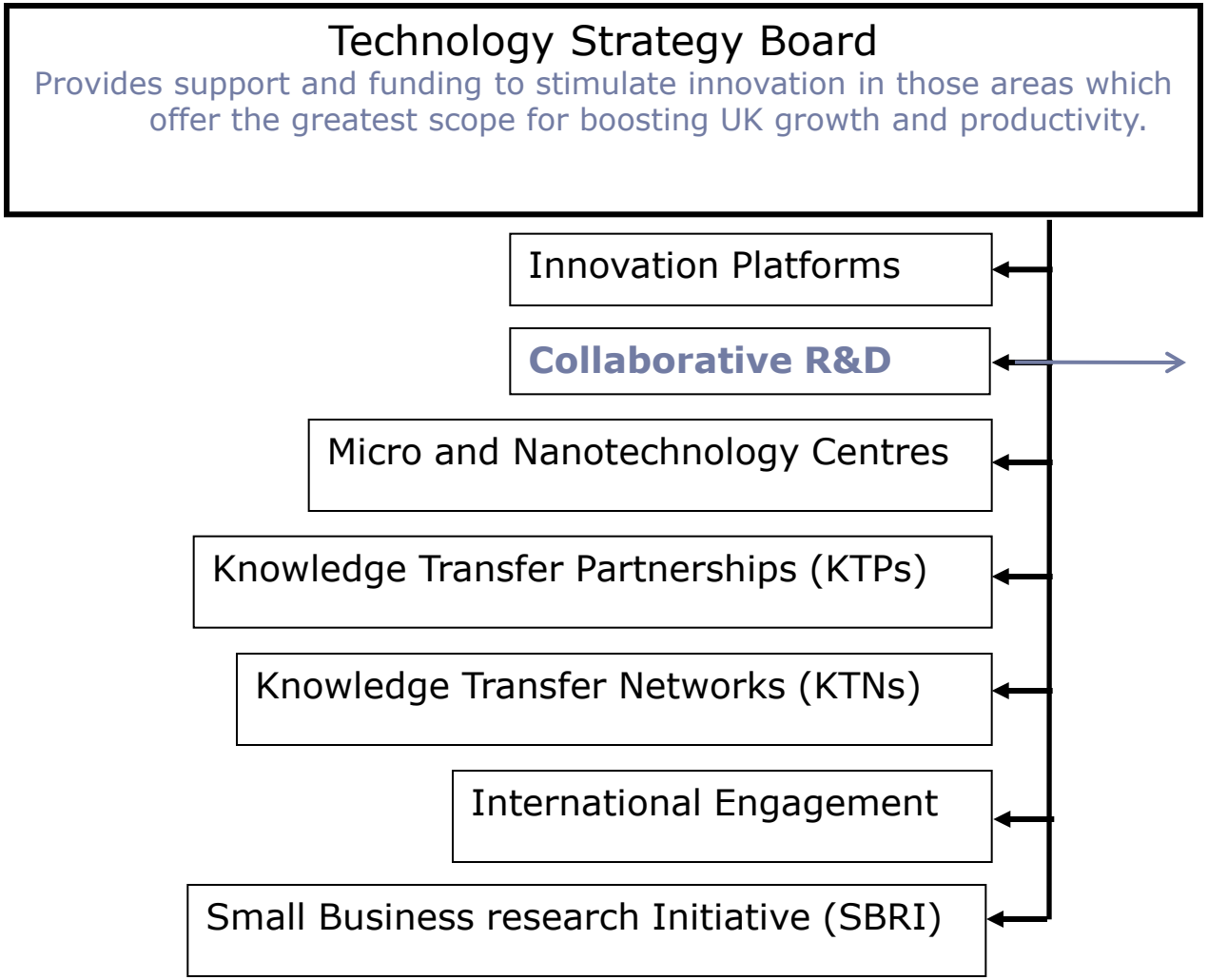
Technology Strategy Board

The Technology Strategy Board has announced a series of research and demonstration activities under the Low Carbon Innovation Platform

- Ultra low carbon vehicle demonstration competition
  - Technology Strategy Board aims to announce the successful projects in March.
  - £10m of funding available.
- Electrification of road transport
  - Call opened 19th January 2009 with a deadline for expressions of interest of 26th February 2009.
  - £10m for business led collaborative research and development
- Open technology competition covering all vehicle technologies capable of delivering carbon reductions
  - This competition will have between £5 and £10m available and applications will be invited from June 2009 with project decisions expected in November 2009.
  - £5 and £10m available.
- University led research on lower carbon vehicle technology
  - In 2009 EPSRC is putting £3m towards academic-led research

24

Technology Strategy Board



Requirements:

- Business and research work on R&D to deliver successful new products and services.
- R&D projects must have two or more collaborators, at least one from business.
- Project areas derived from KTAs .
- UK has capacity to develop and exploit the technology.
- Potential for impact in the right time frame .
- The size of the global market opportunity .
- TSB clearly adds value
- Funding for project usually 50%.

Results

- 2004-2007, > 600 projects approved for funding.
- Average of 5 organisations per project.
- Over a third of the organisations are SMEs.
- £1 billion of R&D investment.

www.innovateuk.org/deliveringinnovation/collaborativeresearchanddevelopment.ashx

Technology Strategy Board

The technology areas for which submissions have been invited:

Phase 1, opened 10 November 2008:

- Photonics: Next Generation Optical Internet Access (1st round)
- Advanced Materials: Sustainable Materials and Products
- Intelligent Transport Systems and Services: Informed Personal Travel

Phase 2, opened 19 January 2009:

- High Value Manufacturing
- Energy Generation and Supply: Maximising Recovery of UK's Oil and Gas Resources
- Photonics: Next Generation Optical Internet Access (2nd round)
- Low Impact Buildings: Design and Decision Tools

Phase 3, opened 16 March 2009:

- Creative Industries: Accessing and Commercialising in a Digitally Networked World
- Energy Generation and Supply: Fuel Cells and Hydrogen Technologies
- Network Security: Interdependency, Complexity and Risk

26

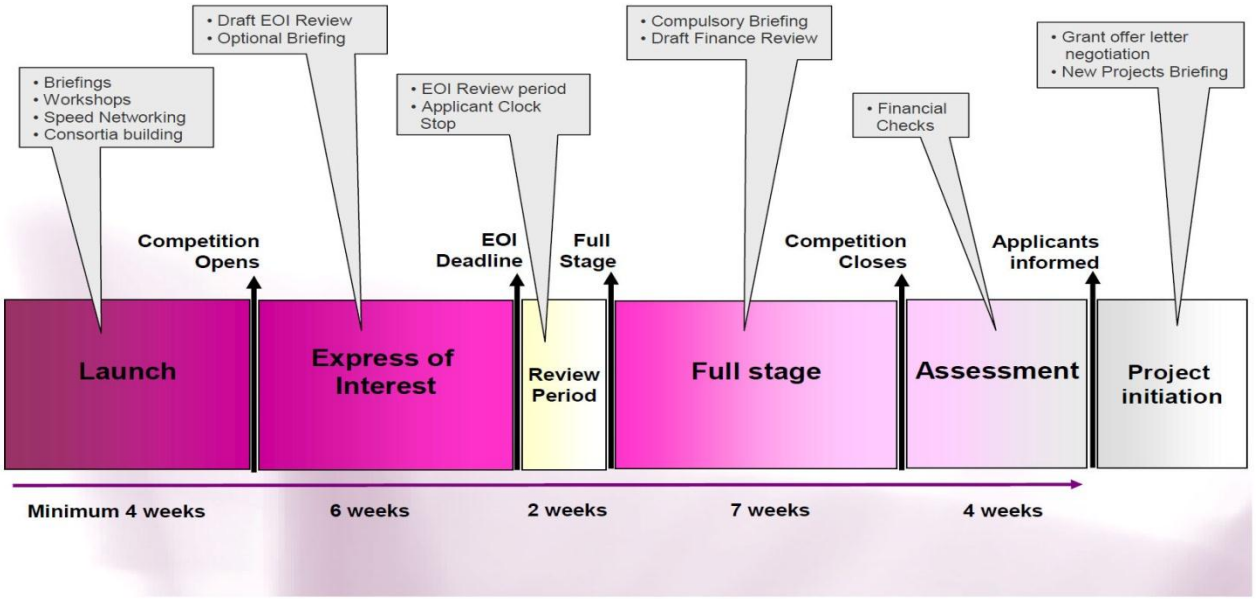
Technology Strategy Board

Current/recent calls:

- Low Carbon Vehicles - Integrated Delivery Programme Competition 3, closing date for outline proposals 22 September 2009
- Fuel Cells and Hydrogen Demonstration Programme, opened 10 September 2009
- Technology Inspired Area Feasibility Studies, opened 1 September 2009
- Digital Britain Feasibility Studies, opened 1 September 2009
- Regenerative Medicine Therapeutics Feasibility Studies, opened 1 September 2009
- Regenerative Medicine - Value Systems and Business Modelling, opened 1 September 2009
- New Approaches to Crop Protection, opens 18 January 2010
- Monitoring of Demonstrator Buildings, opening date to be determined

TSB Collaborative R&D

- 2 stage process; Expression of Interest & Full Stage.
- 19 week Application process.
- Rolling phases with 2 – 3 technology areas per phase.
- Independent assessors used to “grade” applications.
- Large projects, > £10m public sector funding, also assessed.



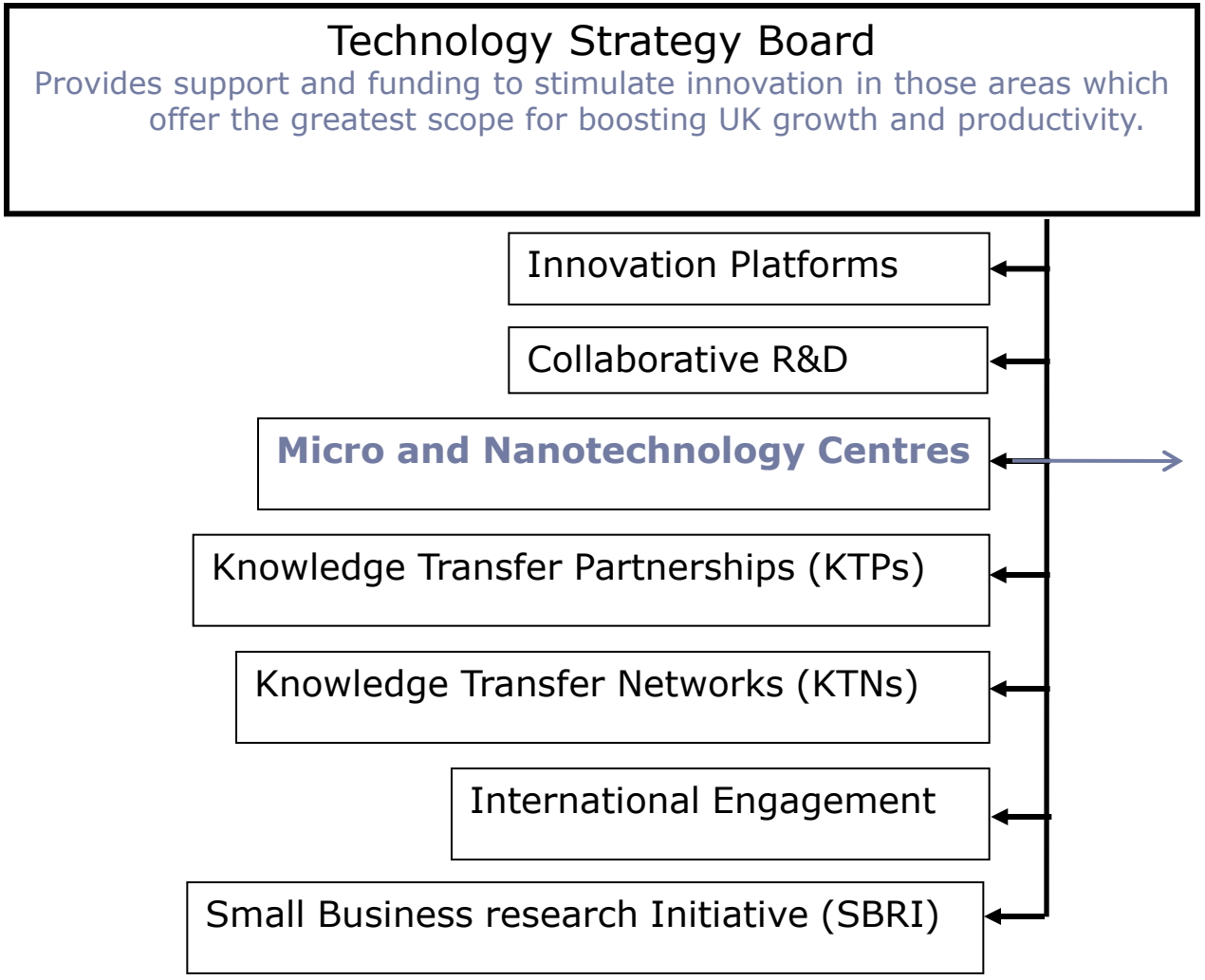
TSB – High Value Manufacturing

- Focus on innovation in four broad areas, “The Four Pillars of High Value Manufacturing”:
  - Products
  - Production Processes
  - Service Systems
  - Value Systems
- Step Change (25-50% improvement in current performance) in:
  - Overall manufacturing costs
  - Whole life-cycle costs
  - Whole life environmental impact
  - Product performance, durability and reliability
  - Sales volumes
  - Time to market
- Funding £24m (with £3m to Value systems).

- Large projects considered.
- Scope and industry sector guidance provided.
- Dates:
  - Information day 5th November 2008
  - Competition opens 19th January 2009
  - Briefing day (optional) 4th February 2009
  - Expressions of Interest deadline 26th February 2009
  - Feedback provided by 16th March 2009
  - Feedback discussion in week beginning 16th March 2009
  - Applicants briefing (mandatory) 25th March 2009
  - Registration of intent to submit (mandatory) 23rd April 2009
  - Deadline for receipt of full applications 30th April 2009
  - Decision and feedback to applicants 29th May 2009

http://www.innovateuk.org/_assets/pdf/competition-documents/highvalmanufacturing_competition_071008.pdf

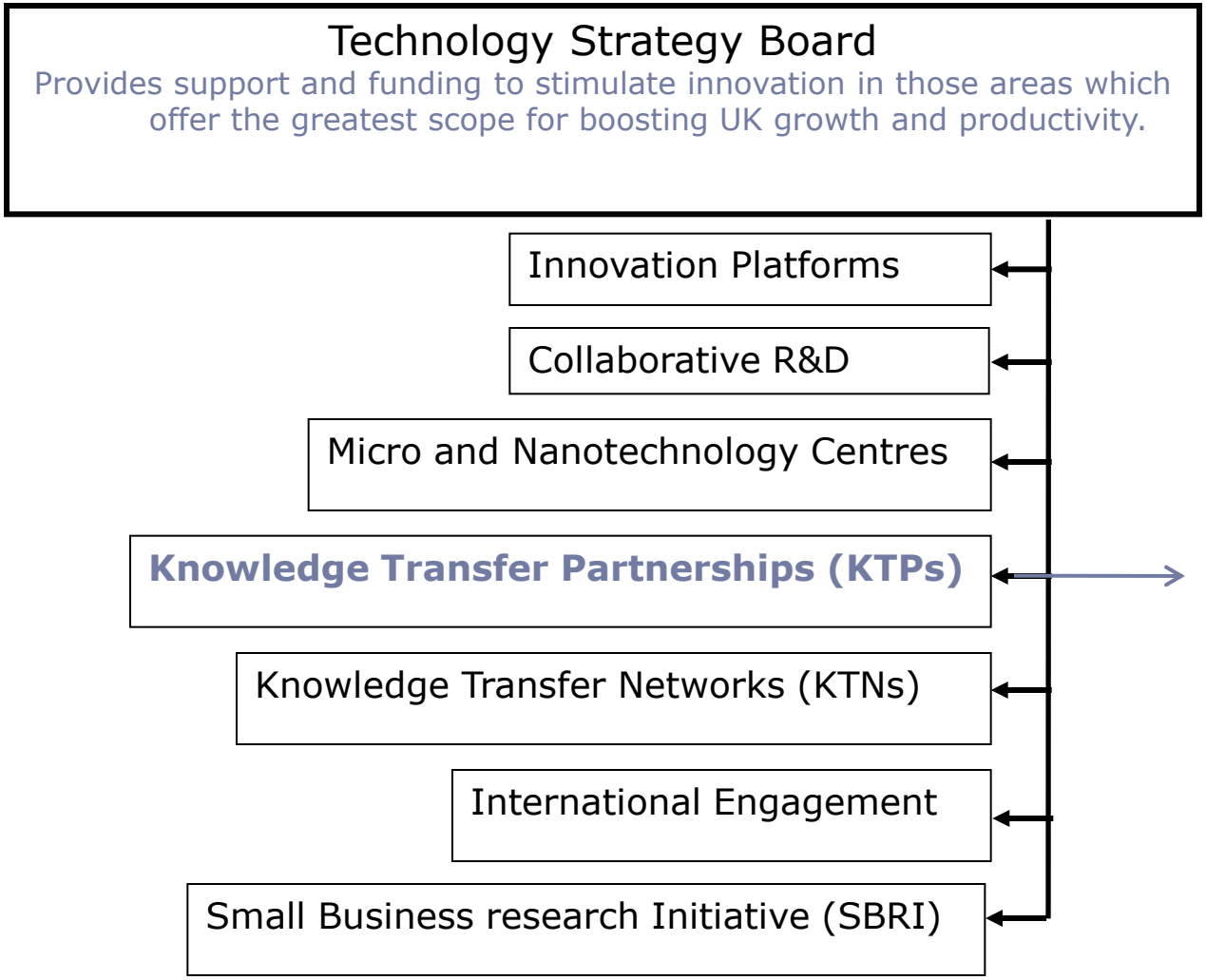
Technology Strategy Board



- **INEX**
- **UK-LMC**
- **MicroBridge**
- **BondCentre**
- **SemeMEMS**
- **Cambridge Uni. Nanoscience Centre**
- **Qudos Technology Ltd**
- **MNT - BAE Systems ATC**
- **KNT-Photonix**
- **MetaFAB,**
- **CEMMNT Hub Ltd**
- **Begbroke Nano**
- **UK-MNT-Bionanotechnology Centre**
- **Eminate**
- **Fluence - Epigem Limited**
- **Dolomite Centre Ltd**
- **Nano Central**
- **Comina - QinetiQ Nanomaterials Ltd**
- **Materials Solutions**
- **NanoForce**
- **Centre for Micro and Nano Moulding**
- **Plastic Electronics Technology Centre**
- **Institute of Occupational Medicine**
- **Safenano**

www.innovateuk.org/deliveringinnovation/micronanotechnologycentres.ashx

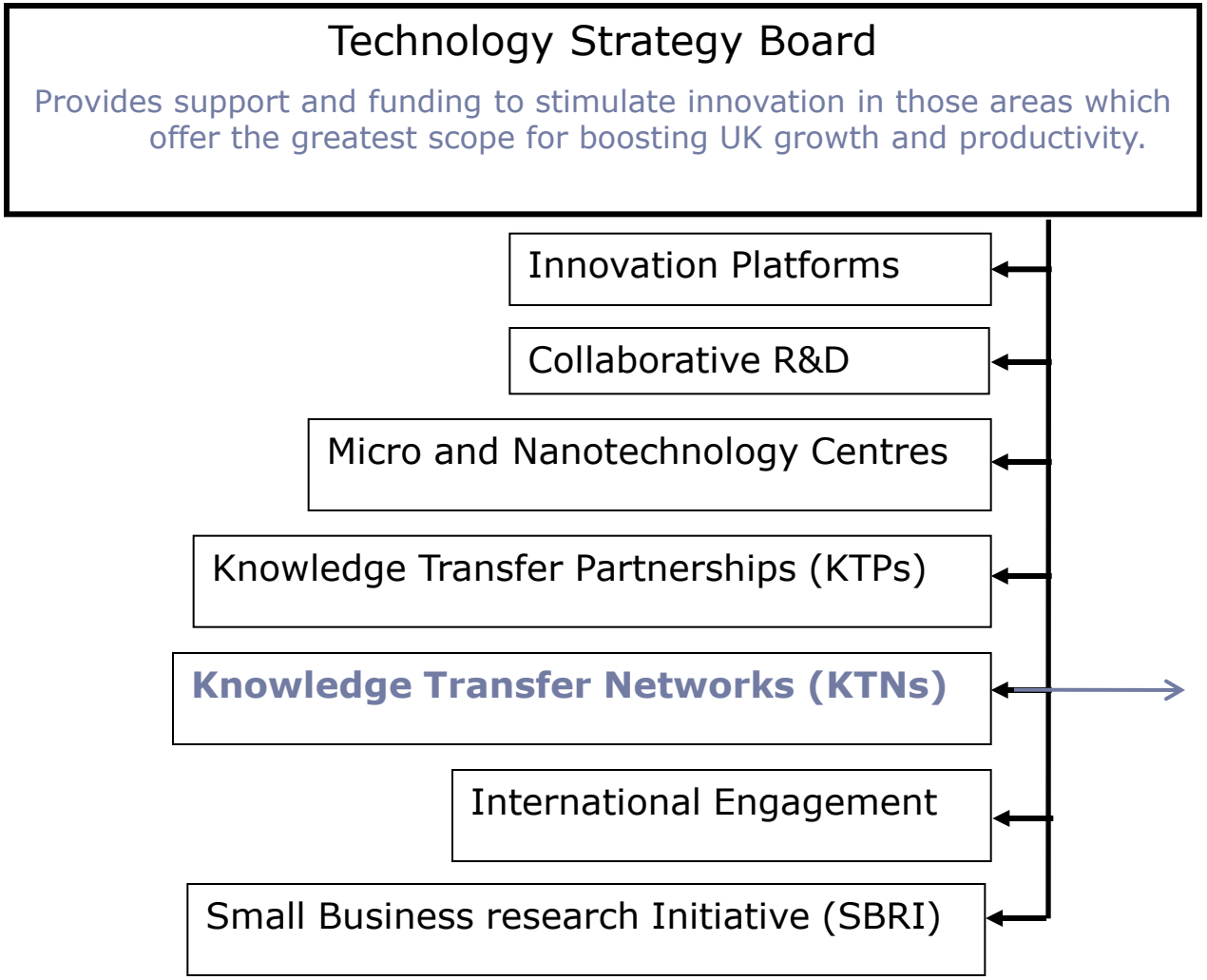
Technology Strategy Board



- Relationship between company and academic institution.
- Recently qualified person employed in company, supervised by academic.
- 1-3 years.
- Funding covers academic costs.
- Costs for company vary between 1/3 and 1/2 of the project costs, depending on size.

www.ktponline.org.uk

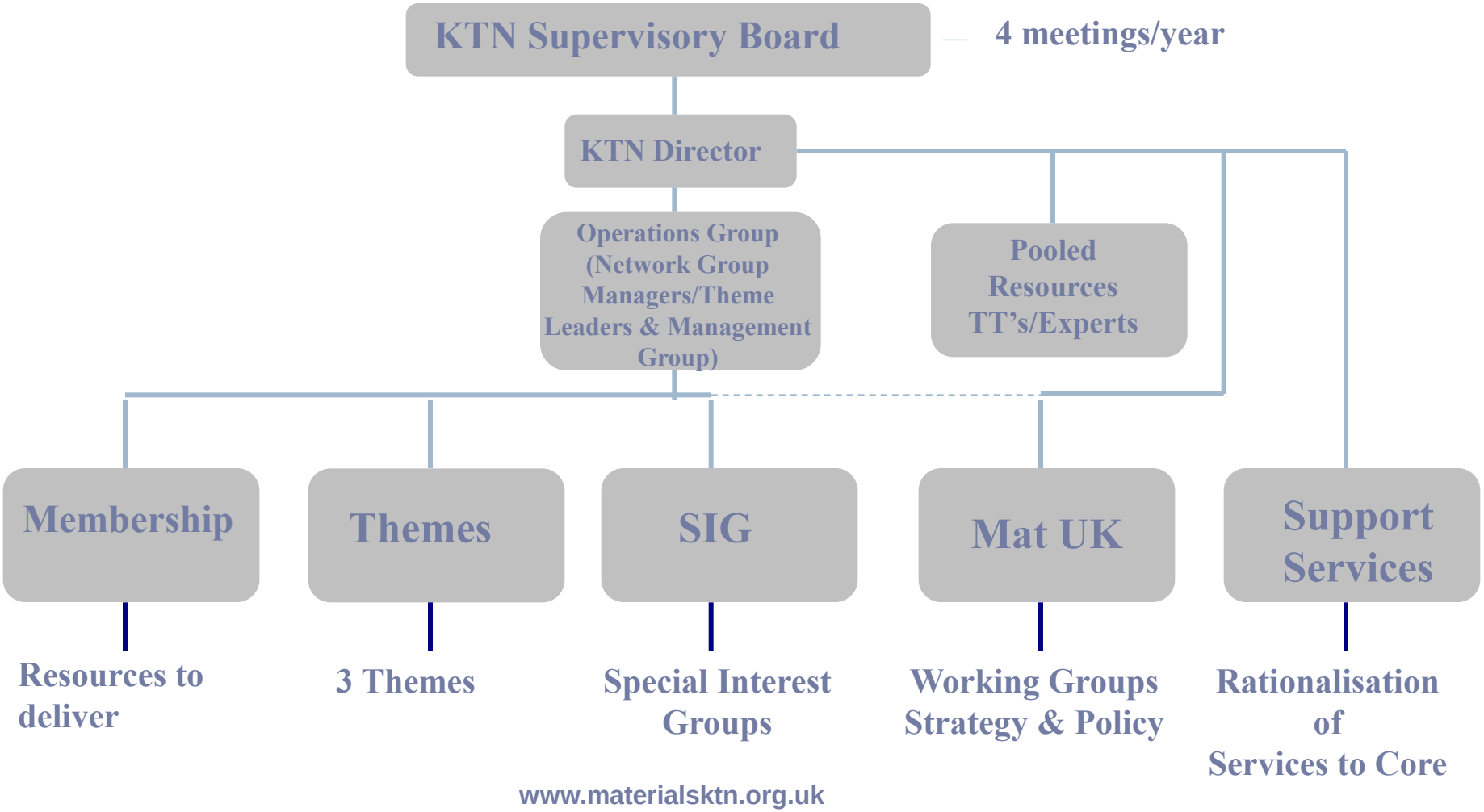
Technology Strategy Board



- Aerospace and Defence
- Biosciences
- Chemistry Innovation
- Creative Industries
- Digital Systems
- Digital Communications
- Electronics, Sensors & Photonics
- Energy Generation & Supply
- Environmental Sustainability
- Financial Services
- HealthTech & Medicines
- Industrial Mathematics
- Materials
- Nanotechnology
- Modern Built Environment
- Transport

https://ktn.innovateuk.org/web/guest/networks

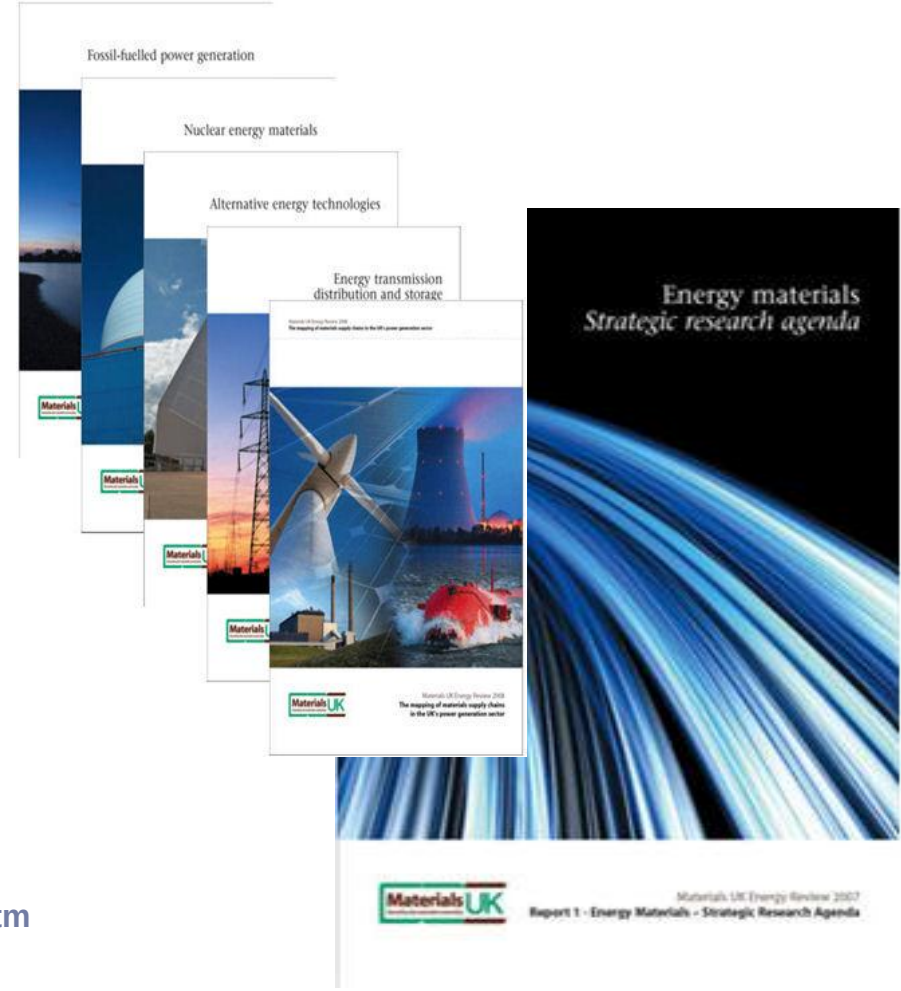
Materials KTN



www.materialsktn.org.uk

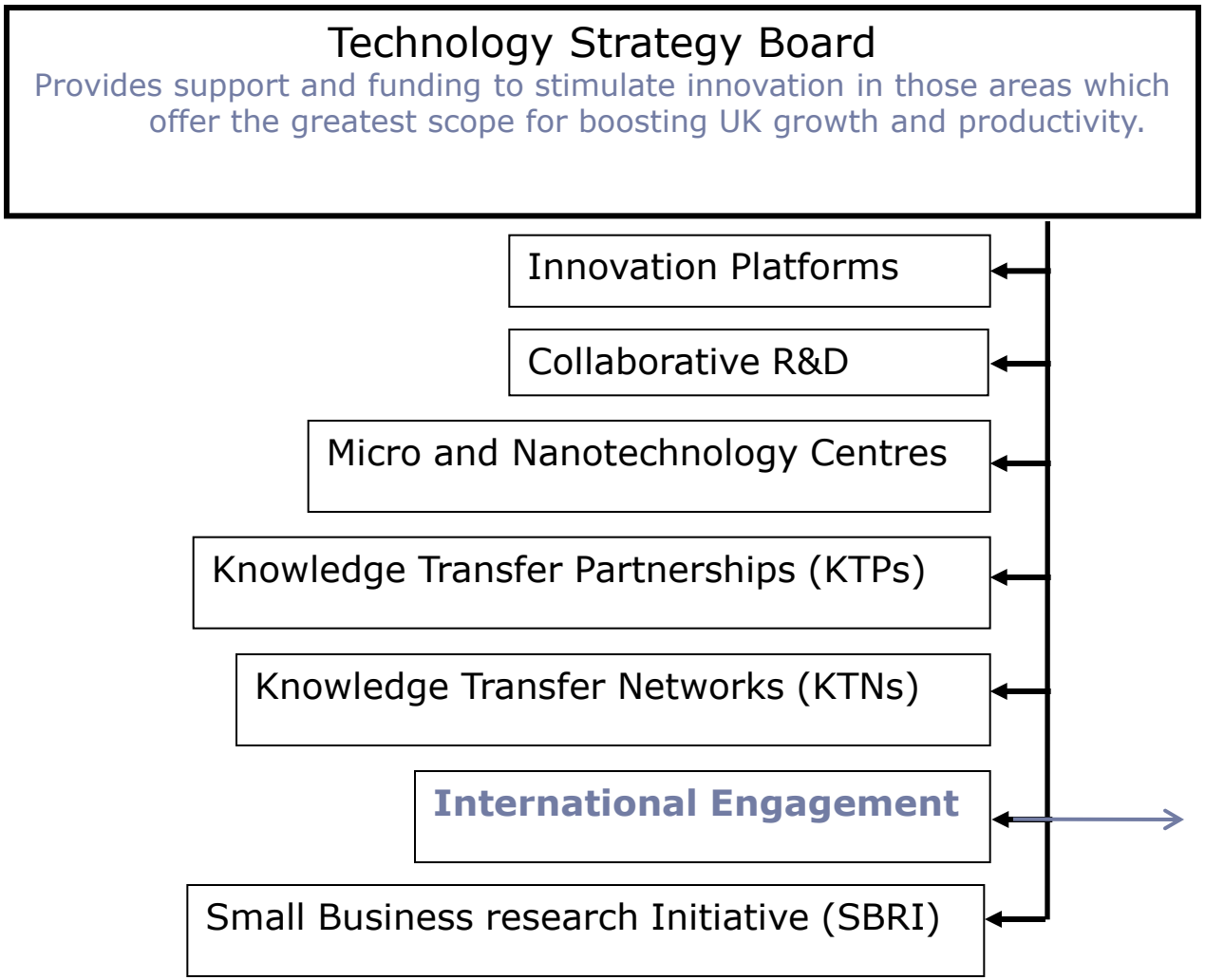
Mat UK – Energy Materials

- Energy Materials Workgroup chaired by Derek Allen, Alstom.
- Subscription based.
- Produced strategic research agenda.
- Need to identify priorities.
- Stakeholder workshop to be run by TSB and MatUK, Spring 2009.
- Possibility of energy materials call/grand challenge end 2009/ 2010.



www.matuk.co.uk/energy.htm

Technology Strategy Board



TSB currently provides:

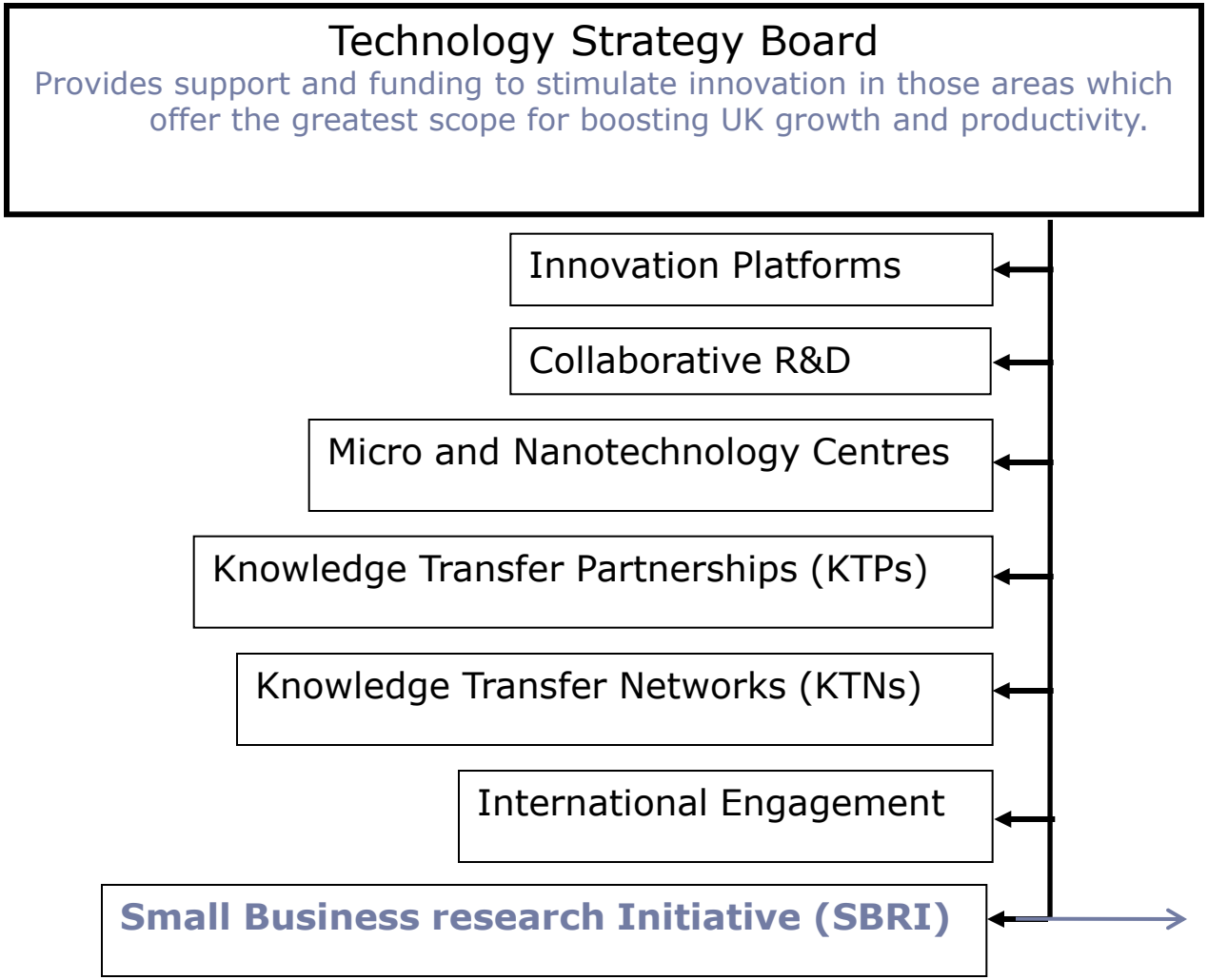
- Advice on EUREKA and support in Eurostars,
- Advice through the FP7UK website and a network of National Contact Points for the European Framework Programme
- Support for some specific EU activities

International programmes include:

- Ambient Assisted Living
- ARTEMIS
- Clean Sky
- European Institute of Innovation & Technology
- ENIAC
- EUREKA
- Eurostars
- Fuel Cells & Hydrogen
- Innovative Medicines Initiative

http://www.innovateuk.org/deliveringinnovation/internationalprogramme.ashx

Technology Strategy Board



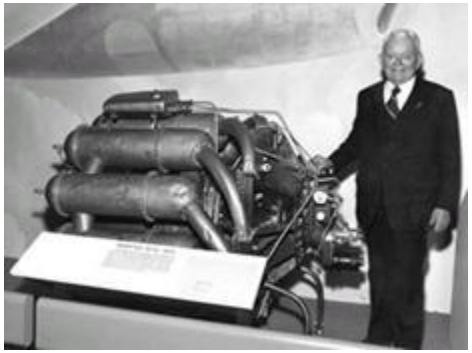
- Procurement programme
- Govt Depts buy research and development services, helping to bring new technologies to market and leading to the possibility of future commercial procurement in the public sector.
- Developments 100% funded
- Targeted at identified needs in each Department, increasing the chance of exploitation.
- Suppliers selected by an open competition process and retain the IPR generated from the project, with certain rights of use retained by the contracting Department.
- Pilots running across two Govt Depts (MoD and DoH) in the second half of 2008.
- Full roll-out of the reformed model to other Departments from April 2009.

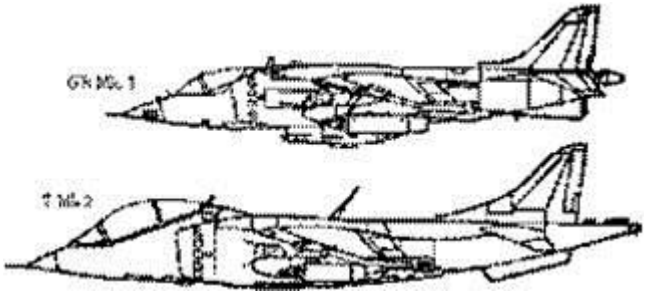
http://www.innovateuk.org/deliveringinnovation/internationalprogramme.ashx

UK Aerospace History

The UK has a long history of technological firsts in aerospace:

- Jet engine
- Airborne radar
- Civil jet airliner (De Haviland Comet)
- Turboprop airliner (Vickers Viscount)
- Jet vertical take off and landing (VTOL)
- Combat aircraft (Harrier)
- Supersonic commercial aircraft (Concorde)

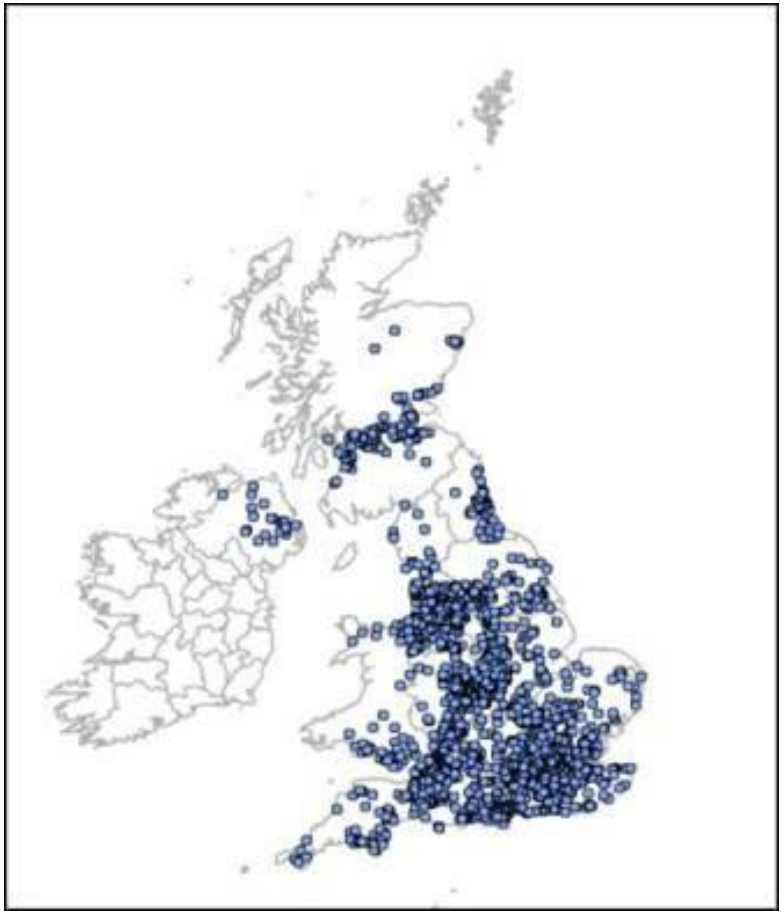




UK Aerospace

- Second largest aerospace industry in the world after the USA.
- Comprises more than 2,600 companies and employs more than 100,740 people directly.
- One of the primary assets of high value-added manufacturing, generating turnover in the UK in 2008 of £20.57 billion.
- In 2008, new orders increased by to a record high of £35.04 billion.
- One of the UK's largest exporters - in 2008, UK companies generated an additional £8.12 billion sales and £11.14 billion orders overseas.
- High investor in research & development. £1.82 billion in 2008,

Source: SBAC Survey 2009



Trade Associations

- AeroSpace Defence Security (ADS) (formerly SBAC)

- Regional Partners include:
  - West England Aerospace Forum (WEAF)
  - Farnborough Aerospace Consortium (FAC)
  - Midlands Aerospace Alliance (MMA)
  - Aerospace Wales
  - Northern Defence Industries (NDI)
  - Northwest Aerospace Alliance (NAA)

UK Aerospace R&D + Innovation

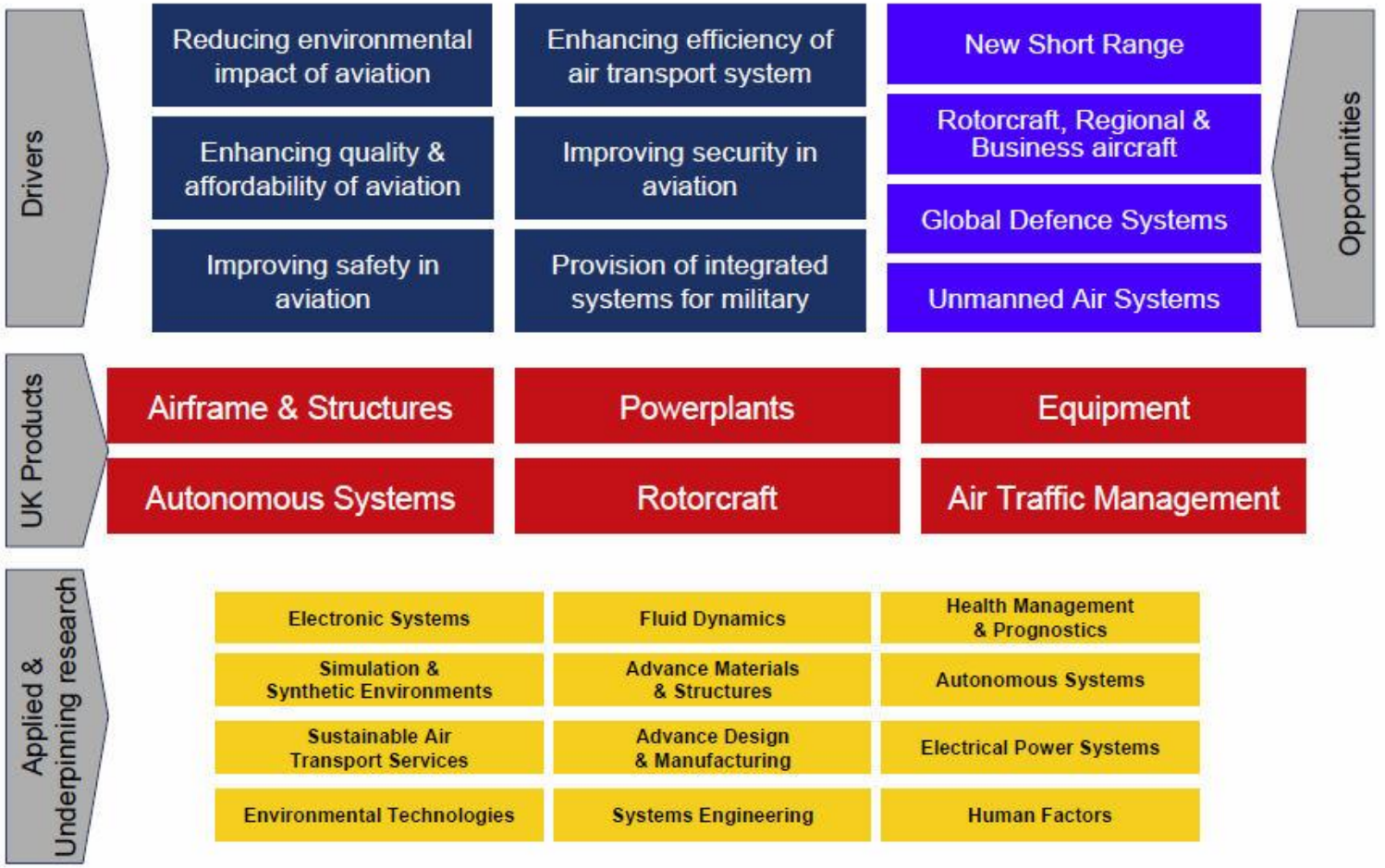
- R&D undertaken in UK by leading companies like BAE Systems, Airbus, Rolls Royce, Bombardier, Boeing and Thales.
- UK Government is working to make UK R&D the most innovative and productive in the world (2006 Budget target of R&D investment = 2.5% national income by 2014).
- Collaboration between government and industry to maintain the UK's global excellence in aerospace R&D.
- The industry-led Aerospace and Innovation and Growth Team (AeIGT), considered how by 2022 "the UK will offer a global Aerospace Industry the world's most innovative and productive location, leading to sustainable growth for all its stakeholders". Report produced in 2003.
- The recommendations in relation to research led to the creation of the National Aerospace Technology Strategy.

National Aerospace Technology Strategy

- The National Aerospace Technology Strategy (NATS) addresses the critical aerospace technologies required to both ensure UK competitiveness in the foreseeable global aerospace markets, and helps industry to meet the ambitious environmental performance targets of aviation.
- NATS catalyses the UK stakeholder community to come together to shape and deliver the nation's aerospace technology agenda.
- The Strategy identifies the technologies and capabilities that must be embedded in the UK supply chain to ensure its long term competitiveness.
- This vision is captured in a comprehensive set of technology roadmaps, authored collaboratively by the aerospace industry.
- The Strategy is delivered via collaborative research and development programmes, with joint investment from industry and Government.
- Research identified in NATS complements that which is conducted by UK companies through other vehicles such as the European Framework Programme.

https://ktn.innovateuk.org/web/national-aerospace-technology-strategy-nats

National Aerospace Technology Strategy



Aerospace & Defence KTN

- The Aerospace & Defence Knowledge Transfer Network (A&D KTN) is a single overarching network spanning Government, Industry and Academia with the principal aim of promoting and enabling innovation in the UK.
- Fully funded by the Technology Strategy Board, all services are FREE and available to anyone with an interest in Research and Technology development relevant to the Aerospace & Defence sectors.
- As the Custodian of the National Aerospace Technology Strategy (NATS), the A&D KTN enables its delivery by ensuring maximum awareness, engagement and alignment within the A&D sectors.

www.aerospaceanddefencektn.org.uk

Aerospace NTCs

The Aerospace and Defence KTN is now responsible for the management of the National Technical Committees (NTCs), which have been set up to advise the KTN, Government and Industry on key technological themes, as well as the future research and technology priorities that should be invested in.

Current NTCs:

- Advanced Design & Manufacturing
- Autonomous Systems Electrical Power Systems NTC
- Electronics Systems NTC
- Environmental Technologies NTC
- Fluid Dynamics NTC
- Health Management & Prognostics NTC
- Human Factors NTC
- Materials and Structures NTC
- Simulation and Synthetic Environments NTC
- Sustainable Air Transport Services NTC
- Systems Engineering and Open Architecture NTC

https://ktn.innovateuk.org/web/national-technical-committees-ntcs

Aerospace Technology Roadmaps

The objective of the Technology Roadmaps is to inform stakeholders from across the Aerospace and Defence community of the expected research and technology development programmes and estimated investment required until 2020.

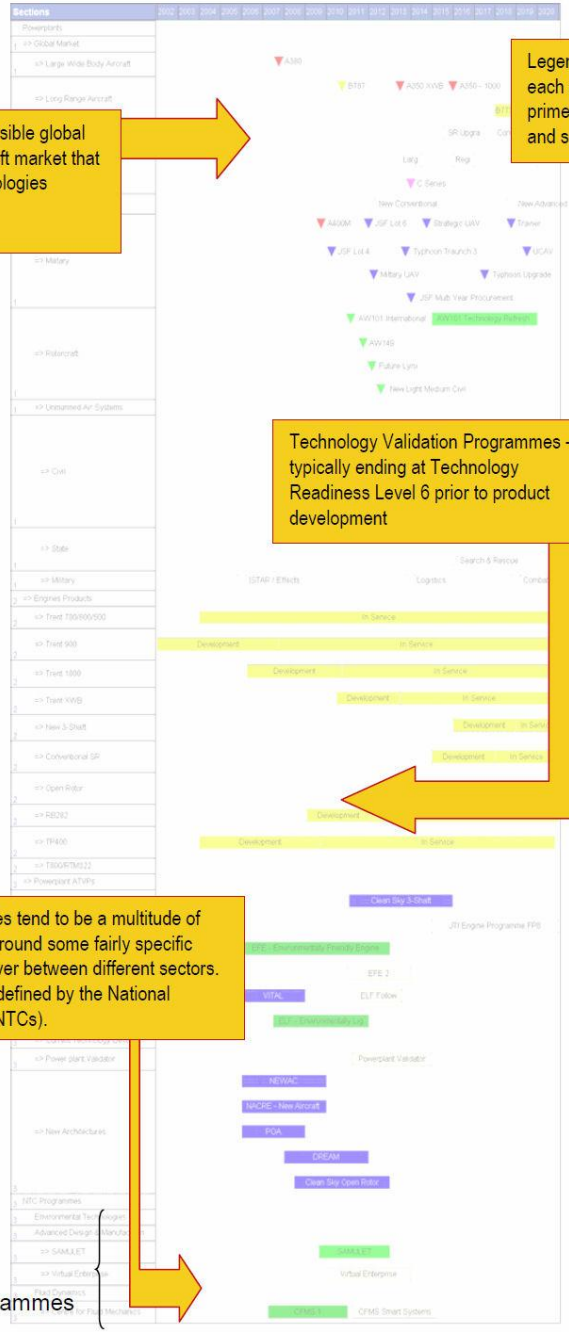
The Roadmaps identify the activities necessary to ensure the UK Aerospace sector remains in a formidable position to compete in the foreseeable market opportunities.

The Roadmaps show:

- Top down review of global market drivers and indicate service entry dates
- How, where and when UK products will fit into global market
- The Technology and Innovation Programmes (TRL 1-4) and Validation and Demonstration Programme (TRL 4-6) that need to develop to ensure UK industry is in a strong position to make the most of the market opportunities.

https://ktn.innovateuk.org/web/national-aerospace-technology-strategy-nats/articles/-/blogs/technology-roadmaps?ns_33_redirect=%2Fweb%2Fnational-aerospace-technology-strategy-nats%2Farticles

How To Read The Roadmaps



The future accessible global aerospace aircraft market that drives UK technologies

Legend – the legend colour codes each section of the roadmap by prime/manufacturer, lifecycle status and source of funding.

Technology Validation Programmes – typically ending at Technology Readiness Level 6 prior to product development

Applied research activities tend to be a multitude of smaller projects based around some fairly specific needs and often cross over between different sectors. These programmes are defined by the National Technical Committees (NTCs).

NTC Programmes

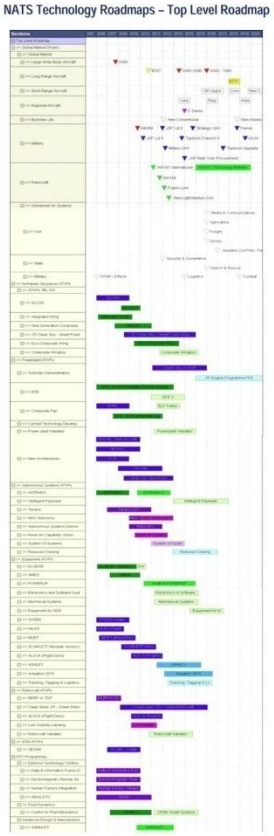
Market Prime/ Manufacturer
- Airbus
- AgustaWestland
- BAE Systems
- Boeing
- Bombardier

Product Lifecycle Stage
- Concept
- Development
- In Service
- Phase 1 Airframe
- Phase 1 Engine

Programme Funding status
- UK - Funded
- UK - Bid
- UK - Aspiration
- MOD - Funded
- MOD - Bid
- MOD - Aspiration
- EU - Funded
- EU - Bid
- EU - Aspiration

National Aerospace Technology Strategy

Top level Roadmap aggregated from individual Roadmaps



[Airframes and Structures](https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8224.pdf)
https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8224.pdf

[Autonomous Systems](https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8226.pdf)
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[Equipment](https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8227.pdf)
https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8227.pdf

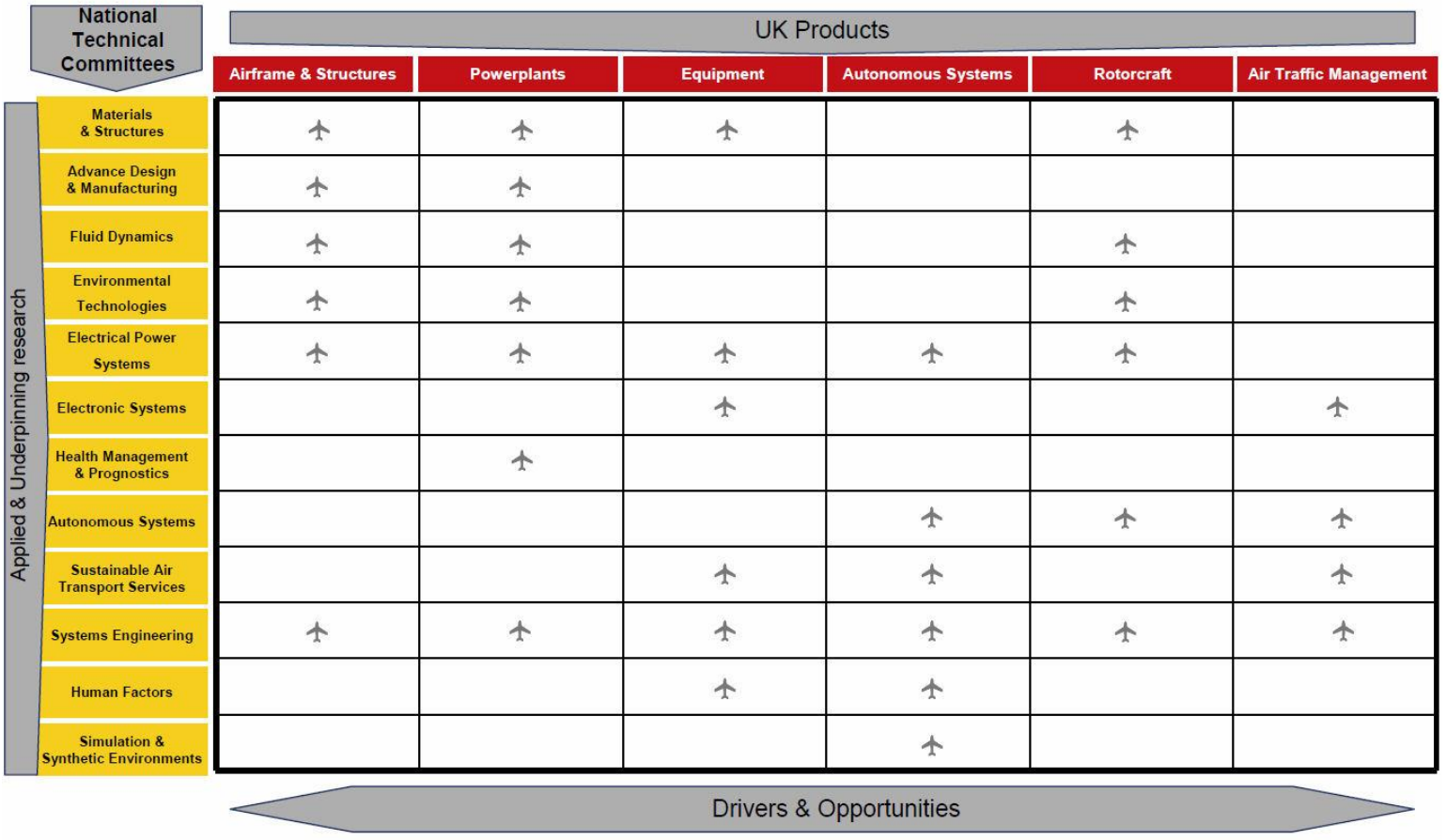
[Powerplants](https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8228.pdf)
(https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8228.pdf)

[Rotorcraft](https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8229.pdf)
(https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8229.pdf)

[Air Traffic Management](https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8225.pdf)
(https://ktn.innovateuk.org/c/document_library/get_file?p_l_id=71242&folderId=195133&name=DLFE-8225.pdf)

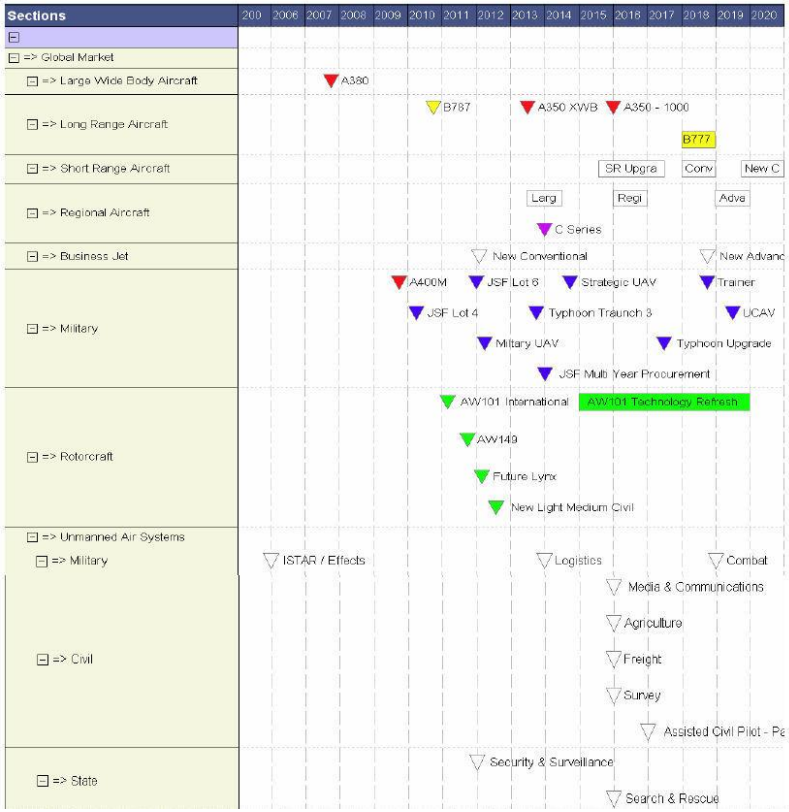
NTC Engagement in Roadmaps

NATS engagement and interaction process



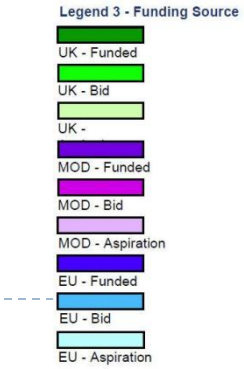
Technology Validation Programmes

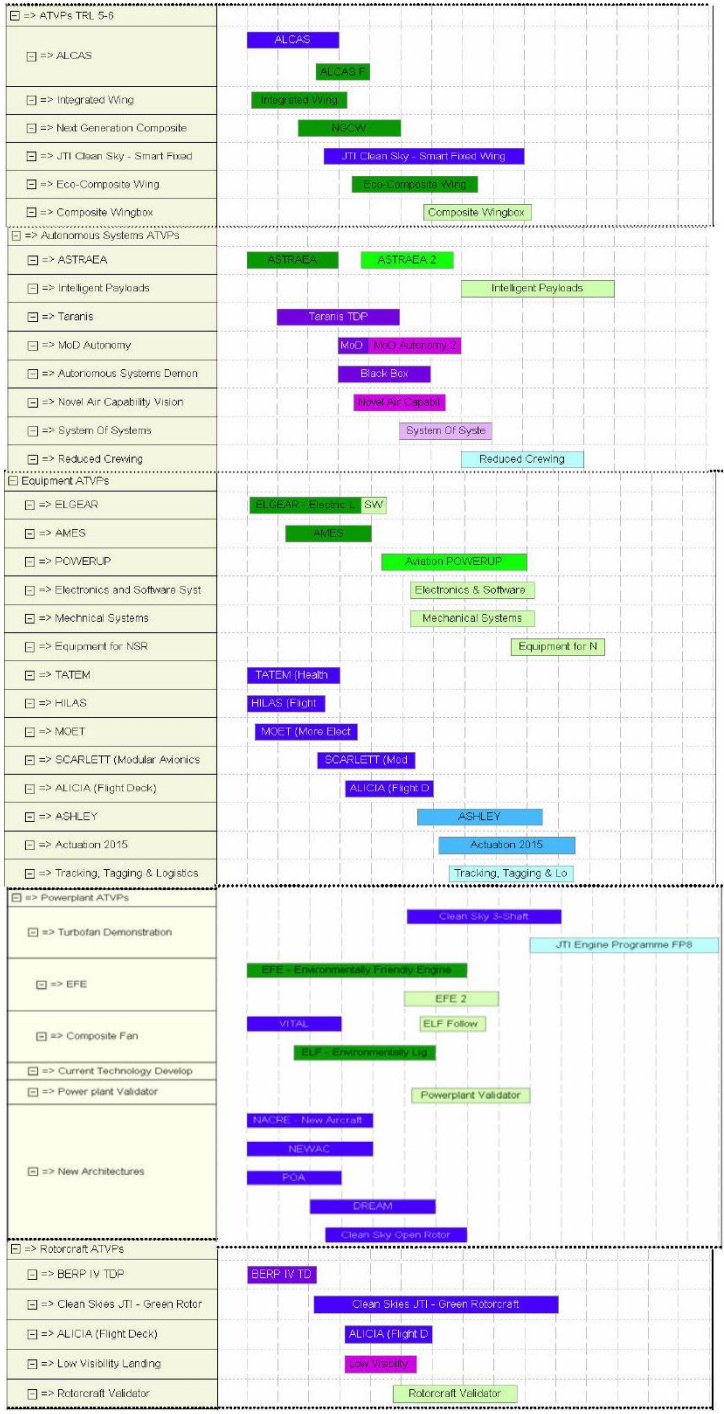
Global market – future platforms



ATVPs are the research programmes that help develop technology for future platforms.

ATVPs



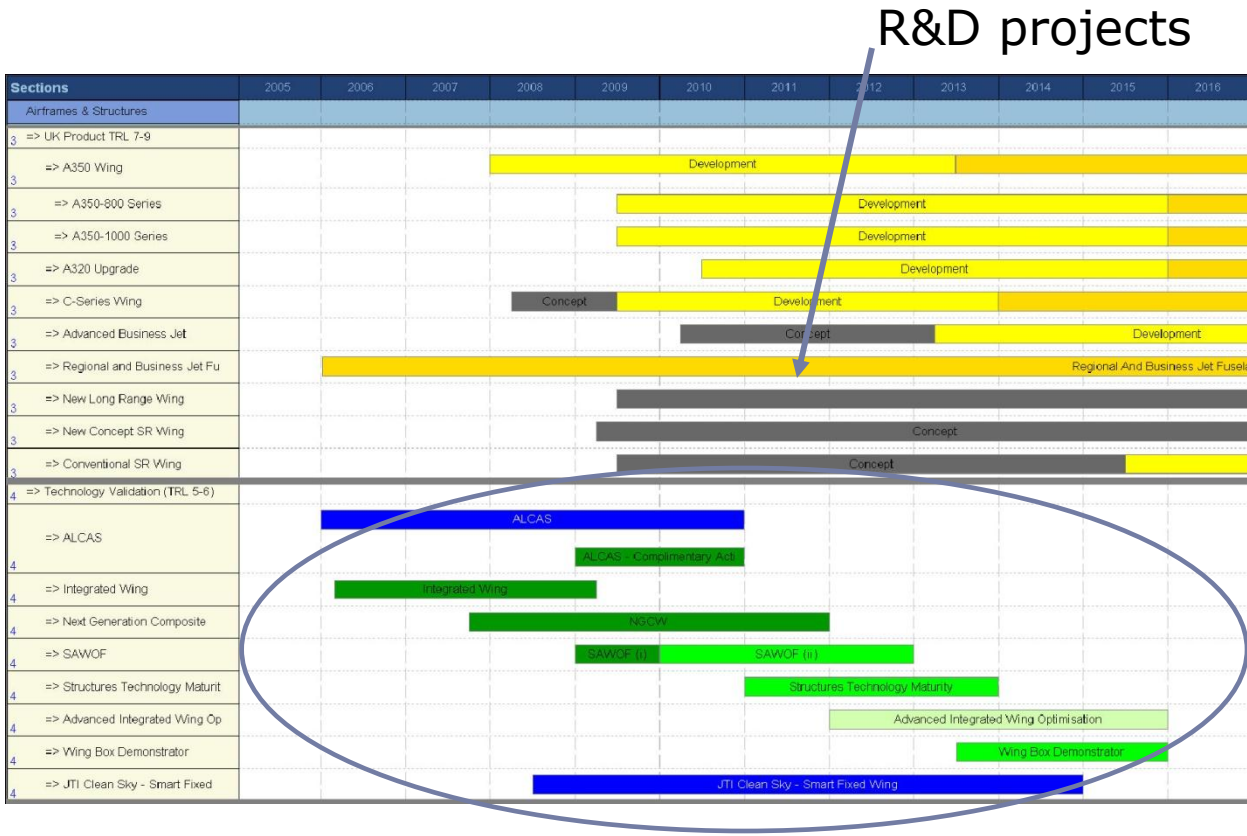


Airframes and Structures Roadmap

Within the Airframe and structures roadmap, composite technology development plays a major role in many programmes:

- ALCAS
- Integrated Wing
- Next Generation Composite Wing
- Clean Skies

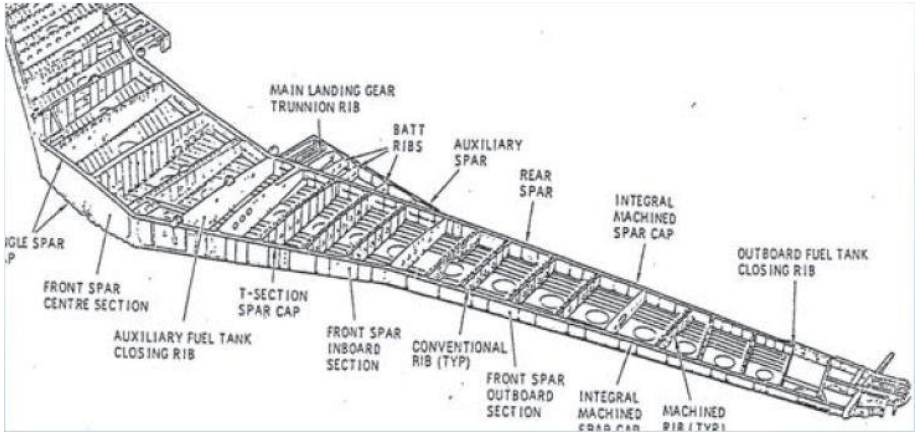
(More details on some of these in following slides)

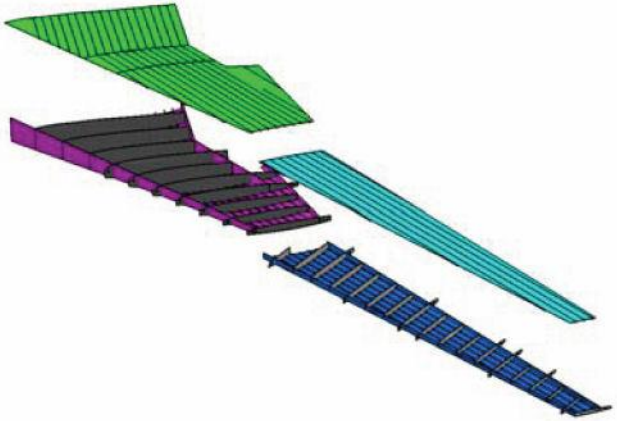


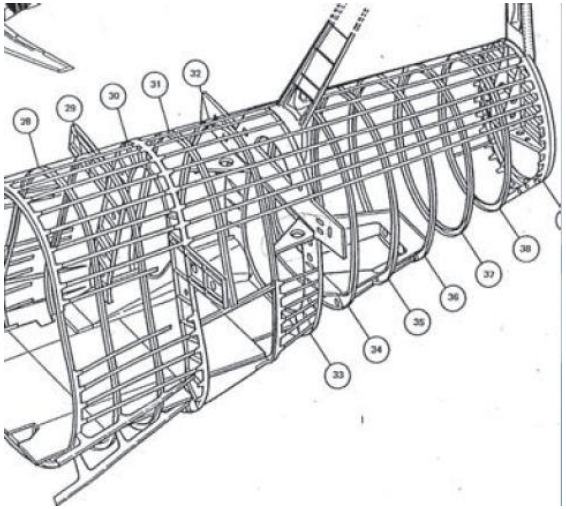
ALCAS

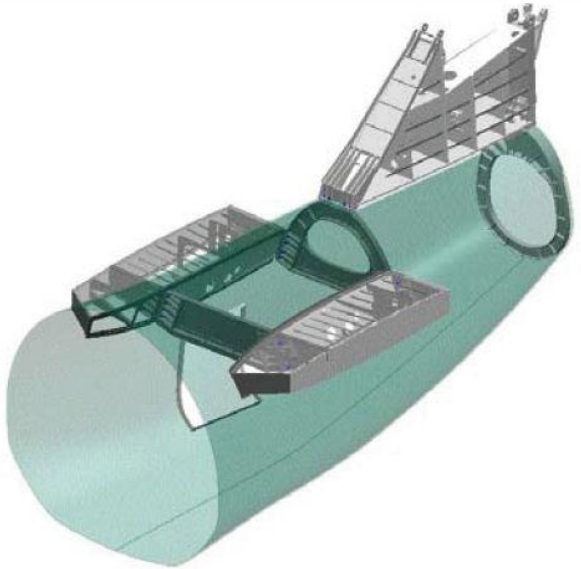
- Integrated Project under the EU Framework Programme.
- 59 partners from 18 countries (12 from UK including Airbus (lead), GKN, ACG Messier Dowty, Bombardier).
- Total cost €101,277,380, funding €53,460,000, 2 years.
- Objective: to develop more affordable composite solutions for primary structure through high component integration.
- Airliner Platform:
  - Objective - 20% weight saving, zero increase in recurring cost against metal
  - Wing – build on Tango. Challenges include the inner wing structure, including engine and landing gear attachment
  - Fuselage - Complex fuselage design features, enhanced damage capability and system integration requirements. Reduced maintenance costs.
- Business Jet Platform:
  - Objective - 20-30% reduction in recurring costs, with a 10% weight saving against metallic structures
  - Wing - focus on high-structural integration. Validation will be through design, manufacture and test of a full-scale wing of partial length
  - Fuselage – design, manufacture and test full-scale rear fuselage

ALCAS Component Integration







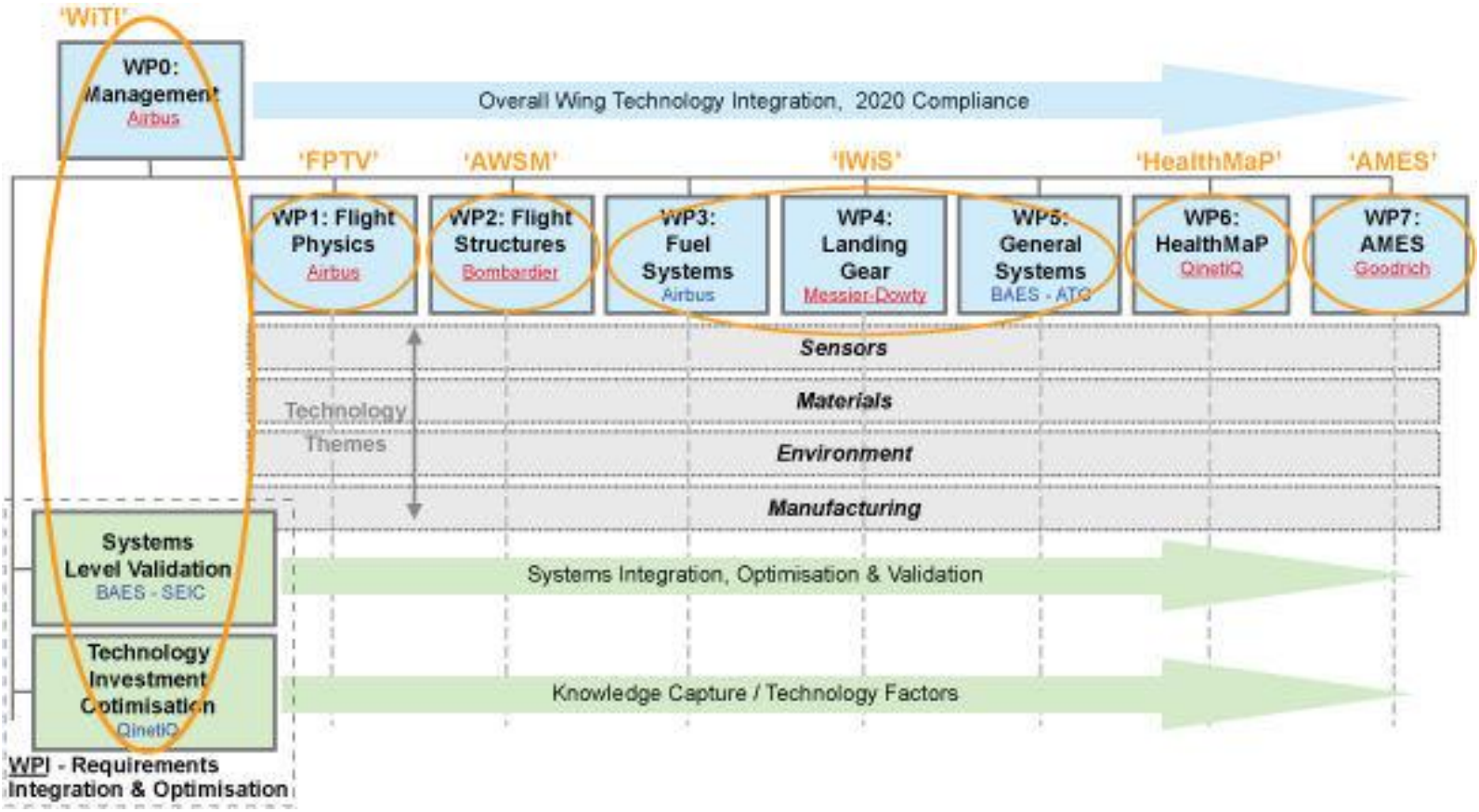


Integrated Wing

- Integrated Wing ATVP is one of the UK national, collaborative, Aerospace Technology Validation Programmes proposed by the Aerospace Innovation and Growth Team (AeIGT), part of the National Aerospace Technology Strategy.
- 21 UK organisations (including Airbus, Bombardier, GE, BAE, QinetiQ, TWI, Messier Dowty, Queens University Belfast)
- Total cost £38 million. 50% from industrial partners. Remainder 2/3 by TSB, 1/3 by RDAs/DAs in South West and South East England, Wales and Northern Ireland. Yorkshire and the East Midlands also support partner facilities.
- The UK has established itself as a centre of excellence for wing design and manufacture. Integrated Wing brings the opportunity to develop and validate 'high-risk / high-potential' technologies and innovations for new wing designs from 2020 by:
  - 'Pulling-through' technologies from UK research community.
  - Validating specific wing related technologies for exploitation in the short to medium term.
  - Optimising integration of advanced technologies to drive 'step-change' improvements.
  - Full lifecycle technology impact assessment (cost and environment are key).

www.integrated-wing.org.uk

Integrated Wing



NGCW

- Funded by Technology Strategy Board - 2007 call in design engineering and advanced manufacture.
- Total project £103 million, including £25m from TSB, £26m from RDAs and DAs and £52 from partners over 3 years.
- 17 partners: Airbus (lead), Advanced Composite Group, Aircraft Research Association, Atkins Ltd, Bombardier Aerospace, Delmia UK Ltd, Eaton Aerospace Ltd, GE Aviation, GE Digital Systems, GKN Transparency Systems, Goodrich Actuation Systems, Hyde Group Ltd, KuKa Automation, Messier - Dowty, Morgan Professional Services, QinetiQ Ltd, Spirit Aerosystems Ltd.
- Aims to keep the UK at the cutting edge of innovation in aircraft wing development by ensuring the UK is competent and well-equipped to maximise the use of weight-saving composite materials in future wing design and development
- The generic challenges faced for future composite wings are similar to those faced on other composite parts of the aircraft, however:
  - specific solutions required due to the unique combination of factors that need to be integrated to achieve an optimum wing solution
  - optimised wing solutions also pose specific manufacturing challenges

NGCW

Objective

To ensure that mature technologies are available to enable the design, development, validation, manufacture, equipping and testing of lightweight, aerodynamically efficient and low cost to produce wings which are optimised with the overall aircraft ensuring minimum environmental impact.

Multi-Disciplinary Optimised Wing	High Volume Low Cost Wing	Integrated Equipped Wing
Development of technologies necessary for design, development and validation:- • WP1 - Integrate • WP2 - Create • WP3 - Develop • WP4 - Produce	Development of technologies necessary for wing manufacture and assembly:- • WP1 - Component Manufacture Processes • WP2 - Assembly Processes • WP3 - Manufacturing System Development • WP4 - Wing Concept Integration & Demonstration	Development of technologies necessary for wing systems installation, equipping and test:- • WP1 - Systems Integration & Installation • WP2 - Systems Demonstrators • WP3 - Installation / Test Equipment & Processes • WP4 - Aircraft Integration

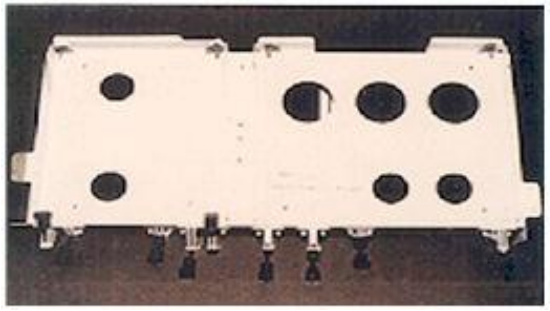
AMRC

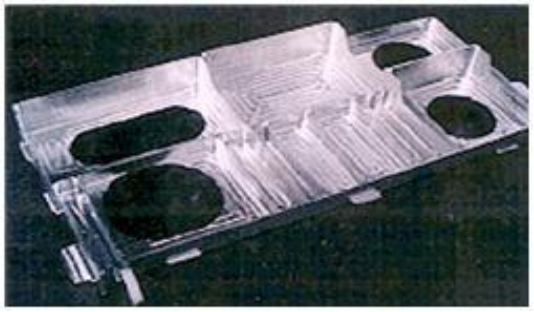
- University of Sheffield Advanced Manufacturing Research Centre (AMRC) with Boeing.
- Dedicated to new, technology-driven solutions for materials-forming, metal-working, and castings for competitive manufacturing.
- 17 Tier 1, 21 Tier 2 companies.
- The AMRC offers:
  - Significant cost and weight reduction in components
  - Netshape forming techniques
  - Dramatic reductions in machining times
  - Dynamic analysis
  - Stress analysis
  - Process development modelling
  - High performance machining
  - Fast part prototyping

The University of Sheffield
Advanced Manufacturing Research Centre
BOEING

www.amrc.co.uk/

AMRC





Monolithic Part (large & thin walled)

	Previous:	Achieved:
Number of Pieces.....	44	6
Number of Tools.....	53	5
Design & Fabrication hr (Tools)	965	30
Fabrication hr.....	13	8.6
Assembly Man-hours.....	50	5.3
Weight (lb).....	9.58	8.56

73% Cost Reduction

Titanium Pintles

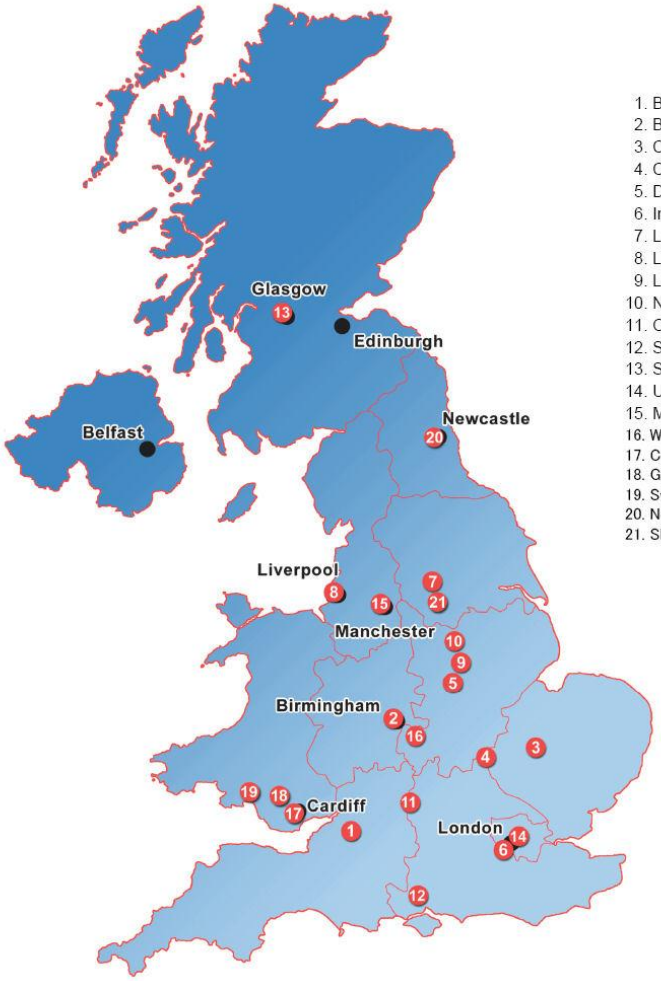
Currently manufactured for Airbus 380 Freighter

Original time	= 145 hrs
Target time	= 50 hrs
Achieved time	= 19 hrs

Automotive R&D Examples

- The UK is a major force in the areas of technical innovation and development for automotive applications.
- There is a comprehensive research and development infrastructure that includes:
  - Vehicle and engine test facilities
  - Design engineering consultancies
  - Specialised new technology R&D companies
  - A vibrant academic community
- There are special academic networks in the fields of:
  - Powertrain systems and driveline technologies
  - Fuel cells and battery vehicles
  - Sustainable power generation and supply
- Motorsport, including development of racing engine capability, is also a significant UK strength.
- Apr 2008, Business Minister Shriti Vadera announced New Automotive Innovation and Growth Team (NAIGT) to build upon the strengths of the sector and addresses the challenges facing the industry.

Key Automotive Universities



1. Bath
2. Birmingham
3. Cambridge
4. Cranfield
5. De Montfort
6. Imperial Colleg
7. Leeds
8. Liverpool
9. Loughborough
10. Nottingham
11. Oxford
12. Southampton
13. Strathclyde
14. UCL
15. Manchester
16. Warwick
17. Cardiff
18. Glamorgan
19. Swansea
20. Newcastle
21. Sheffield

1	University of Bath	www.bath.ac.uk
2	University of Birmingham	www.eng.bham.ac.uk
3	University of Cambridge	www.eng.cam.ac.uk
4	Cranfield University	www.cranfield.ac.uk
5	De Montfort University	www.dmu.ac.uk
6	Imperial College London	www3.imperial.ac.uk
7	Leeds University	www.its.leeds.ac.uk
8	University of Liverpool	www.livjm.ac.uk
9	Loughborough University	www.lboro.ac.uk
10	University of Nottingham	www.engineering.nottingham.ac.uk/
11	University of Oxford	www.eng.ox.ac.uk
12	University of Southampton	www.soton.ac.uk
13	University of Strathclyde	www.strath.ac.uk
14	University College London	www.engineering.ucl.ac.uk
15	University of Manchester	www.eps.manchester.ac.uk
16	University of Warwick	www2.warwick.ac.uk
17	Cardiff University	www.cardiff.ac.uk
18	University of Glamorgan	www.glam.ac.uk
19	Swansea University	www.swan.ac.uk
20	Newcastle University	www.ncl.ac.uk
21	University of Sheffield	www.shef.ac.uk

NAIGT

- New Automotive Innovation and Growth Team formed April 2008
- Industry-led project facilitated by BERR's (now BIS) Automotive Unit
- Tasked with looking at:
  - opportunities for automotive sector in the UK
  - barriers and obstacles for realising these opportunities
  - strategy and mechanisms for accelerating progress
- NAIGT vision:

  A competitive, growing and dynamic industry making a large and increasing contribution to employment and prosperity in the UK, and playing a decisive global role in developing exciting, low carbon vehicle transportation solutions

NAIGT ‘Big Ideas’

Test Bed UK

- A bold low carbon vehicle system pilot to act as a powerful catalyst for UK investment

Supplier Help

- Establish a UK supply chain council to improve collaboration and develop a sourcing roadmap
- Establish a Manufacturing Institute to help leverage R&D and Manufacturing technology

An Automotive Council

- A collaborative industry and Government strategic steering partnership to build a stronger UK auto sector

Industry Consensus Technology Roadmap

- To drive Collaborative R&D efforts and harness Government investment more effectively

Test Bed UK

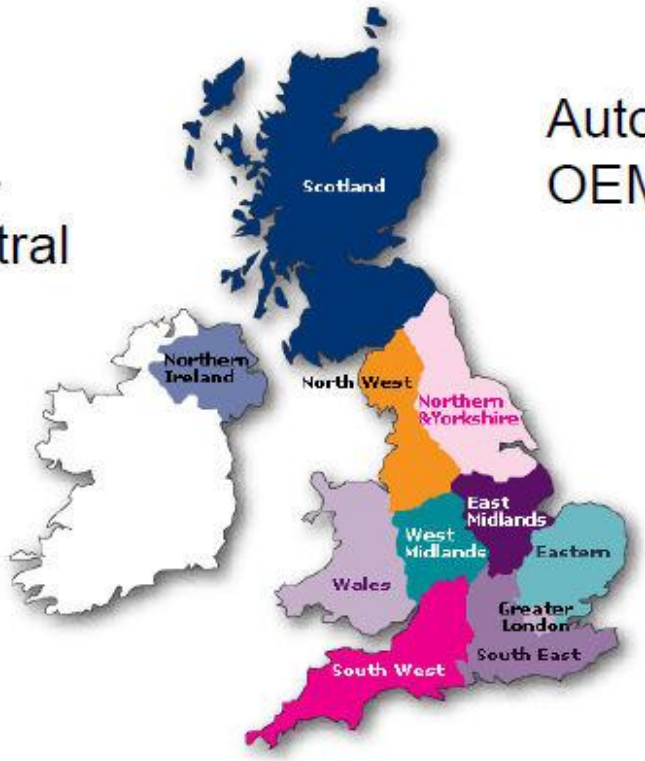
Test Bed UK

Government –
Local and central

Finance sector

Infrastructure
Providers

Consumers



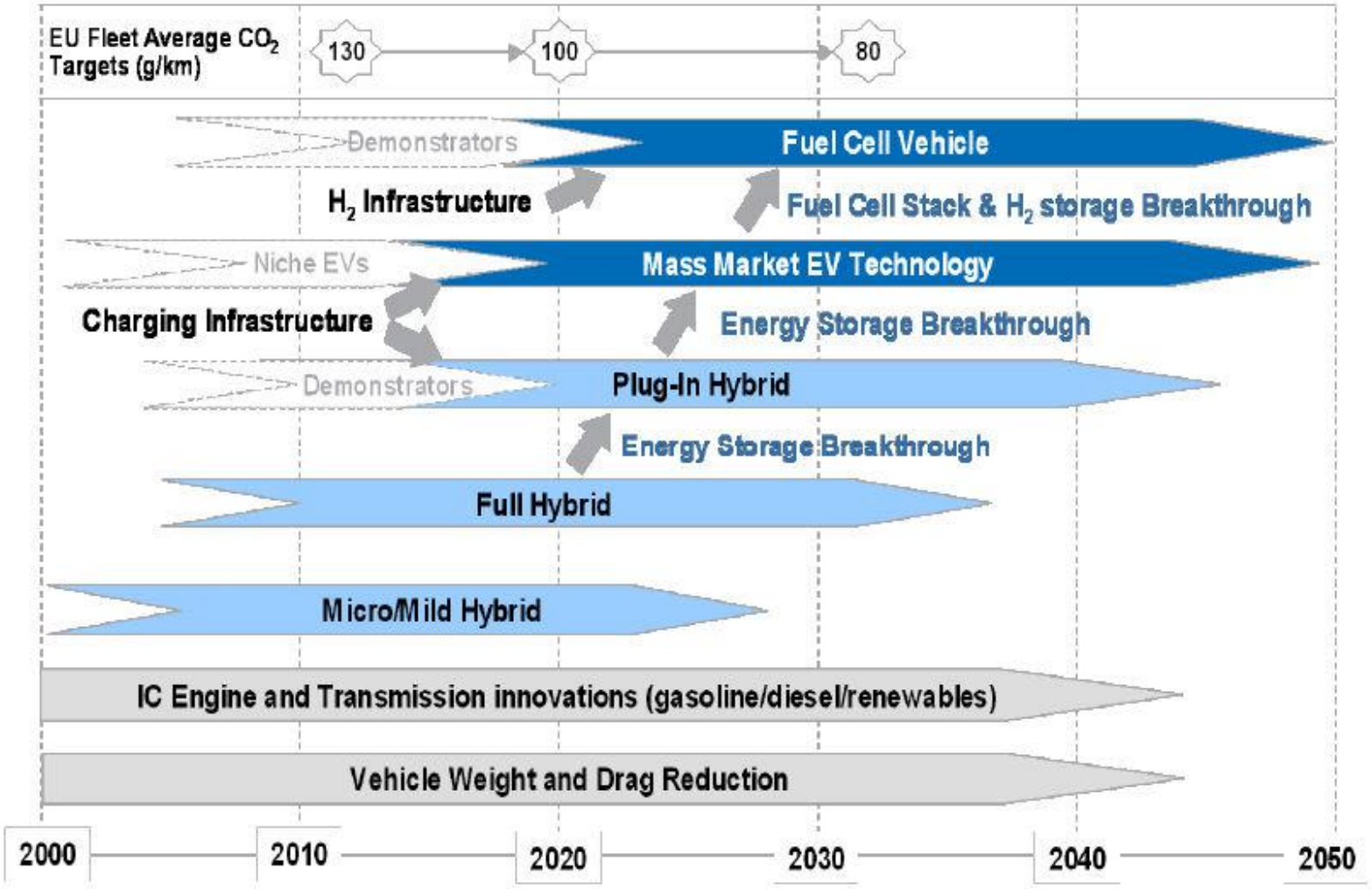
Automotive
OEMs

Academic &
Technical
Institutions

Suppliers

Test Bed UK would be responsible for managing the major activities within NAIGT roadmaps. Programmes such as Electrification of Transport would be developed within the brand.

Roadmap

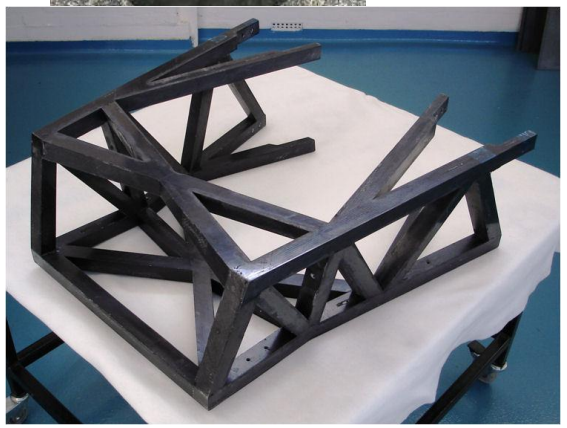


Research

	SHORT TERM 5 – 10 years from production	MEDIUM TERM 7 – 15 years from production	LONG TERM 10 – 20 years from production
	INDUSTRY		UNIVERSITIES
Propulsion	• IC engine optimisation • Boost systems for downsizing • Flexible valve/actuation for engines/transmissions • Low cost compact e-motors	• Higher efficiency IC engines • Capacitive boost systems • All electric actuation systems • Optimised range extender eng. • Lower cost electric motors	• Zero loss motors (superconducting) • New IC engines with 70%+ thermal efficiency • Thermal/heat energy recovery • Motor/Fuel Cell materials
Energy Storage	• Improved quality / durability 200+ Wh/kg & $800/kW.h cost battery systems • Low cost power electronics	• Next gen batteries 300+ Wh/kg and $500/kW.h cost • Flexible power elec. modules • Other forms of energy recovery (mechanical/chemical etc)	• 3rd gen batteries 400+ Wh/kg & $200/kW.h cost • New low cost solid state power conversion systems • Hydrogen storage technology
Vehicle Efficiency	• Lightweight structures and interiors • Low rolling resistance tyres / brakes	• New vehicle classes and configurations • Combination of function to reduce weight / cost • Minimised weight / losses	• Flexible re-configurable multi-utility vehicle concepts • 50% weight reduction from 2008 • Advanced aerodynamic concepts
System Control	• Optimised vehicle energy management • Intelligent thermal managment	• Information enabled control (Topology, V2V, V2I, traffic etc.) • Intelligent P/T and HVAC mgmt	• Autonomous P/T and vehicle control integrated with active safety
Energy + Fuel Supply	• Optimised 1st gen biofuels using waste products • 2nd gen biofuel processes	• Intelligent energy / re-fuelling infrastructure (i.e.fast charge) • 2nd gen full scale biofuel demo	• 3rd gen biofuel processes • 2nd gen biofuel infrastructure
Processes + Tools	• Process + delivery tool development and connectivity	• Auto-optimisation methods using virtual systems	• Artifical Intelligence to deliver complex multi-criteria system optimisation

FastFrames

- Aim – to develop a novel manufacturing method for lightweight, low cost composite body structures.
- Partners – Cranfield University, Lotus Engineering, Ford Motor Company, Caterham Cars, Vantico, Tenax Fibres, Vision Controls, BTI Europe.
- Conclusions:
  - Materials and process technology developed for large, very lightweight framework structures having very high stiffness and low materials and labour cost.
  - Should achieve a 60 % weight saving c.f. Steel at equal stiffness for complete vehicle body.
  - FastFrames developed manufacturing technology is expected to be viable for 1000 - 3000 vehicle frames per year per manufacturing cell.
  - Higher weight design using hybrid fibres and processing and tooling approaches may be viable and cost effective at much greater production volume.



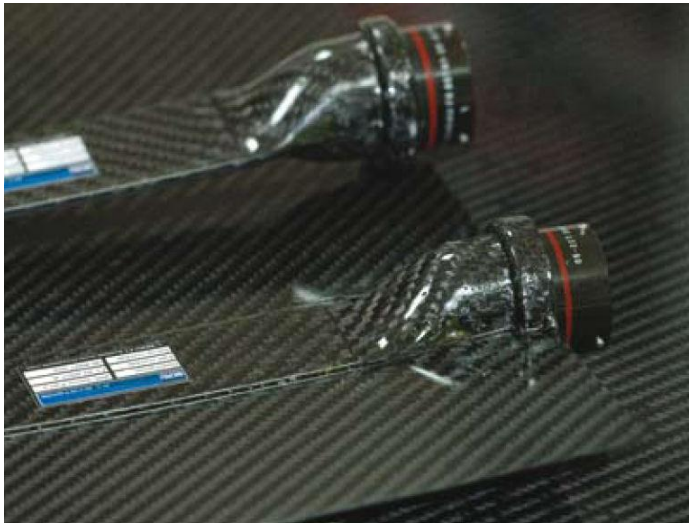
LIFECar

- 3 year, £1.9m project part-funded by TSB.
- Partners; Morgan, Riversimple, Linde AG, QinetiQ, University of Oxford, Cranfield University.
- Demonstrator car:
  - Fuel cell, 45% efficiency
  - 4 electric motors with regenerative breaking
  - Ultra capacitors for energy storage
  - Weight < 700kg
  - 0-62 mph (0-100kph) < 7s
  - 250 mile (400km) range
  - Top speed around 90mph (145kph).

Wire in Composite

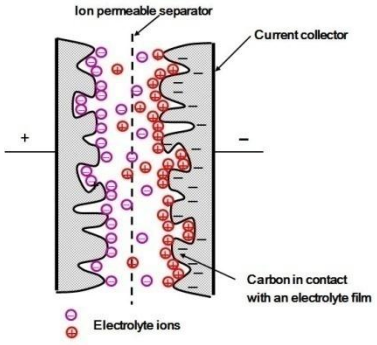
BERU F1 Systems

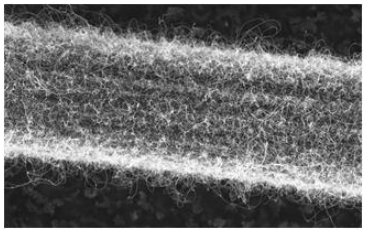
- WiC isolates wires from physical and chemical damage in a bespoke composite sleeve.
- Permitting designers to improve packaging
- WiC can be formed to virtually any shape, offering the ability to incorporate sharp bend radii without the straining or chafing of a conventional harness.
- Originally designed for motorsport applications, now being transferred into multiple industry sectors.
- In 2006, the MIA recognised the company's achievement and awarded it its prestigious Technology and Innovation Award

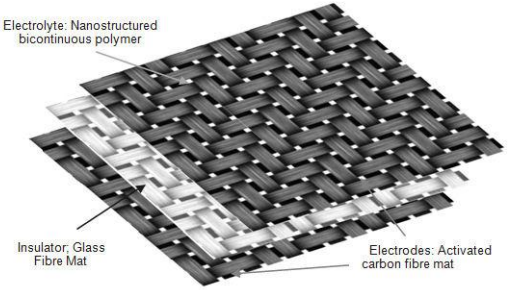


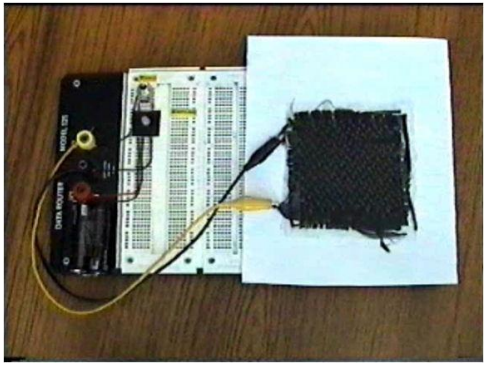
Energy Storage

- Giving a composite structure the added functionality of being able to store energy could allow further reductions in weight through elimination of heavy batteries.
- Work at Imperial College has produced a composite supercapacitor.
- Prototypes being developed for aircraft tertiary structures and automotive application.





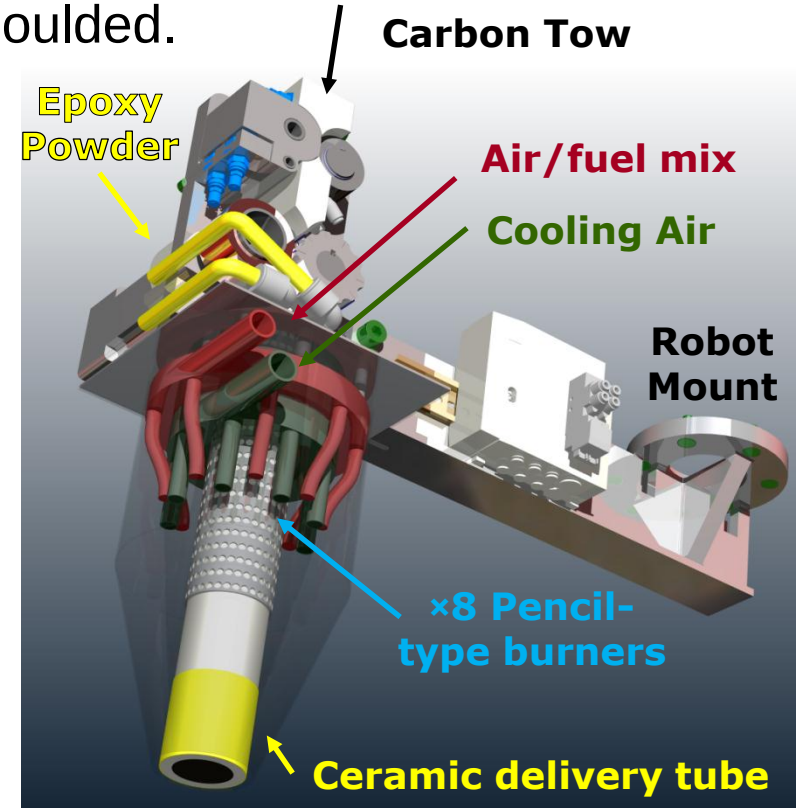




Courtesy of Imperial College

Bentley RayCell Carbon Composites

- Industrial funding 2008-2011.
- Chopped carbon tows and epoxy powder sprayed through burner.
- Powder converted to semi-liquid and adheres to tool surface.
- Net-shape charge —› compression moulded.



AFRECAR Project

- TSB funded 2009-12.
- The AFRECAR project builds upon earlier research to develop low cost, composites from recycled carbon fibre for use in high grade structural applications.
- The two main aims are:
  - Developing alignment techniques for short recycled carbon fibre to make high fibre volume fraction (up to 60%) composites.
  - Developing a supercritical fluid recycling process to larger scale demonstration. This has the potential to yield recycled carbon fibre with properties close to virgin fibre and to recover useful chemical products from the polymer.

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