Anglo French Innovation and Technology Partnership on Materials and Components for Missiles

The purpose of this paper is to introduce and raise awareness of the Innovation and Technology Partnership on Materials and Components for Missiles (MCM ITP) that is being performed under a Technical Arrangement between French Delegation Generale pour l'Armement (DGA) and UK Ministry of Defence (MOD). Both the management structure and technical scope and content of this five-year programme will be presented and discussed. It is hoped that the information may stimulate enquiries from interested parties that may wish to engage with the MCM ITP (enquiries should be directed to the author). In particular reference is made to the first MCM ITP Annual Showcase to be held in Lille 22–23 June 2009 presenting the first year results from around fifty projects on underpinning (low Technology Readiness Level (TRL)) weapons science and technology. These and future MCM ITP projects will provide a portfolio of enabling and cross-cutting research building blocks (technology, tools and techniques) that can be leveraged to meet future military capability challenges and to address emergent requirements for complex weapons and smart munitions. They will serve to address research and development objectives in the 'design and ownership of weapons'; meeting capability and legislative needs whilst reducing cost of ownership and time into service.

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Overview

The Innovation and Technology Partnership (ITP) will deliver the research needs of UK and France whilst building the technology base of a future European guided weapon capability.

The military benefit of the programme will derive from accessibility to a portfolio of advanced technologies generating transformational and disruptive responses to capability needs (discussed later) arising in the 2010 to 2020 timeframe.

This programme addresses technologies aimed at increasing effectiveness and reducing through life cost, manpower needs and deployed logistics costs of future missile systems to satisfy the common capability and technology needs of the governments and industries of UK and France. The programme:

- Secures the participation and contribute to the development of a strong European guided-weapons defence technological and industrial base.
- Ensures the free flow of technology and information across national boundaries within the participating trans-national companies, except where national security restrictions have specifically been applied, both to deliver research outputs more effectively and to improve industrial capability and effectiveness.
- Framework ensures the capture and exploitation of novel technologies emerging from Small and Medium Enterprises (SMEs) and Universities, providing sufficient understanding of state of the art technology to create a foundation and stimulus to further innovation and technology growth.
- Mechanisms permit ongoing interactions between industrial and government specialists to enable effective transfer of and access to current knowledge.

Management structure

The Anglo French MCM ITP is a consortium based activity that has evolved from similar UK initiatives such as the Guided Weapons Tower of Excellence and Defence Technology Centres. It is a broader collaborative partnership that includes MOD, DGA, and UK-French industry/academia.

The Anglo-French MCM ITP management board (MB) comprises representatives from MOD (SIT – DTIC), DGA and MBDA (the prime contractor) and is the executive body that oversees this 3 to 5 year circa £10M per annum contract. The ITP MB direct the programme on behalf of the Technical Arrangement Management Group (TAMG) which consists of senior representatives of MOD and DGA; the TAMG has ultimate responsibility for this Anglo-French initiative.

The UK's Defence Science and Technology Laboratory (Dstl) take a lead technical role, representing the interests of Science Innovation Technology (SIT) – Defence Technology and Innovation Centre (DTIC), and have responsibilities in the provision of strategic guidance, technical assurance and governance. The French Direction de l'Expertise Technique (DET) has a similar technical-strategic role within MCM ITP and is the DGA equivalent of Dstl.

Dstl negotiated the original contract on behalf of DTIC, and provide ongoing commercial support, e.g. contract amendments, and guidance on intellectual property rights and security aspects issues. The contract start was 3rd December 2007.

The funding construct is for 50% government funding and 50% industry private venture funding, with MOD and DGA sharing equally the government contribution. In the case of academia and SMEs there is scope for 'contribution in kind'. The goals are for 50% of the work to be performed by UK suppliers and 50% by French suppliers. The aim is for truly collaborative projects where Anglo-French teams work concurrently on common project. Single nation collaborative projects permissible, where there is an expectation of subsequent UK-French partnerships being formed.

The consortium is led by MBDA and comprises a core team that includes other 'industry primes' that act as themed technology leads, known as 'domain leads'. Eight domains have been defined to cover the capability and technology drivers identified within the UK DIS [1]/DTS [2] and the French PP30 [3], [4].

1

Domain 1: Systems studies – lead MBDA (UK)
Domain 2: Radio frequency (RF) sensors – lead Thales Airborne Systems (Fr)
Domain 3: Electro-optic (EO) sensors – lead Selex Galileo (UK)
Domain 4: Rocket propulsion – lead Roxel (Fr)
Domain 5: Turbojet propulsion – lead Microturbo (Fr)
Domain 6: Warheads (and lethal mechanisms) – lead QinetiQ (UK) & Nexter (Fr)
Domain 7: Fuzing and safety and arming units – lead Thales Missile Electronics (UK)
Domain 8: Materials & electronics – lead MBDA (Fr)

Table 1

	Domain	Domain Lead	Nationality
1	System level studies	MBDA	UK
2	Sensor studies – RF	THALES	FR
3	Sensor studies – IR	SELEX	UK
4	Rocket propulsion	ROLEX	FR
5	Turbo propulsion	MICROTURBO	FR
6	Warheads	QINETIQ (+NEXTER)	UK
7	Fuzes and SAUs	THALES	UK
8	Materials and electronics	MBDA	FR

The Domain Leads have defined the domain strategy and are responsible for engaging lower tier suppliers and academia to provide enhanced pull through/more focussed exploitation of research and development projects. There is an aspiration, which has been achieved, to secure at least 30% work share from academia/small to medium size enterprises. There is also a desire to leverage project work to support PhD studies. To date, 3 PhD studies have been launched with direct funding from the programme.

Government technical points of contact have been established, one Dstl and one DGA per domain, who provide support and advice on: domain strategy/military capability gaps/requirements; previous and relevant national programmes, and provision of knowledge on innovation, technology and supplier base. There is also one technical co-ordinator per nation, again Dstl and DGA, who ensure coherence across the domains and who seek to identify opportunities for cross domain working.

The collaborative approach is consistent with contemporary thinking [5], [6], regarding the transformation in relationships between government, industry and academia, and the value added that such a 'triple-helix' process can confer. Essentially, in a triple helix construct, there is a distinction between *laissez faire* and active state intervention, where in the latter a knowledge based economy is able to stimulate innovation and growth through careful recombination of existing institutions. The benefits of using a triple helix model of government, industry and academia is amplified by the additional Anglo-French dynamic.

The MCM ITP programme is contracted in phases known as Tasks. Each Task typically includes circa 20 to 30 projects spanning across the eight Domains.

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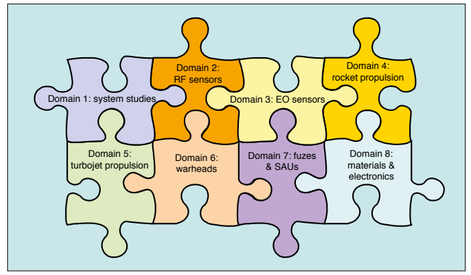

Anglo-French Innovation & Technology Partnership on materials & components for missiles.

A cross domain innovation fund is also available for ad hoc ideas outside the normal tasking cycle to allow rapid seed corn funding of potentially disruptive ideas from academia and SMEs. A useful link can be found Reference 7.

Circa fifty projects from year one will be presented (in English language) in unclassified form at the first Anglo French MCM ITP show case event scheduled to be held on 22nd and 23rd June 2009 in Lille, France. Contact details for those interested in attending are provided at [8]. The technical programme is yet to be formalised and will be published in due course.

The MCM ITP capability space covers five families of precision effect weapon systems (across land, maritime and air environments). These include:

- Short range air to air
- Medium range air to air
- Short range precision strike
- Medium range precision strike
- Long range precision strike

The programme is bounded to address lower technology readiness level (TRL) solutions typically between TRL1 to TRL3/4. The work is hence future focussed – 'high risk/high payoff'; both in development of new technology solutions and use of novel commercial off the shelf (COTS) applications.

Established Intellectual Property (IP) terms and conditions are in place across the programme. Three categories of deliverable documents have been agreed and can be designated by the supplier/information owner.

- Category A – unclassified foreground and background technical information intended for open publication.
- Category B – foreground and background technical information which is not suitable for open publication and which does not contain commercially sensitive information.
- Commercially Sensitive Information (CSI) – foreground and background technical information
  - From which the owner reasonably believes that he could derive commercial benefit, or
  - Which, if released to a third party, would, in the reasonable opinion of the owner, result in material economic injury to him or advantage to his competitors.

In terms of ownership of Intellectual Property MOD/DGA have the free of charge right of unrestricted use of Category A Technical Information. The rights of use of Category B Technical Information and CSI are more prescriptive to protect the interests of both government and industry. Principles are clearly established, and defined in detail in the schedule of requirements governing the MCM ITP contract. These conditions allow for enhanced collaboration and technology transfer between UK and France.

Military drivers and capability needs (for 2010–2020 missile applications)

The Consortium Members, in conjunction with the government technical points of contact have identified a set of future capability needs, which typically include:

- Precision and proportional effects
  - Tuneable effect
  - Selectable effects
  - Scalable effect
  - Multiple effect
- Low collateral damage
- Increased lethality
- Increased safety
  - Primary user
  - Third party
  - Use of Insensitive Munition (IM) solutions
- Increased reliability
- Increased survivability
  - Low observability
  - Increased manoeuvrability (speed/agility)
  - Physical protection and hardening of sub systems and components
- Improved range/endurance/persistence
- Reduced mass/volume
- Ability to exploit network enabled capability (NEC)
  - Better integration into kill chain and targeting cycle
  - Mission agility (programmable/re-role in flight)
  - Use of missile intrinsic BDI to aid BDI/BDA
  - Safety; mission abort function
- Enhanced through life capability management (TLCM)
  - Modularity/commonality
  - Counter-countermeasures
  - Flexible upgrade; designs that offer technology insertion opportunities
- Reduced whole life costs (WLC)
  - Affordable low cost technologies and systems solutions
  - Longer air carry life
  - Low maintenance and training requirements
- Inter-operability/inter-changeability
- Autonomous/semi-autonomous operation
- Modelling and simulation tools (and synthetic environments)

Military drivers include:

- Complex operational environments
  - Urban (high clutter, highly populated)
  - Countermeasure
  - Man made (high electromagnetic/radio frequency interference)
  - Natural (extreme hot/cold)
- Mixed target set (land, maritime, air)
  - Land (mortar site, fortified position/building, mobile and relocatable, air defence unit, armoured fighting vehicle, main battle tank, hard and deeply buried)

  - Maritime (blue water, brown water, fast inshore attack craft (FIAC), Littoral)
  - Air (Fixed wing, rotary wing, UAV, micro-munition, guided bomb, missile, rocket, artillery shell and mortar)
- Role flexibility
  - Conventional vs. asymmetric scenarios
  - War fighting, peace enforcement and peace keeping
  - Integration on different platforms (land, maritime and air)
- Compliance with national and international legislature, directives and guidelines
  - Safety
  - Legal
  - Ethical

Each domain has a strategy that seeks to address the identified future military drivers and capability needs for 2010–2020 missile applications. Domain strategy workshops were undertaken at the start of the MCM ITP contract to review capability gaps, candidate technologies/solutions, and exploitation paths. Each domain strategy is reviewed and revised on an annual basis. A shopping list of generic research interests/topics has been included within each domain strategy and used to solicit proposals and ideas from the UK-French defence industrial base and other lower tier suppliers. Representative shopping lists, for the eight domains, are reproduced here for illustration.

Domain 1: System studies

This domain covers three classes of activities:

Studies for future weapon concepts and architectures

- Elaboration and assessment of very new concepts

Development of new guided weapons techniques in the specific fields of:

- Aerodynamics and stealth
- Guidance, control and navigation
- Image processing

Studies of alternative life cycle models

- Modelling and simulations
- Processes and tools
- Modularity and re-use

Domain 2: Radio frequency sensors

Three themes are identified within Domain 2 these include:

RF devices

- Transmitter components (solid state amplifiers, high power amplifiers)
- Antennas
- Electronic scanning antennas (reflect arrays, micro electro-mechanical machined systems (MEMS) devices, active arrays)
- Mechanically gimballed antennas (RF component, servo/mechanical components)
- Receivers (use of commercial off the shelf (COTS) in receiver architecture)
- Frequency references
- Increased use of digital circuits in intermediate frequency (IF)/radio frequency (RF) sub-assemblies

Dual mode seekers

- Integration of electro-optic (EO) sensors for dual mode seekers
- Dual mode dome material
- Data fusion

Synthetic aperture radar (SAR) processing

- RF components to be involved in a SAR seeker

Domain 3: Electro-optic sensors

This domain has three themes:

On-board weapon sensors/seekers

- Passive imaging
- Active imaging electro optic (EO)
- Semi active laser (SAL)

Other on board weapon sensors

- EO altimeters
- Active and passive ranging where this does not conflict with Domain 7 (fuzing and safety and arming units)

Novel and/or low technology, tools and techniques

- Mature multi-colour detector arrays
- Improved reliability for detector cooling
- New beam steering techniques
- Processing on the detector chip
- Conformal optics
- Fibre optics
- Use of polarisation
- Use of hyper-spectral

Domain 3 strategy

- Lower cost components and systems
- Lower cost and more cost effective sensors
- Lower through life costs
- Improved target/background discrimination capability
- Improved ability to defeat all types of countermeasures
- Low observability

Domain 4: Rocket propulsion

Six major topics are identified within Domain 4 and include:

- Thrust modulation
- Thrust vector control
- Insensitive munitions (IM) issues
- Use of sensors for service life surveillance and extension
- Hybrid propulsion
- Smart motors

Domain 5: Turbojet propulsion

Domain 5 encompasses technologies relevant to expendable gas turbines. The research themes for the domain include:

- Increased weapon performance/capability (through improved engine fuel consumption)
- Enlarged flight/start envelope and increased power off-take
- Depletable engine
- Improved engine/aircraft integration
- Disruptive engine architectures
- Reduced unit cost (through innovative design, new materials, novel manufacturing techniques, etc.)

Domain 6: Warheads (and lethal mechanisms)

The scope of Domain 6 covers all target defeat mechanisms (explosive effects, penetrators & novel 'non-lethal' effects etc) and all aspects associated with the explosive train (excluding the Fuze & SAU) as well as any mechanisms that are necessary to the deployment or reconfiguration of the lethal package to achieve tailored effects. Six general themes are identified:

- Technology for insensitive munitions (IM)
- Improved performance efficiency
- Effects against a wider target set
- Improved degree and type of effect
- Tools and techniques
- Novel/disruptive technology

Domain 7: Fuzes and safety & arming units

The 'fuzes and safety and arming unit (SAU)' domain, covers technologies and concepts to detect, locate and discriminate targets for pre and post impact applications (fuzes), and technologies to control and initiate the arming and detonation of the 'warhead effector' at a safe point (SAU). Topics in this domain fall into four sub-areas:

- Pre impact target detection, location and discrimination
- Post impact target detection, location and discrimination
- Safety Systems (in line & out of line)
- Initiation technologies (for warhead or propulsion systems)

Domain 8: Materials & electronics

This domain has two themes (Materials and Electronics).

Materials

- High performance materials for guided weapons structures including materials-related nanotechnologies
- Refractory composites for high temperature applications e.g. thrusters
- Multi-functional materials and mechanisms for control actuation
- Materials and techniques for thermal protection, vibration and shock control
- Emerging technologies for EMC protection
- Low observable materials for stealth

Electronics

- Electronics & micro sensors for guidance, control of guided weapons
- Electronics & micro sensors for guided weapons health and usage monitoring systems (HUMS).
- Electronics for data links
- Guided weapon cabling and data transmission technologies
- Power supply technologies

Table 2

	Precision & proportional effects	Low collateral damage	Increased lethality	Increased safety	Increased reliability	Increased survivability	Improved range/ endurance/ persistence	Reduced mass/ volume	Ability to exploit network enabled capability	Enhanced through life capability management	Reduced whole life costs	Interoper-ability/ interchange-ability	Autonomous/ semi-autonomous	Modelling & Simulation tools & synthetic environments
Domain 1 Systems studies														
Domain 2 Radio frequency sensors														
Domain 3 Electro-Optic sensors														
Domain 4 Rocket propulsion														
Domain 5 Turbojet propulsion														
Domain 6 Warheads & lethal mechanisms														
Domain 7 Fuzes & safety and arming units														
Domain 8 Materials & Electronics														

Domain has no impact on military driver or capability need.
Domain has some impact on military driver or capability need.
Domain has significant impact on military driver or capability need.
Capability need.

Contribution matrix: domain interests mapped to capability needs (for 2010–2020 missile applications).

Summary and conclusions

The scope of MCM ITP covers 'tools and technologies to enable affordable and responsible whole life management' of future guided weapons and precision munitions. The broad portfolio of 'ideas' and 'growth' projects should realise incremental capability enhancements in short, medium and long term and offer opportunities for disruptive capability enhancements in the medium to long term. The work is aligned to future military needs in both UK and France but will require further focussed investment to mature the most promising technologies to a higher TRL.

The consortium approach described is consistent with contemporary thinking and provides a step change in the way MOD-DGA interact with their respective industries; considerable value added is accrued. Dstl are a key facilitator in this transformational process.

The showcase event offers a unique opportunity for UK and French government, suppliers and academic institutions to communicate and interact, and share knowledge and future visions; the complex weapon and smart munitions communities will be well represented. Prospective participants (and existing stakeholders) are therefore entreated to attend.

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