# BAE SYSTEMS Feedback on the Lambert Review

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## Acknowledgement

This document has been produced with ideas and contributions from Lambert Dopping-Hepenstal, Richard Blockley and Chris Rogan. The content has essentially derived from the cross-company University Partnership Steering Group, chaired by the author.

# Contents

# Executive Summary

This document addresses the Lambert questions and raises a number of related points, which have essentially derived from the experiences of the cross-company BAE SYSTEMS University Partnership Steering Group. Consequently this gives a large company perspective and places emphasis on longer-term strategic challenges that span a broad spectrum of science, technology and business processes. The overall national system will need to span the needs of both small and large industry.

We have some excellent partnerships with a large number of universities and the funding agencies, EPSRC in particular, which is enabling us to address some of the issues that we raise here. However, we welcome the opportunity to contribute to the Lambert Review and review the overall system.

There are three key players in any partnerships – academia, industry and the *funding agencies.* The latter is important in terms of creating the overall framework with incentives or barriers and assigning responsibilities. Clarity of the relative responsibilities of the different funding agencies, across the *spectrum* of industrial requirements (consultancy, short term, long term strategic, key challenges / priorities), would be useful, leading to an indication of how well we are doing. The way in which industry is consulted or involved is important so that we are an equal partner and not consulted after key funding allocations for industrial research in academia have been decided. When large grants are awarded to universities with a flexible requirement to link with industry, industrial requirements can be found to match the academic capabilities rather than the other way round.

Before interacting with or influencing the academic sector and attempting to align industrial needs with academic capabilities there is a need for better awareness:

- Awareness of the wealth of academic capabilities that exist,
- Awareness of industrial requirements *and which ones are important.*

Conferences and literature is an information source for some but better forms of 'marriage brokering' would be helpful and effort is needed from industry to raise the profile of its priorities and from academia to raise the profile of its capabilities, with appropriate support from funding agencies.

Research funded in the academic sector can be divided into the three categories:

- Not relevant to industry
- Relevant to industry
- Claimed to be relevant to industry.

We would prefer to get an appropriate balance between the first two categories and minimise the third. Even then the second category is an umbrella heading for a complete spectrum of industries and a complete spectrum of industrial priorities, incorporating both personal and corporate priorities. The important issue is getting clarity on the sub-category that has impact on industrial capabilities.

Our perception is that a significant portion of national funding is distributed in a way that is sub-critical to achieving sufficient scale of impact on industrial capabilities. Most research progresses in an incremental evolutionary way with little revolution. Regardless of the willingness of academia and industry to work together, funding schemes that are too granular, producing a multitude of weakly connected increments in progress, are unlikely to provide good examples of impact on industrial capabilities and can easily be missed. However a variety of mechanisms might be possible via which the increments are aligned to provide greater scale of impact on industrial capabilities. This could include a more strategic approach to some of the bigger industrial challenges, co-ordinating and building the best academic

capabilities with continuity of research themes and aligned funding e.g. via larger projects or project clusters characterised by continuity, integration and compatibility.

Consequently, we feel that the overall system could give greater impact on industrial capabilities in a way that is mutually beneficial to industry, its academic partners and the funding agencies by including a more structured and strategic approach. At the same time it would be helpful to review the balance of funding across the spectrum of industrial needs and the biases in the overall national and European funding schemes, which influence the requirements that our academics address. For example there is a perspective that European funding schemes pave the way for our universities to support non-UK industries and that there is a lot of emphasis on SME's and spinouts in many funding schemes.

Another key issue for us is the cost of timely involvement with academic research programmes relevant to the wide spectrum of science and technology that impacts our products. We are concerned that the number of technologies we need and the entrance ticket for timely involvement are both growing and the consequences of not being involved will be experienced downstream at the technology insertion stage. The academic research is being done, we would like to be involved but we cannot afford significant cash contributions across a wide spectrum.

Other discussion points covered include:

- Inertia is driven by the peer review process and the Research Assessment Exercise – the mature areas get more mature and gap widens against immature areas
- Some courses are driven by what is popular with the students rather than whether there are careers waiting for them.
- Intellectual property: Establishing a sensible and balanced approach with due recognition of all contributions.

# 1. Introduction

*Background*

Over the last four years BAE SYSTEMS has introduced a new approach to improve its relationships with the academic sector and *associated organisations that influence the direction and investment in the academic sector*. A partner-briefing document is attached. As a result of this we are building some excellent relationships with our Partners in the academic sector and with EPSRC. Our primary interaction is driven by our strategic capability needs, which have to be addressed through long-term relationships. The *rapidly* changing defence and aerospace market can appear to be at odds with *long-term* academic relationships. However, this is a question of balance and scale and can be resolved through real Partnerships that more closely link the academic teams to the industrial needs so that capabilities evolve appropriately.

However, these relationships have been developed to work within the constraints of the overall system and it's many components and we welcome the opportunity to review this.

*Our Challenge*

- Influence the academic sector and position its skills base to have significant impact on BAE SYSTEMS future capabilities via
  - Research and Technology
  - Aligned Education and Training
  - Recruitment pool creation from aligned undergraduate and graduate courses
- Monitor a broad spectrum of global academic research in science and technology for our product portfolio and associated engineering and business processes
  - Identify those that will impact our business and products
  - Effect and fund timely technology / process insertion, maturing and tailoring the academic research output for use in the industrial context
  - Plan for technology insertion and associated implications e.g. compatibility, cross-disciplinary trade-offs during the spin-in process, multiple technology insertions, consequential research needs, resource, and costs.

There is a growing need to monitor a larger number of technologies with their TRLs (technology readiness levels) and be able to integrate them sufficiently quickly into the products required by the changing defence market.

## 2. Continuity, Integration and Compatibility for Scale of Impact on Industrial Capabilities

*Continuity:*

- Larger or linked projects under longer term research themes to get sufficient effort behind the challenges
- Less stop-start research projects

*Integration:*

- Industrial products span a broad spectrum of science and technology and require Breadth and Depth
- Assemble the best academic skills to address the cross-disciplinary challenges
- Problems, challenges and breakthroughs occur across the discipline boundaries

*Compatibility:*

- Build from the existing capability base in industry and academia
- Consequences and costs of accommodating new technology / processes etc
    - Industrial planning to influence / accommodate - early industrial involvement
    - Implications - other research or product changes may be necessary.

We need to question whether national funding is being allocated in a way that is sub-critical to achieving 'scale of impact' on industrial capabilities where 'sub-critical' can reflect the size and maturity of the research teams and the level of effort behind the research output.

Academic research and capabilities need to step ahead of what industry needs in the future and be in a position to have *sufficient scale of impact on industrial capabilities*. Careful consideration of how to characterise and position research programmes that will achieve 'scale of impact' is needed, with due consideration of all the financial, and scientific and technical stakeholders and their contributions. Considerations are many but should include getting a sensible balance on some of the following issues:

- Bottom-up ideas from individual academics, industry-related or not
- Industry driven long-term requirements frameworks / research themes
- Small stand-alone, uncoordinated projects versus large scale integrated projects or project clusters
- Technology insertion and the total cost, from research into business or product.

Our perspective is that there is scope for greater co-ordination, noting that small stand-alone projects are often not followed through, do not always find there way into industry and only in exceptional cases will have sufficient impact on industrial capabilities to be held up as a good example. We also recognise enthusiasm, from many of the academics that we interact with, to contribute towards addressing our needs, which require continuity of effort from the best academic teams. Consequently we feel that there is scope to review and improve the overall funding schemes in a mutually beneficial way.

Larger industries in particular have products than span a number of disciplines in science and technology and require both *breath and depth in science and technology*. Carrying out the in-depth single discipline studies is only part of the research since challenges and problems lie across the discipline boundaries as well as the potential for breakthroughs.

Apart from the occasional revolution in research from a small project, we are dependent on research that evolves incrementally. Each increment usually has, at best, a modest impact on industrial capability. However, when a sufficient number of increments can be aligned

(through continuity, integration etc) there is a far better chance of seeing some scale of impact on industrial capabilities – and an increased expectation of breakthrough.

In some of the larger US based programmes the research can have many 10's if not 100's of man-years dedicated to research deliverables. Although we may not be able to compete on the same funding scale, there is scope for taking a smarter approach. Large-scale, integrated projects or project clusters with long term continuity of industrial drivers (visions) and planned exploitation routes for successful research are more likely to have scale of impact on industrial capabilities and create an environment for some revolutionary research.

There appears to be scope for greater co-ordination of *some* of the national research budgets to harness, co-ordinate and evolve the best academic capabilities to have a greater scale of impact on the UK's industrial sector. Issues relating to requirements across multiple disciplines, multiple skills bases, continuity, compatibility and integration are better addressed as early as possible in the maturity of the research and technology to allow for breakthroughs and to avoid problems downstream. Large scale integrated research projects, spanning and integrating disciplines, driven by industrial visions of future capabilities allows for breadth and depth in research and technology and an automatic exploitation route to impact industrial capabilities. Spinning off aligned education and training courses and refreshing undergraduate courses as the academic skills base evolves provides further benefit.

# 3. Unfavourable Biases within the Funding Schemes

Our perspective of the larger funding schemes is shown in the table.

| **Funding Schemes** | **Industry required to contribute funds to university** | **Scheme financially supports industrial involvement** |
|---|---|---|
| National | Ranges from Essential to Encouraged | Rare |
| EU | Normally not required | Typically 50% of industry costs. |

Most UK based funding initiatives linking industry and academia require a significant investment from industry, typically to pay for it's own research contribution and part-fund the academic research. In contrast, the EU framework funding schemes fully fund the universities and part fund the industrial research contribution. Conditions of involvement in EU programmes have encouraged UK universities to team up with industries in other European countries. Teaming up with a non-UK European industry is a straightforward way for our universities to gain EU funding. In summary, available funding schemes may be giving more incentive to UK universities to link with European (non-UK) industry than to link with UK industry. The EU schemes are focused on industrial drivers; require a stronger commitment from industry compared to national schemes but also part fund industry to take their requirements to universities. National schemes impose or attempt to impose a cost on UK industry to link up with UK universities and, in general, are less focused on industrial drivers or introduce them in a less direct way.

The net effect is that EU schemes are more strongly supportive of industry than the national schemes, typically characterised by:

- Industry gets its requirements addressed without funding the universities
- Industry gets part-funded for its own research involvement and management
- Industry specifies the requirements
- Industry receives and manages the budget.

However, they encourage stronger links between our universities and other European industry rather than UK industry. Although there are a mixture of other features and views on EU schemes, national schemes to balance this would be welcomed.

There is also a perception that there is a lot of support for SMEs and spinouts in national funding schemes and that industrial needs are not considered early enough in the funding schemes e.g. approaching industry after funding has been allocated puts industry as a secondary partner. These points are discussed later.

# 4. Features of the Industrial-Academic Gap

*Spin-in cost of Academic Research and Technology for Existing Industry*

On completion of an academic research programme further work is required to embed the delivered research and technology into industrial products and processes. The cost of maturing the academic output so that it can be used in an industrial context is significant.

*Pre spin-in cost to industry for involvement in major academic research programmes*

- Benefits from industrial involvement at an early stage stem from
  - Specifying industrial requirements to help direct the research
  - Clarifying and evolving the context in which the research output could be used for different industrial applications
  - Putting the research into a multi-disciplinary context and minimising conflicts across multiple research programmes and disciplines
  - Industrial planning for spinning-in the R&T output including cost, alignment with other R&T outputs / developments, resourcing etc.
  - *The importance of planning* - Competitiveness – timely and efficient introduction of appropriate technology into products that span many areas of science and technology
- The rising entrance ticket for involvement – a concern for us is the growing number of technologies that we need and the rising entrance ticket for timely involvement.

*Potential Barriers for industry*

- Cost of timely involvement across our broad spectrum of science and technology needs
- Intellectual property ownership – universities anxious to get additional funding and establishing enthusiastic commercial departments to achieve it
- Balanced recognition of each others contributions
  - Diagnosis: Knowing the challenges and research directions – particularly in the context of having impact on industry
  - Remedy: Having the capability to address them.

  Both are important and should be appropriately recognised in true Partnerships. Industry and academia contribute to both in variable degrees but the first is generally weighted towards industry and the second towards academia. A key part of the diagnosis is that it is usually linked to a *vision, which provides a framework for potential solutions*. The generalisation is to underplay the first, in the context of acknowledging industry's contribution and establishing reasonable IPR. This will encourage some industries and industrial researchers to hold onto the problems until they can find time to solve them.
- Too much emphasis on new spin-out companies and not enough emphasis, barriers in some cases, on spin-in to existing companies with a need
- The peer review process propagates inertia in academic capabilities – preserves the status quo.
- RAE has encouraged academics to focus on areas where they can publish and has encouraged universities to recruit academics who can publish

*Use of Academic Research in Industry*

An enormous volume of research is carried out in academia. Although difficult to quantify it is generally felt that only a small amount of this finds its way into industry and its products. In addition to the problems described above, keeping track of potentially relevant research nationally and around the globe is a challenge. Keeping track nationally would be a key step since our academic researchers operate globally. However statistics on how much academic

research is relevant to industry can be misleading because of flexibility in the interpretation of industrial relevance and involvement.

*Alternative approaches in the US – industry led academic research*

Some major US research programmes are industry led. These typically involve an industrial consortium with a lead industry that manages the budget and a number of universities with appropriate skills. Industry clearly drives the programme – *the budget is placed with and managed by the requirements' owners*.

# 5. Industry's influence on Investment in HEI

There are three key groups of players – the industrial sector, the academic sector and the academic funding agencies. Although the discussion focuses on how well the academic and industrial sectors work together, the funding agencies are in a key position to influence the nature of industry-academia involvement. Our perception is that a number of large grants are awarded to universities with a requirement to involve industry but with a considerable degree of flexibility. This can leave freedom to target any part of the industrial requirements spectrum and can default to a granular breakdown of the budget with weakly or unconnected evolutionary progress increments. There is also a risk of inertia – industrial requirements are found to match the academic capabilities rather than the other way round. There is scope for greater co-ordination and visibility of industrial priorities and an assessment of how well they are being addressed. Our Partnership with EPSRC serves as an example that aligns the best academic capabilities with an industry-specified requirement framework and this has resulted in an enthusiastic response from the academics involved. This comes closest to an approach used in the US (above), where *the budget for use in the academic sector is placed with and managed by the owners of the requirements in industry*.

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*Company Commitments to Investment in HEI – Letters of Support*

Whereas EU funding schemes usually require a formal industrial commitment the situation is quite variable across national schemes. A significant amount of funding can be labelled as 'supporting industry' based on Industrial Letters of Support. This is one of the main mechanisms used by the funding agencies to check for industrial interest in academic proposals for research funding. It is important for industry to advise the funding agencies on the relevance of a research proposal and help direct national research funding to the right areas and best researchers. However, these letters of support are generally free format and left to the interpretation of reviewers, which allows a variable approach across the UK's academic sector and the industrial sectors. In general there is no firm requirement for the results to be passed to industry and, in some cases, industry has to pay to get access - far less desirable than industry contributing additional funds to continue the research. In summary, letters of support are indicative of industrial interest but can vary considerably in real commitment from industry. If an academic has a good idea, it is not difficult to find someone in industry who will provide a supporting letter. Most industries really benefiting would probably be prepared to complete some form of 'Industrial Support Pro-forma' if requested.

A better approach is required to establish the *real level of commitment from industry*. Often this is primarily based on the level of funding that industry contributes to the university but

- As noted for EU schemes, a real commitment can be given by industry without passing industrial funds to the university
- Some industries cannot afford to fund everything in academia that they have a real interest in.

The type and level of commitment should depend on the nature of the research programme. A number of options could be considered for projects that range from small, perhaps driven by ideas from an individual academic, to larger scale, longer term projects for strategic areas within an industrial requirements framework. A form of industrial commitment, often viewed with some scepticism, is 'in-kind' support i.e. non-cash contributions towards the goals of the research programme such as internal industrial research, access to equipment, provision of data. There is good basis for the scepticism but it ought to be possible to devise schemes that identify real industrial commitment e.g. relating to a commitment to management, assessment of output and a planned exploitation route.

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*Current mechanisms and responsibilities*

- Mechanisms for industry to influence the main HEI funding bodies are variable and not always clear.
- Current mechanisms appear to give strong support for SMEs and spinout companies. Support for large industry with its need to remain competitive by *spinning-in new technologies* is less clear. It is good to see that grants are awarded where the number of SMEs involved measures performance as long as there is technology insertion and large industry is not overlooked.
- A number of schemes involve flexible funding awards to universities and are subject to industrial involvement. With this approach:
  - The degree of alignment of the academic skills base and the industrial needs is a secondary consideration
  - Industrial requirements can be found to align with the academic skills rather than the other way round
- Current mechanisms may leave gaps in the coverage of industrial requirements in the academic sector together with an element of chance. A *more structured approach* with greater clarity and *a more pro-active and visible mechanism would help bring industrial needs to the surface.*
- Clarity of responsibilities and coverage between the main funding bodies would be helpful, including identification of gaps and an overall picture for the UK.
- With current mechanisms involving inertial schemes and assessment changes to the academic skills base are likely to be incremental

*Barrier to Change – The Peer Review*

- Mature areas have a large capability in the academic sector with large numbers of academics submitting proposals and reviewing each other's proposals – a self-propagating mechanism.
- Immature, new or novel areas are often difficult to get started because of difficulty in finding a suitable reviewer for the area. In some cases, industry has to provide funding to initiate new capabilities in the academic sector.

*The Challenge of Changing the Academic Skills Base*

- New mechanisms for achieving this are required
- The Research Assessment Exercise has encouraged academics to remain in areas where they can be more prolific with publications
- Mechanisms are needed to encourage academics to move out of their comfort zones into areas where their underlying skills can be applied
- Introducing new undergraduate courses to meet future industry needs – most industries would not know how to go about this.

*Interpretation of Industrial Requirements and Priorities*

Current mechanisms leave considerable scope for different interpretations of industrial requirements and it is often too easy to say that academic research has industry support. 'Academic research supported by industry' can mean many things ranging from a passing interest to a prioritised industrial need with commitment. A more structured and robust approach is needed to help direct funding towards industrial priorities.

*Responsiveness to Industrial Requirements*

Although there are many examples where individual academic groups are as responsive as their capabilities will allow them to be, the overall system does not respond sufficiently quickly to changes in industrial needs. In some cases it is not clear how industry can influence investment to HEIs.

*Information - Visibility and Clarity of Industrial needs*

An important first step is to gather the information, clarifying the process for establishing the UK's industrial needs that could be addressed in the academic sector. With this in place we could attempt to map the funding bodies onto appropriate requirements categories and establish indicators or measures.

*Considerations for Decision-making on Direction and Investment*

- *Requirements indicator* on an appropriate scale for each industry sector (noting that zeros are acceptable).
- *Maturity indicators* on an appropriate scale for research areas to help get an appropriate balance of investment across mature and immature areas, overcoming inertia etc.
- *Investment indicator*

This should, for example, clarify that far more investment is put into the mature area Computational Fluid Dynamics compared to the far less mature area Computational Electromagnetics and the maturity gap is never narrowed.

# 6. Response to the Lambert Questions

**We would like to identify best practice and examples of excellence in business-university collaboration in the UK and abroad.**

*Use of information in academic publications*

- There are two problems:
  - Identification of potentially relevant research / information to industry
  - Maturing the academic output into something industry can use i.e. technology transfer / technology insertion
- Usually a specialist is needed to interpret the academic publications and embed it into an industrial context
- Companies with specialists, such as large industry with corporate research centres, can make use of relevant information - if they are aware of it. However, there is a lot of information and it is increasingly difficult even for large industry to dedicate resource to keep pace. This is a particular challenge to companies such as BAE SYSTEMS whose business and products span *a broad spectrum of science and technology and business processes.*
- Much of industry, SME's in particular, may not have specialists. So they will be dependent on the academic bridging the gap to the industrial application, consultants or teaming with large industry.
- Maturing the academic output is costly and variable
- Comment: There is a lot of academic output that is not used or not used quickly enough. There have been attempts to bridge the academic-industrial gaps via Fraunhoffer Centres (Germany) and Faraday Centres (UK) with mixed success. The BAE SYSTEMS academic partnership programme (briefing attached) will partly address the problems, subject to the constraints off the overall system. Our Academic Partners will act as our eyes and ears in the academic community bringing the latest information to our attention.
- There is scope for bolder initiatives here to bridge the industrial / academic gap. The concept of *academic-industrial partnerships* with a range of financial incentives to pull together both parties is worth further debate. This could take many forms and accommodate a variety of initiatives that could vary significantly in scale.

*Joint Ventures between universities and business*

- BAE SYSTEMS – Academic Partnerships: The partnerships have been established to focus our requirements in research and technology, education and training and recruitment on selected partners. A briefing is attached.
- Systems Engineering Innovation Centre (SEIC): This is initially driven by BAE SYSTEMS, Loughborough University and the East Midlands Regional Development Agency but will grow to involve other industries, including SME's. A briefing is attached.
- Aeronautics Innovation Centre (AIC): This is evolving driven by BAE SYSTEMS, Northwest Development Agency and Northwest universities.
- DARPS (Defence and Aerospace Research Partnerships): These came out of Foresight and aligned networks of universities with industries to address agreed research topics. They were generally viewed favourably but the scale of impact has yet to be proved. There were significant difficulties associated with establishing agreements. Also the second round of DARPS did not recognise the significant change in the industry sector.

*Informal Contacts*
For a company our size there are a substantial number of these, covering all of the aspects raised in the question. Some of these are helpful but it is also a mechanism for diffusing the company's requirements and funding across too many university groups. This can give rise to different views being put forward on our needs and confusion over individual views, local site views and corporate business priorities as well as funding our needs in the academic sector more than once. Although we recognise the value from informal contacts we need a far more structured approach to address the issues above. This has resulted in the BAE SYSTEMS University Partnerships Programme (briefing attached). A more structured national approach is worthy of consideration.

*Formal Contacts*
- There are many examples of formal arrangements, primarily associated with our University Partnerships Programme. A particular feature of this is too establish strategic partnership agreements and multi-year contracts with our partners, in contrast to the more diffuse approach described above, which often involved short term arrangements.
- Our agreement with EPSRC should lead to the placement of a significant number of industrial CASE awards with our supply chain – a mechanism of involving them in the latest developments.
- Our North American business interacts with universities in quite a different way. It is by involving them in bids for major research programmes from DARPA, DOD etc. In the successful bids the academic teams become sub-contractors.

*How relationships came about*
The main relationships have resulted from our university partnerships programme. Currently we have approximately five Strategic Partners (co-ordinating partners with a broad view of business-driven, multi-disciplinary domains) and fifty Primary Partners (partners with the in-depth skills. The engineers and scientists from across the company (the owners of the requirements) select the partners. Knowledge of the academic capabilities is often historical but interaction with EPSRC, for example, is key for identifying and confirming academic capabilities in a given area. The university partnership programme included establishing relationships with the funding bodies to influence investment directions and gain leverage. This has resulted in two key partnerships:
- The partnership with EPSRC
- The partnership with East Midlands RDA and Loughborough University leading to the Systems Engineering Innovation Centre.
- It is hoped that others will follow.

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**If you do not have or would like to strengthen such relationships, what are the main barriers to doing so?**

*Management and Organisational Issues, Present Mechanisms for priority setting, decision-making etc*
- Clarification of the overall UK picture would be helpful – the funding agencies, their responsibilities, how investment strategies are formed, how industry can influence to make sure that the UK's industrial needs are being addressed (or missed)
- Current mechanisms for priority setting, decision-making etc are unclear (see Industry's Influence on Investment in HEI above). In particular
  - Industry's influence on this is unclear
  - Performance measurement of how well the national investment into HEI addresses industry's priorities is unclear

*How can businesses and universities best organise themselves*

- The key to this is the third partner, the funding agency
- There are many examples where businesses and universities work together well
- Current funding mechanisms set the tone for partnerships and usually put industry as a far from equal partner leaving the scope for the university commercial departments to set the terms and conditions on how the national funding is used. Industries can then be selected that fit in with these conditions. Those that do not accept can end up with not getting access or timely access to the research output funded out of UK taxes.

*Changes to encourage collaboration*

- Funding initiatives for research that is intended to address the UK's industrial requirements should at least make industry an equal partner. Current mechanisms involve industry in a way that puts the decision-making in the hands of the university. Good examples do exist such as the BAE SYSTEMS – EPSRC Strategic Partnership but there is scope to do far more.

*Barriers*

- Intellectual property, university commercial departments taking harder line
  - There are two challenges in academic research - knowing the direction of research / what are the key problems and then how to tackle them. Both are important and require recognition.
  - EPSRC, for example, usually has no involvement in IP discussions
  - National guidelines and even goal posts within which to work would help
- Academic teaming can be difficult due to competition between the universities
- Research Assessment Exercise has problems
  - No real incentive to work with industry
  - Encourages academics to remain in research areas where they can be prolific with publications. Moving out of the comfort zone towards industrial needs can compromise numbers of publications.

*Present arrangements understood and appropriate*

- No to both

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**A third set of questions relates to how business can attract the best graduates and postgraduates with the skills and for the development of relevant courses in universities?**

*Quality of graduate recruits*

- Graduates vary in quality, but we can normally find the standard we require. The capabilities have improved over the past few years, but we would recommend adoption of an OU style Key Skills Assessment and Certificate to prove attainment level in communication, IT, numeracy etc.
- We are concerned that universities are not keeping track of industry's future needs - hence the current lack of structural engineers. It is a long pipe-line requiring better understanding between academia and industry.
- This is not restricted to technology - it is more difficult for us to recruit suitable commercial and project management graduates.

*How do businesses communicate their needs for relevant courses?*

- UK co-ordination on this and opportunity for industry to get its requirements across are unclear. Again we usually play a secondary role in influencing the use of national funding to address our needs.
- Through our Academic Partnership Programme we are evolving closer relationships with our partners to address our training and education needs as well as our research needs. This gives us opportunities to become involved in Advisory Boards. In particular, mainly through our own funding but sometimes with external leverage, our partnerships are leading to the development of business-specific courses e.g. Masters in Systems Engineering and Aircraft Engineering, undergraduate course (MEng) in Systems Engineering.
- Our Partnership with EPSRC gives us greater opportunities to influence post-graduate courses and jointly fund new courses.
- *Undergraduate courses:* This is probably where we have least influence in getting the courses to adapt sufficiently quickly to our needs. In general, we are not talking about major changes but opportunities to evolve courses. A difficulty relates to universities attracting sufficient numbers of suitable applicants for their undergraduate courses. To do this they are often steered by national surveys of what is popular amongst the applicants. For example, aerospace / aeronautics comes out very high. Consequently universities will keep their aerospace courses running even though there are too many. In summary, the courses can be driven by what is popular with the students rather than what industry needs and regardless of whether there is a career waiting for them.
- We would welcome the opportunity to become involved in designing and evolving relevant undergraduate courses

*More attractive career paths for science and technology graduates*

- Although there are improvements, undergraduates are probably still not particularly well informed on career opportunities for different industries. The problem is partly demonstrated by undergraduate surveys (see above).
- The professional bodies and industry could probably do more to enthuse graduates towards our industry sector and more generally – career promotional tapes.
- BAE SYSTEMS is approaching this through its ‘Developing You’ programmes, which help to clarify career paths and competencies needed. Courses can then be provided from our academic partners to address the competency needs. This systematic approach needs to be combined with promotional material to raise interest and excitement in industrial careers.
- The BAE SYSTEMS DY approach is an attempt to resolve issues within a national culture where engineering careers are not highly rated. Consequently it is only part of the solution and the national culture will hinder the success of this approach.
- A scheme of tax incentives to support industrial placements is a potential mechanism for encouraging graduates into industry.

**The review team will also want to understand whether financial considerations currently help or hinder the relationships between business and universities.**

*More attractive financing arrangements*

Financing arrangements is one of the keys to significantly improving the situation and underlies many of the problems described above. Generalising a little:

- The research and educational requirements are owned by industry
- The 'ownership' of the majority of the funds is passed to universities
- The universities set the terms and conditions for industry to become involved
- Industrial influence on undergraduate courses is very much 'bottom-up' from industry. A more structured national approach should be considered.

Alternative financing arrangements are used by the EU and in the US, which are worthy of consideration.

*Influence of Tax Credits*

- The system is generally viewed as complex but they are new and may need to mature
- Too early to give an assessment.

# 7. Conclusions

In conclusion we hope that some initiatives can be undertaken to

- Enable industrial requirements to have more influence on research directions and funding allocations
- Achieve better scale of impact on industrial capabilities through more structure and strategy with a less granular, incremental use of funding, which results in incremental research progress. Key words for us are continuity, integration and compatibility (with existing capabilities)
- Clarify the relative responsibilities of the different funding agencies across the spectrum of industrial requirements for large and small industry. Assess how well the different sections of the requirements spectrum are being addressed.
- Involve industry in a timely way as an equal Partner alongside academia and the funding agencies
- Clarify how industry can influence the different schemes and funding allocations, involving industries that make a real commitment and not necessarily a cash contribution
- Replace weak links for industrial involvement by stronger industrial involvement.

There are many ways of addressing a number of the issues raised, which are worthy of further discussion.

# Attachment 1: Briefing - BAE SYSTEMS Academic Partnerships

## The Requirement – Future Capabilities

The overall driver is to establish strong footprints in the academic sector, to help evolve future capabilities, by

- Establishing long term BAE SYSTEMS - University Partnerships around a capability, building centres of expertise
- Focusing requirements and investment in a particular technology with a chosen academic centre or group of centres

The capabilities are evolved through addressing requirements in

- Research and Technology
- *Linked* Education and Training
- *Linked* Recruitment Pool Creation

through the same Academic Partners.

## Breadth, Depth and Integration

Business and products need *in-depth* specialist capabilities across a *broad* science and technology spectrum. Hence the need to assemble a set of Academic Partners with the in-depth capabilities to cover our requirements spectrum – our Preferred Academic Capability Partners. Partners with relevant capabilities can then be invited to jointly address business-driven, multi-disciplinary requirements.

## Requirements Framework

The framework, a set of requirement pigeonholes for Research and Technology, Education and Training, and Recruitment, evolves to cover the company's requirements:

Aerodynamics
Communications Networks
Control Systems
Cost Engineering
Electromagnetics
Electronics
Human Factors
Knowledge Management
Manufacturing
Materials
MEMS and Nanotechnology
Numerical Simulation Tools
Operational Analysis
Photonics
Software Engineering
Sensor Systems
Signal and Data processing and Fusion
Structures
Synthetic Environments
Technology Management

## BAE SYSTEMS – EPSRC Partnership

BAE SYSTEMS and EPSRC have signed an agreement to jointly sponsor academic research with the main aims:

- Make sure that funding is going into the best research to meet the future needs of the aerospace and defence sector
- Establish networks of leading academic groups
- Provide funding stability to key research groups
- Encourage research across discipline boundaries
- Evolve educational and training courses alongside research developments

## *Technical Focus Groups*

Cross-company Technical Focus Groups are aligned with each component of the Requirements Framework. The Focus Groups bring together the specialists from across the company and their business requirements. The Focus Groups provide the primary interface to the Preferred and Primary Academic Capability Partners.

## Preferred and Primary Academic Capability Partners

Preferred Partners are the academic groups that provide the in-depth building block capabilities to cover our spectrum of requirements *with minimum duplication*. The Preferred Partners that are active at a given time is dependent on the level of requirements in the framework areas. Active Partners are called Primary Partners.

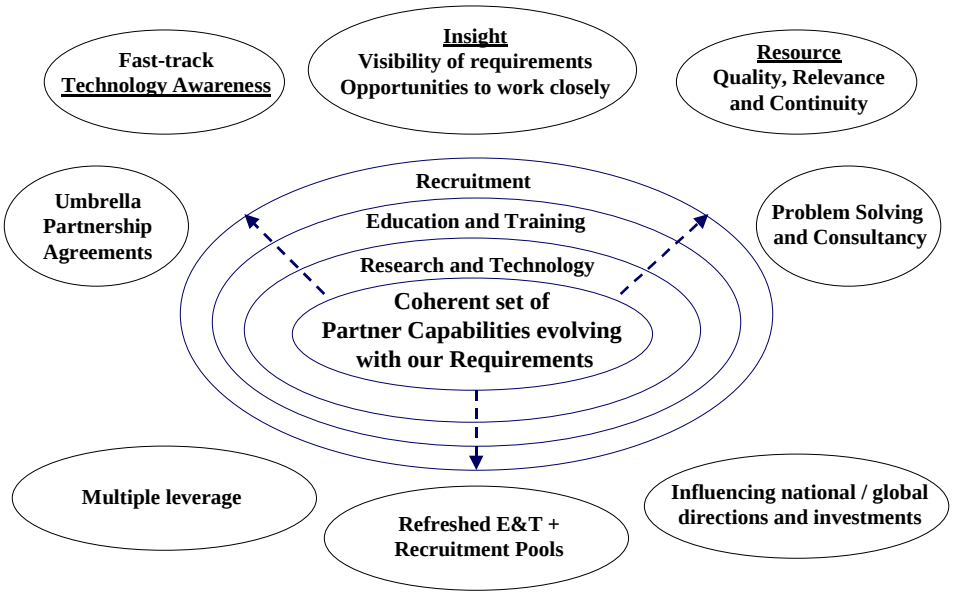
## Strategic Requirement Domains and Strategic Capability Partners

Strategic Requirements Domains are broad, business-driven, multi-disciplinary requirement areas. They have been identified by the BAE SYSTEMS businesses as priority areas to be addressed in the academic sector to support the company in establishing *future capabilities*. The requirements cover Research and Technology, Education and Training, and Recruitment. A network of our Preferred Partners is normally required to provide the capability to address the broad requirements. The network is co-ordinated by a Strategic Capability Partner with knowledge across the domain as well as some of the in-depth skills. The first three Strategic Domains and corresponding Strategic Partners are:

| | |
|---|---|
| Aeronautical Engineering: | Cranfield |
| Systems Engineering: | Loughborough |
| Signal and Information Systems: | Edinburgh and Heriot-Watt |

Domains evolving are Support Engineering, Distributed and Co-operative Systems, and Naval Engineering.

## Inter-related Partnership Benefits




## Model Overview: In-depth disciplines feeding into Business-driven Requirement Domains

***Ticks are indicative only and will be dependent on the level of requirements in each area***

| | | A1: Aerodynamics | C1: Communications Networks | C2: Control Systems | C3: Cost Engineering | E1: Electromagnetics & Stealth | E2: Electronics | H1: Human Factors | K1: Knowledge Management | M1: Manufacturing | M2: Materials | M3: MEMS & Nanotechnology | N1: Numerical Simulation | O1: Operational Analysis | O2: Ordnance and Fire Control | P1: Photonics | S1: Software Engineering | S2: Sensor Systems | S3: Signal and Data Proc' and Fusion | S4: Structures | S6: Synthetic Environments | T1: Technology Management |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cross-company Technical Focus Groups** | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| **Aligned Preferred Academic Partners** | | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ | □□□□ |
| **Requirements Framework** → | | | | | | | | | | | | | | | | | | | | | | |
| **Funding Domains** | **Systems Engineering** | | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | | ✓ | ✓ | | | ✓ | | ✓ | | ✓ | |
| | **Support Engineering** | | | | ✓ | | ✓ | ✓ | ✓ | | | | ✓ | | | | | | | | ✓ | |
| | **Aeronautical Engineering** | ✓ | | ✓ | ✓ | ✓ | | | | ✓ | ✓ | ✓ | ✓ | | | | | | | ✓ | | |
| | **Signal and Information Systems** | | ✓ | | | | | | | | | | | | | ✓ | | ✓ | ✓ | | | |
| | **Distributed and Co-operative Systems** | | ✓ | | | | | | ✓ | | | | ✓ | ✓ | | | | ✓ | ✓ | | | |
| | **Naval Engineering** | | | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | | ✓ | | | | | | | ✓ | | |
| | **Direct Primary Contracts** | ✓ | To address requirements that do not fall under a Strategic Domain through one or more Preferred Partners | | | | | | | | | | | | | | | | | | | ✓ |

- Funding is channelled through the Strategic Domains or via direct interaction with Preferred / Primary Partners
- Each Strategic Domain has a Strategic Steering Group. Relevant Technical Focus Groups feed into this or an R&T sub-group to the Steering Group to provide a coherent set of requirements.

# CREATION OF A UK-BASED SYSTEMS ENGINEERING INNOVATION CENTRE (SEIC)

## *Loughborough University - BAE SYSTEMS - East Midlands Development Agency*

*Systems Engineering provides the framework for the integration of people, processes, tools and technology in order to improve the management of risk, product configuration and technology insertion in the development of innovative products. It ensures that product development adds the value necessary to establish new and vital competitive advantage for UK industries.*

## 1. The Vision: An International Centre of Excellence in Systems Engineering

1.1 Systems Engineering is an essential ingredient for modern Engineering & Technology companies to become, and remain, successful. Effective Systems Integration, created through the application of an appropriate Systems Engineering approach, can fuel the evolution and inter-connection of products, services and organisations to generate innovative step changes in value creation and competitiveness.

1.2 When coupled with sound Project Management, good Systems Engineering is the key to delivering complex, multi-technology products and services which meet customer's needs and generate shareholder value. For BAE SYSTEMS (a major international systems, defence and aerospace company), future company growth will be fuelled by its core capabilities in Systems Engineering and Systems Integration.

1.3 Having foreseen this need over ten years ago, BAE SYSTEMS have been actively nurturing these capabilities through the implementation of new systems technologies, product development processes and, most importantly, through the enhancement of the skills and abilities of people. Its own internal demand for these capabilities is insatiable – nearly 30% of its engineering population needs to be systems trained.

1.4 Every Engineering enterprise, large, medium or small, involved in the delivery of even moderately complex multi-technology products or services can benefit from the application of effective Systems Engineering & Systems Integration. Good Systems Integration is a rare capability.

1.5 This centre will be the hub of an academic and industrial network providing benefits to engineering companies across the United Kingdom.

## 2. The Opportunity: Best Practice in Knowledge and Technology Transfer

2.1 Other Universities across the UK are moving to establish Departments or Centres for Systems Engineering, including industrial links for research & exploitation and creating a supply of young, dynamic Systems Engineers. Loughborough University, through its strategic partnership with BAE SYSTEMS, has already been doing this for ten years

2.2 There is now an opportunity to establish a national resource in the form of a Systems Engineering Innovation Centre and a UK Network of Systems Engineering Universities and Industrial Partners centrally located at Loughborough University.

2.3 BAE SYSTEMS will move key systems research programmes to Loughborough to work with known academics. Invitations to participate will also be made to strategic industrial partners from various industrial sectors, including SMEs across the UK with an emphasis on those from the local regions.

2.4 The network will accelerate the provision of education and training in Systems Engineering at many levels from schools liaison, through apprenticeships, to undergraduate and postgraduate courses.

2.5 The network will build links with universities and companies in the US, where there are considerable strengths in Systems Engineering but, to a lesser extent, in Systems Integration. The UK has a leading position in a field of knowledge and expertise it can now formalise, maintain and advance.

2.6 Loughborough University has a long and successful track record in strategic partnerships with technology-based organisations based locally, nationally and internationally. Its mission, and strength, is in understanding the world of work and ensuring its teaching and research is always relevant to industry and commerce.

2.7 The University also values such an opportunity to deploy staff flexibly within strategic partnerships, especially with companies like BAE SYSTEMS who have world-class facilities and programmes of teaching and research activity.

## 3. The Commitment: Creating an Industry – University – RDA Partnership

3.1 The Systems Engineering Innovation Centre would be a new facility built on Loughborough University's campus, offering access to research laboratories, synthetic environment laboratories, virtual engineering capabilities, office accommodation, conference facilities, a lecture theatre, exhibition area and a highly integrated communications infrastructure.

3.2 With a core management team to oversee the facility and its activities, the centre will provide space for R&D specialists with support staff and be a resource for any business requiring access to specialist facilities and expertise.

3.3 BAE SYSTEMS will contribute management and R&D staff, equipment and software, significant investment in research and teaching contracts, links to other BAE SYSTEMS sites and international business collaborations.

3.4 Loughborough University will contribute the land and will also provide the Director of the Centre together with additional management, teaching and R&D specialists; access to other laboratories on campus and all university facilities; Research Council scholarships; national and international research partnerships with other universities and businesses and links to its well-established Enterprise Club.

3.5 The third strategic partner, East Midlands Development Agency (*emda*), will contribute towards the building costs of the Centre and assist in developing its links with the region's business community.

## 4. The Benefits: UK and the Regions

4.1 Few opportunities arise for a body of knowledge and expertise with such global potential to develop with a base in the UK. BAE SYSTEMS has a preference to develop the core of its own Systems Integration knowledge base here. While maintaining more confidential R&D activities elsewhere, the company recognises how valuable its people, process and technology approach is to the rest of the UK's ability to produce higher value added goods and services. The new Centre will open its doors to a wide range of opportunities to share and grow that knowledge base.

4.2 The East Midlands has a diverse business base with particular strengths in high performance engineering, healthcare industries, food technologies, clothing and textiles and creative industries. *emda* has well-defined strategies for developing capacity and capability for Innovation, Business Birth-rates, Cluster Development and Workforce Development. The centre will complement these.

4.3 The Systems Engineering Innovation Centre will provide a unique focal point for encouraging global ambition in our small to medium businesses, enabling them to learn how to exploit technologies of the future through an Integrated Systems approach and provide opportunities for accelerated growth.

4.4 The Centre's activities will make a vital contribution to the growing national network of new business Incubators and Innovation Centres, developing the capability of our business support mechanisms including university links, and to pushing the boundaries of e-business within global supply chain relationships.

4.5 On a long term basis *emda* will establish the Centre at the heart of its Cluster Development activities, particularly in conjunction with the emerging SBS services and the new Manufacturing Advisory Service. These links will also benefit other UK Regional Development Agencies' Cluster Development plans.

4.6 Taking an Integrated Systems approach to the development of new products and services using sustainable technologies is a particular area of emphasis *emda* has identified at this early stage of anticipating the Centre's potential role in the region.

4.7 The Centre will stimulate and support the national development of Engineering in school