UNIVERSITY OF CAMBRIDGE

CSaP

Centre for Science and Policy

"Men of the Professor Type" Revisited

Exploring the relationship between National Security challenges and academic research

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Executive Summary

1. This study represents the first stage in a project that aims to explore, develop and test mechanisms to promote engagement between academia and the National Security (NS) domain. It is aligned to RCUK's Global Uncertainties Programme. It has also taken, as a point of reference, the National Security Strategy and a recent White Paper - *National Security through Technology* - which identifies a set of research challenges. (pp 5-6)

2. The main input derives from over 75 interviews with academics, officials and industry representatives. "Issues" and "solutions" identified here have been analysed and turned into a set of problems and propositions. Evaluation Criteria have been designed covering both Short-Term Delivery and Long-Term Impact[1]. (pp 6-7)

3. The underlying problems are presented under three headings: Trust & Communications; A Clash of Cultures; and Resources & Red Tape. A key conclusion is that there is a need to create conditions where relationships of trust can be established; these should change ingrained habits & assumptions along the way. *Perspective is provided with examples of productive & flourishing collaboration.* (pp 9-13)

4. Eight propositions, grouped under two headings, are presented and evaluated in Chapter 3. These are:

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5. Five prioritised work-streams are then selected for **short-term action** by the CSaP Fellow (pp 28-29). These will be pursued in the second phase of the Fellowship project, from July-December 2012. In summary:

i. NS Data Release Scheme Run a trial selecting sensitive data for managed release for research, addressing all obstacles (legal, technical, etc).	**ii. Information on the Research-Base** Work with RCUK to develop & promulgate guidance on how to access information about past & current research projects.
iii. Guidelines for IP/IPR Issue guidance on the use of IP and IPR following a review of working practices in NS Departments.	
iv. Knowledge Exchange Schemes Run a trial NS Fellowship Scheme (with visits to three universities). Explore options for Visiting Professorships.	**v. NS Portal for Research Proposals** Work with stakeholders to explore options for a gateway giving academic researchers access to NS end-users.

6. A further five **strategic recommendations,** intending long-term benefits, are made for consideration by senior stakeholders. (pp 29-30). In summary:

1. Research Centres Commission a strategic study into the merits of new NS Research Centres: identify factors behind success & failure of models, testing the vision against capability needs.	**2. Accelerators & Incubators** Work with the TSB on engagement with academic research partners & Tech Transfer teams to nurture the development of IP through SMEs and university-focused Accelerators, etc.
3. An Academic RISC Support proposals for an academic *GU Alliance* modelled on RISC, providing strategic engagement between academia, industry & HMG; proposals are made for early deliverables.	
4. NSC Associates Support knowledge exchange by establishing a multi-disciplinary academic network of *NSC Associates* who can respond to both strategic and operational requirements.	**5. New Interface to Access the Research-Base** Consider developing a state-of-the-art interface to provide access to databases (in RCUK, TSB, etc) on UK research, for all stakeholders, extended to cover the historical record.

[1] Light Green for Short Term Deliverables | Light-Blue for Long-Term Outputs

7. This paper – revised to reflect outputs from a CSaP workshop at the Royal Society on 13 June2012 – will be circulated to interested parties, including all interviewees, seeking their support in taking forward the recommendations. The Executive Summary (with a copy of the full report if appropriate) will be sent to the NS Council (Officials) Science & Technology Committee and to the Strategic Advisory Group of the GU Programme. These senior stakeholders are asked to consider the five strategic recommendations.

8. This project has been supported by a generous award from ESRC under their Knowledge Exchange Scheme, for which we are very grateful. The author also thanks: all those interviewed in the Inquiry Phase of the project (listed at Annex 1); Professor Nick Jennings (Chief Scientific Advisor at the Centre for the Protection of National Infrastructure); the Master and Fellows of Pembroke College, Cambridge; and the Centre for Science and Policy (CSaP): this project was only made possible thanks to contributions from Ms Julia Graham (who took the record of our Global Uncertainties Workshop in the Royal Society), Mrs Jackie Ouchikh (Head of Programmes), Dr Nick Gray (Associate Adviser), and Dr Robert Doubleday (Head of Research).

Chapter 1. Introduction

Context

1.1 In August 1939, shortly before Britain declared war on Germany, the operational head of the Government Communication and Cypher School (Commander Alistair Denniston) wrote to the Foreign Office about the need to recruit "men of the professor type"[2] in order to help address the challenge of intercepting, decrypting and interpreting enemy communications from his headquarters in Bletchley Park.

1.2 Almost seventy years later, in October 2008, the Council for Science and Technology (CST) produced a report entitled *How academia and government can work together*. This was founded on the premise that a healthy engagement between academics and policy makers is essential to the provision of informed, evidence based, world-class policy making. It concluded that engagement between academics and policy makers was not sufficiently strong: like many countries, the CST concluded, the UK struggles to make the relationship work.

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1.3 This study represents the first stage in a year-long project that aims to explore, develop and test new mechanisms to promote engagement between National Security (NS) stakeholders[3] and academics, including improving access to expertise, and support for the transformation of research into usable products and services. It follows in the wake of the 2008 CST report, but there are a number of distinguishing factors that connect the work to Denniston's letter (notwithstanding an atavistic tone to his language that jars our 21st Century ear):

- the NS focus adds new complexities, not least security and ethical sensitivities that have traditionally added resistance to effective engagement; *over the last decade the equation has changed with a shift in national focus away from "defence" towards "security";*

- the research requirements of the NS domain are associated with practitioners as much as, if not more than, than policy makers – that it to say, they stem from capability gaps (such as tools to detect home-made explosives or protect against malign cyber-code); *matters are all the more pressing, given the dramatic decline in the number of scientists and researchers working in Government laboratories associated with defence and security, from more than 60,000 to less than 5,000 over c 40 years.*

1.4 This study is aligned to a major theme of the UK Research Councils (RCUK). The Global Uncertainties (GU) Programme[4] addresses the cross-cutting, interdisciplinary and international nature of security challenges affecting us all. It focuses on six areas: Terrorism; Cyber-security; Threats to Infrastructures; Countering the Proliferation of CBRN Weapons & Technologies; Transnational Organised Crime; and Ideologies & Beliefs. In launching this Programme, RCUK acknowledges that the research base in Britain's universities has a vital contribution to make to the security of the UK and its citizens, as well as the wider world.

1.5 However, there is a disjunction between this scholarship and potential beneficiaries working in Government – a disjunction that has been exacerbated by over 100 years of secrecy. There is a place for need-to-know, when critical sources and methods, or sensitive plans and policies, are at stake; but there is also a place for need-to-share, and confusion can arise about the requirements of risk-managed security and the practice of risk-averse secrecy, inhibiting effective communication and dialogue. *There is no better illustration of this culture than the rules operating in Bletchley Park during World War II, that forbade the intelligence analysts of Hut 8 (working on the translation, evaluation and distribution of military Enigma signals) from talking to the*

[2] R. Erskine, 'GC and CS Mobilizes ''Men of the Professor Type''', *Cryptologia*, 10 (1986), 50–9 (50).
[3] For the purposes of this project, we focus attention on the research requirements of the Centre for the Protection of National Infrastructure (CPNI); the Home Office's Centre for Applied Science & Techology (CAST) and Office for Security & Counter Terrorism (OSCT); the Office for Cyber-Security & Information Assurance (OCSIA) in the Cabinet Office; the Defence Science & Technology Lab (Dstl) in the Ministry of Defence; and the Security & Intelligence Agencies or SIA (GCHQ, MI5 and MI6). Other departments and agencies with an interest in the outcome of this research include the Civil Contingencies Secretariat, the Joint Intelligence Committee, Law Enforcement Agencies, and the National Security Council.
[4] See RCUK's *Global Uncertainties Programme Strategic Plan: 2011-16*.

"boffins" in Hut 6 who worked on decrypting those signals. Fortunately the rule was never strictly obeyed, allowing collaboration to make better sense, for instance, of corrupt decodes.[5]

1.6 This Fellowship aims to address these barriers through an approach that combines strategic analysis with the development of practical solutions. I have taken, as a point of reference, the National Security Strategy[6] and – stemming from it - the recent White Paper *National Security through Technology* which identifies seven priority challenges well-suited to collaborative research between academics and NS stakeholders. In summary:

Table 1. Priority NS Research Challenges

Source: HMG White Paper *National Security through Technology* (February 2012) p 38

- develop effective neutralization and protection from improvised explosive threats
- identify and effectively mitigate CBRN (chemical, biological, radiological and nuclear) threats
- ensure the UK and its assets are protected from cyber threats
- understand human and social dynamics in undertaking defence and security operations
- develop ability to communicate rapidly/effectively within/between all relevant organizations, including ability to manage information from sensors deployed in hostile or challenging environments and develop accurate information pictures in real time
- extract value from complex, multiple data sources, media and streams
- develop the ability to identify/assess future risks & threats (with S&T requirements aligned to these).

1.7 How, then, can we promote better engagement between NS stakeholders and academia in order to tackle challenges like these? This is the key question underpinning this project.

The Inquiry Phase

1.8 The principal input to this Inquiry Phase has been over 75 interviews conducted with academics, Government officials, and industry representatives (including consultants). An effort was made to achieve diversity in academic discipline, a range of different NS departments, and a bias towards non-Government voices. The majority of the researchers interviewed have experienced working with HMG, but useful insights came from a small number of academics who have only worked collaboratively with industry. Despite being based in Cambridge, I have also made an effort to interview academics away from the Fens, and am grateful to John Wand at ESRC for providing introductions to a number of Principal Investigators involved in GU projects around the country.

1.9 A list of interviewees is attached at Annex 1, respecting the need for anonymity of members of the Security and Intelligence Agencies (SIA). In summary:

Table 2. Analysis of Interviewees by Sector and Discipline or Department

Research Discipline		*Behav'al & Social*	*Bio-science*	*Business*	*Chemistry/ Materials*	*Computer Science*	*Engineering*	*Maths*
Academia	39	9	3	5	4	6	9	3
Industry	11	3	0	0	0	1	5	2
Total	***50***	***12***	***3***	***5***	***4***	***7***	***14***	***5***
Government Departments			*GO Science*	*Home Office*	*MOD*	*OCS IA*	*SIA*	
HMG	26		1	7	5	1	12	
Grand Total	**76**							

[5] Christopher Grey (2012) *Decoding Organization: Bletchley Park, Codebreaking and Organization Studies* CUP, p 132.

[6] HMG (2010) *A Strong Britain in an Age of Uncertainty: The National Security Strategy*. This identifies the four highest priority risks facing the UK until 2015 as: terrorism (including a CBRN attack); hostile attacks on UK cyber-space and/or large-scale cyber-crime; major accidents or natural hazards (eg coastal flooding or a 'flu epidemic); and international military crises. (p27).

1.10 Additionally, I attended a number of conferences and other events, all of which provided opportunities to explore, further, the relationship between Government and academia:

- the Global Uncertainties Annual Meeting (March 2012);
- CSaP's "Risks & Uncertainties Conference" (March 2012);
- the "World Cyber Security Technology Research Summit" at the Centre for Secure Information Technology, Queen's University, Belfast (March 2012);
- a "Religious Conflict Seminar" at Church House, Westminster, organised by the Open University (March 2012);
- the European Study Group with Industry at UEA, organised by EPSRC and the Industrial Mathematics Knowledge Transfer Network (April 2012);
- CSaP's "Understanding Cyber Risks to Infrastructure" Workshop (April 2012);
- The launch by the Centre for Defence Enterprise of a themed call - *Advanced Design, Fabrication and Manufacture: Defence Implications for Emerging Technologies* – at Duxford (June 2012).

1.11 The Inquiry Phase has produced an extensive list of "issues" and "solutions" relating to engagement between Government and academia. These have been subjected to a process of compression in order to produce a set of problems and propositions contained in Chapters 2 and 3 respectively. The full list is in Annex 2.

1.12 I have established a set of criteria for evaluating proposed solutions, and these are applied to each of the propositions in Chapter 3; these are set out in the table below. The distinction is highlighted between Short-Term Delivery and Long-Term Impact: the former helps planning the second phase of this Fellowship, when I will develop and, where appropriate, test some solutions; the latter helps the development of strategic recommendations for stakeholders and decision-,makers, particularly in Government, to incorporate into their plans. *Colour coding is used throughout this paper, with light-green shading for short-term delivery proposals, and light-blue shading for proposals relating to longer-term impact.*

Table 3. Criteria for Evaluating Success

Short-Term Delivery

- **Short-Term Deliverable**: what is the likelihood that the proposed solution includes an output that could be delivered before the end of 2012?
- **Scale of Short-Term Impact**: assess the significance of the impact if this output was delivered, deriving from the early realisation of one or more of the following benefits, or significant progress towards achieving these:
  - strategic co-operation between end-users & academics leading to activities (including problem-based research) being aligned with shared goals;
  - end-user support for the transformation of early-stage research into products and services;
  - shared horizon-scanning activities identifying and responding to emerging challenges & priorities.
- **Resistance**: assess the scale of resistance to delivering the output before the end of 2012 (eg logistical challenges such as cost/resources).

Longer-Term Impact

- **Likelihood of Impact**: what is the likelihood that the proposed solution would lead to one or more of the following benefits within one year of implementation:
  - strategic co-operation between end-users & academics leading to activities (including problem-based research) being aligned with shared goals;
  - end-user support for the transformation of early-stage research into products and services;
  - shared horizon-scanning activities identifying and responding to emerging challenges & priorities.
- **Scale of Impact**: assess the significance of the impact if a proposed solution was realised (deriving from the delivery of number of different benefits or the substantive quality of one specific benefit);
- **Resistance**: assess the scale of resistance faced by the proposed solution (e.g. given cultural issues inside HMG and academia, or the current state of the relationship between academia & government, or logistical challenges such as cost/resources).

1.13 A first draft of this paper was circulated at the end of May to all of those who contributed to the Inquiry Phase, with an invitation to comment; I also benefited from access to a new report by Professor Phil Sutton, Visiting Professor of Science, Engineering & Technology Strategy at the Department of Electronic & Electrical Engineering at Imperial College, London.[7] My paper was the subject of a CSaP Global Uncertainties Workshop held in the Royal Society on 13 June 2012, when the findings were reviewed by 25 representatives of Government, Academia and Industry; this final version reflects the outcome of that workshop.

The International Dimension

1.14 There is an international dimension to these national security issues.

1.15 At a strategic level, this is reflected in the United Kingdom's international responsibilities. For instance, the United Nations *Universal Declaration of Human Rights* of 1948 asserted that "everyone has a right to life, liberty and security of person". More recently, the Lisbon Treaty (2009) introduced the concept of the security of the European Union (EU) itself: Article 3 of the Treaty on European Union establishes the Union as a security provider to its citizens, aiming "to promote peace, its values and the well-being of its peoples". There is also an ambition to harmonise the field of civil protection against natural or man-made disasters, with the Union seeking the "competence to carry out actions to support, coordinate or supplement the actions of the Member States' (Article 196 Treaty on the Functioning of the European Union).

1.16 At a tactical level, there are numerous opportunities for collaborative engagement with research projects overseas. Under circumstances where there is something of a vacuum in terms of initiatives stemming from HMG, many British researchers respond to security-related calls emanating from the United States (eg DARPA or the Department of Homeland Security) and Europe (e.g. the Framework 7 Programme). *EC funding through Horizon 2020 currently stands at €80bn for the period 2014-2020, and the European Parliament has recently asked for a revision to €100bn. The growing significance of the Europe is reflected in the fact that it accounted for c 24% by value of all* ***new*** *awards to the University between February 2011 and January 2012.*

1.17 This paper focuses on the national dimension (i.e. the relationship between UK Government stakeholders and the UK research base), but we should not forget this international context.

[7] Phil Sutton CBE FREng (23 May 2012) *Factors Affecting The Value Of UK Universities To The UK* Department of Electrical and Electronic Engineering, Imperial College London.

Chapter 2. Summary of Problems

2.1 I set out below, an analysis of the issues that emerged in the course of interviews. In the interest of succinctness, these have been compiled under three major headings, and presented to reflect the weight of opinion and concern behind the problems. (The full list, disaggregated, is to be found in Annex 2).

I. Trust and Communications

2.2 The largest number of interviewees (39) highlighted problems associated with establishing a trusting relationship where interlocutors understand one another. Communication is difficult between the two cultures at the best of times, but it is made worse in the NS domain.

I.i. "100 Years of Solitude"

Secrets and security constrain collaboration.

2.3 Generally, NS agencies and departments within HMG are perceived by academics and researchers as over-secretive, a closed shop, impenetrable; it is difficult to reach relevant decision makers or experts, and there is far more "take" than "give". The somewhat idealised example of successful collaboration represented by mathematicians working in Bletchley Park during WWII is cited so often that it becomes the exception that proves the rule. The introverted behaviour of British agencies is contrasted with examples of effective liaison and collaboration between UK universities and well-funded US Federal agencies (eg DARPA, the Department of Homeland Security, and the American Intelligence Community). The work of Andrew Marshall's Office of Net Assessment (ONA), in the Pentagon, is a particularly noteworthy example: for decades it has taken an in-depth and multi-disciplinary approach to engaging with research around the world in an attempt to develop a strategic and long-range understanding of strategic challenges; at the moment, Professor Stefan Halper of Cambridge's Department of Politics and International Studies is leading a project for ONA on China's use of the "Three Warfares" in the South China Sea, following earlier work on an "exit strategy from Afghanistan".

2.4 Denial of access to relevant but sensitive information (in both data and physical projects) is particularly frustrating for researchers and can lead either to failed initiatives or sub-standard and inadequate research. A risk-averse and hard-pressed NS community is unwilling to countenance efforts to anonymize data, expressing fears that this doctored information can be unpicked. There can also be confusion and suspicion over control of Intellectual Property Rights (see section on "Red Tape", below).

2.5 The impasse is not helped by the fact that few academics are well-versed or well-trained in handling classified material, and too few are cleared. Academics can be constrained by fear of Freedom of Information requests, and some are affronted by the need for security clearances: they may object, on ethical grounds, to being involved in defence-related work; some think it is antithetical to the principles of open, academic research; others are concerned they will be let into a secret that they already knew!

2.6 The following quotes from interviews give a sense of the feelings among researchers:

- *"We cannot have our research evaluated on invisible outputs. We do invisible work, but that's called consulting and we charge out at a completely different rate. I'm happy to apply restrictions of outputs if we're being paid £1m by an American company under a consultancy contract. But the Security and Intelligence Agencies need to recognise this is a cultural issue: this is 2012, not 1950!"*

- *"Stop thinking that you're defending the Empire against the Kaiser's spies. We live in a post-imperial world. Think and behave as if you were Denmark, with the focus on effective defence."*

- *"There is no balance in the relationship: lots of nice people come to our Labs, ask lots of interesting questions, and depart without giving anything back. This pattern is repeated. There has to be a trade. It can't be a one-way process. Government has got two things that researchers like - real-world problems and data that is not normally available to them. But this doesn't happen."*

I.ii. Ships Passing in the Night.

"Docking" and "translation" challenges hinder effective communications.

2.7 There are insufficient opportunities or mechanisms for engagement and communicating, especially at a peer-to-peer level. Those arrangements that do exist are sub-optimal, suffering in particular from language barriers. Officials patronise academics and provide poor feedback; academics appear disconnected from concerns of policy makers and practitioners. This is nothing new – similar problems existed within war-time teams working in Bletchley Park's Naval Section: "To the intelligence officer, cryptographers were apt to appear as unworldly, absent-minded, eccentric, ill-dressed academics. To the cryptographer, the intelligence officer could appear to be too political by half and often as a shameless empire builder."[8]

2.8 Each world appears opaque to the other. It is difficult to know who does what. This knowledge management challenge has been exacerbated by a significant reduction in the population of HMG scientists who once made it their business to know what was happening in the research base; and there are poor structures for knowledge exchange. But language barriers exist between academic disciplines as well, making it difficult for Government to engage with multi-disciplinary research: it requires time to achieve effective translation.

2.9 If both sides suffer from too many silos, a particular concern arises from increasing levels of fission within academia: the drive towards research excellence leads academics to establish themselves as specialists in a narrow field, and there is perceived to be insufficient commitment to multi-disciplinary research and/or learned journals that support multi-disciplinary science. *One HMG scientist picked out Surrey University as a rare exception reputation, with almost all its research being multi-disciplinary.*

2.10 The 'London-centred' location of many HMG events tends to reinforce the position of London University & London research centres (especially as it may be difficult for universities from outside to afford over-night accommodation for staff to attend London 9.00am start events). *This has created, according to one senior professor in a university in the Midlands, the "just down the road" syndrome.*

II. A Clash of Cultures

2.11 There is a perception, voiced by 32 interviewees, that cultural issues (habits, traditions, values, and prejudices embedded in both academia and HMG) are getting in the way of effective engagement and delivery. There appear to be a set of unflattering views that academia holds of Government officials, and vice versa, pointing to entrenched stereotypes that could be partially dispelled through greater engagement and interaction.

II.i. The Ivory Tower

The researcher as viewed by the official.

2.12 Academics are perceived by NS stakeholders (as well as those in industry and even some academics) to prefer research to application - "preferring a voyage of discovery to a journey!", to the extent that the "pull-through" to much-needed capabilities is rarely achieved. This is reinforced by incentives within academia, with a traditional focus on publications, although the new **Research Excellence Framework** provides greater scope for applied "impact" and even accommodates the evaluation of secret or classified work.

2.13 Academics appear to lack discipline, with a tendency to drift away from the project plan to what interests them. The research world is frequently dividing into narrower specialisms, but academics are uncomfortable with team-working and struggle with multi-disciplinary collaboration (often using different vocabularies)[9]. There is often a lack of collegiality: one HMG interlocutor expressed surprise at how industry partners were much more collaborative, even with their own competitors.

[8] C. Morris (1983) "Navy Ultra's poor relations" in Hinsley, H. and Stripp, A. (eds) *Codebreakers. The Inside Story of Bletchley Park.* Ocford. Oxford University Press.

[9] It has been suggested that the development of Doctoral Training Centres and the approach taken in EU-funded projects will erode this.

II.ii. Yes Minister!

The official as viewed by the researcher.

2.14 Civil Servants are perceived by academics and researchers - and by many in the public sector itself - to lack strategic vision (exemplified, it is said, by the cyber-security domain). They tend to over-specify and over-circumscribe a set of short-term requirements and they are in thrall to process (see the reference to Red Tape, below). Officials are perceived to be untrusting, ignoring what academic best practice and the evidence-base has to offer;[10] this is not helped by frequent changes in personnel, as Civil Servants are posted in and out of jobs every few years. At worst, Civil Servants expect scientists to rubber-stamp political decisions; and there is a tendency to go for comfort over quality, relying on established academics or consultants.

2.15 Officials are risk-averse, always expecting a result from research and failing to take a portfolio view. Policy makers appear to chase their tails, participating in committees that produce policies that aren't always put into practice. Operational agencies are seen to "log-roll", heaping up requirements indiscriminately and wanting immediate solutions. The generalist tradition leads to a confusing rotation of non-specialists through the complex functional maze of Whitehall departments (*"Divisions do what they say on the tin. They divide!" observed one senior Government technologist).*

III. Resources and Red Tape

2.16 This represents the third area of concern, with 28 respondents identifying resourcing and bureaucracy as a cause for concern. However, the prevailing view at the project workshop was that these problems are not insurmountable – they can be overcome with sharing and best-practice.

III.i. The Resource Challenge.

A tendency to fire and forget.

2.17 HMG stakeholders lack the resource to make an effective contribution to projects (including, academics complain, no hospitality budget to network!), with a culture of "fire and forget". Furthermore, annualised Government budgets fail to align to university/research time-scales. By extension, there is a ready assumption that academics will work for HMG *pro bono* and the change in universities to full-cost funding hasn't fully registered.

2.18 These concerns need to be put in context. The UK Research Councils are spending £18.3 billion on academic research in the country's universities between 2011-12 and 2014-15, and our academics are also tapping substantial resources available from industry and from overseas schemes (including the US Government and the European Union). More money would always be welcomed, but the predominant frustration comes from a lack of commitment or engagement by public servants. This is contrasted with the approach taken by industry: research projects are often connected to a company's strategic road-map, and it is not uncommon either for company technologists to be co-located with a research team or for there to be frequent check-point meetings.

III.ii. Red Tape.

Bureaucracy: Making the Possible Impossible.

2.19 There is too much red tape and bureaucracy - on both sides - when instigating research. HMG's procurement mind-set – with its emphasis on "suppliers" delivering a clearly-specified product or service - runs counter to high-quality research and the process of serendipity which are thought to generate the most exciting outcomes in laboratories. Some HMG Departments now run lists of authorized "suppliers", freezing out – in the opinion of a number of interviewees – high-quality research and small teams; this is also a down-side of the

[10] See Mark Henderson (2012) *The Geek Manifesto* London, Bantam Press. The author describes the phenomena in Government of evidence-shopping, imaginary evidence, clairvoyant evidence, mishandled evidence, and secret evbidence.

Doctoral Training Centres now being established by Research Councils. At our workshop, a plea was made to focus more on "alliances" than contracts.

2.20 A particular concern focuses on confusing practices over Intellectual Property (IP): universities operate different rules (sometimes mandating that the university owns the IP in a central authority, sometimes allowing the individual academic to hold the IP), as do Government Departments (sometimes insisting that IP resides with HMG as "procurer" of research; sometimes allowing it to be retained by the researchers).

2.21 It is also claimed that many of the systems for commissioning research are slow and cumbersome – in universities themselves, in Research Councils, and even in Government organisations dedicated to stimulating innovation such as the Technology Strategy Board. [But it should not be forgotten that processes are there for a purpose - to ensure fairness and rigour.]

Counterpoint

2.22 This chapter has concentrated on problems, issues and challenges to effective collaboration. But we need to keep this in context and provide some counter-balance. There are many examples of fruitful and well-managed relationships, often facilitated by Chief Scientific Advisors and Scientific Advisory Committees.

2.23 There was a broad consensus among interviewees in both Government and academia that events such as Panels and Workshops, bringing the two sides together to explore challenges and build an in-depth understanding of the issues, are to be welcomed. There has been productive activity in this area in recent years, such as MOD's *DCDC Strategic Trends Programme*, Blackett Reviews[11], GCHQ's Summer Workshops for Applied Maths Problems (SWAMP), and EPSRC Ideas Factories on *Countering Terrorism in Public Places* and *Achieving Adaptable Assets: Sustainable Integrated Infrastructure*. Other Case Studies appear below.

HOCAST/HOSDB had success with an **Innovative Research Call**, encouraging new research into the detection of home-made explosives; they also held an EPSRC Sandpit into Cargo Screening providing the generic challenge – how to find out what's in a sealed container in under 60 seconds. Seventeen research teams presented the results of their work at Central Hall in November 2011, including Cranfield (Automatic Screening of CT Baggage Imagery); KCL ("Nuclear Quadrupole & Magnetic Resonance: Detection of Explosives"); Leeds (Terahertz Quantum Cascade Laser Imaging Techniques for Explosives & Weapons Detection"); Newcastle ("People Screening for Threats"); Nottingham Trent ("HotSpot X-Ray Diffraction Imaging for Materials ID"); UCL ("Intelligent Baggage Scanning", On-Belt Tomosynthesis", and "X-ray Phase Contrast Imaging in Baggage Scanning Systems"); and Warwick ("Near Infrared Spectroscopy for Personal Screening").

European Study Groups for Industry occur at least once a year with customers coming with problems that are presented to 60-80 academics who try to crack the challenge in the course of a residential week. Problems and solutions are published in this open programme, with companies paying £5,000 to submit a problem. At the 65th such gathering, at UEA in April 2012, challenges came from Government as well as industry, with AWE seeking help in developing a model for the reduction of specific area of powders with age, the Environment Agency seeking help with probabilistic flood forecasting, and Dstl presenting two problems including "Liquid Interactions with Porous Media and the Environmental Fate of Toxic Materials".

The Centre for Defence Enterprise ran a project entitled *Underpinning Defence Mathematics* with security-cleared staff from the Smith Institute and the Electro-Magnetic Remote Sensing Defence Technology Centre (including SMEs & universities). They selected two problem sets and ran a call where mathematicians were invited to workshops to discuss the challenges; ultimately three out of fifteen applicants were awarded research contracts of up to £50,000; each project lasted six months, with regular progress meetings, ending with a "dissemination event" that brought all stakeholders together to discuss outcomes. They also organised 4-5 internships lasting a few months, where a current PhD student was posted into a DTC company to work on a project aligned to the calls and related research, with frequent interaction with all concerned; costs were divided between EPSRC and MOD. This was judged "fantastic for all" according to one participant, providing a stimulus both for research and for the companies concerned; outcomes included patents and jobs.

[11] A Blackett review panel consists of a small number of academics and industry experts who have a wide range of interests focused around a particular topic, with a few key government attendees such as CSAs. The GCSA chaired two Blackett review panels in 2010: one considered cyber security issues from a Government perspective; another explored how best Government could identify and plan for high impact/low probability 'black swan' events.

2.24 There is a track-record of NS departments commissioning research from academics - often at an *ad hoc* and tactical level, but delivering benefit to all. The SIA have also opened up their records to historians (with authorized histories published in recent years)[12], helping analysts make sense of current intelligence. *Professor Chris Andrew quotes the words of Winston Churchill: "the further backwards you look, the further forward you can look".*

2.25 Initiatives like these should be encouraged. They help build relationships of trust. They enhance communications and erode concern about Government secrecy and negative perceptions about academia's ability to deliver; work-streams can spring from them, leading to important research and the development of new capabilities.

2.26 However, even in this area, we should note caveats that were raised by interlocutors. For instance, workshops and sandpits may help to lay down the foundations for effective collaboration, but this is worthless without the follow-through that is all too often lacking. There is also concern that such gatherings can lack diversity of academic input (e.g. in terms of age and experience), threatening "group-think" and conventional rather than innovative approach. Furthermore, communication problems between different academic disciplines can be so great that even a week's confinement together in an "Ideas Factory" will not solve them.

Concluding Remarks

2.27 As with the CST study, the key conclusion to emerge from my Inquiry is that barriers to collaboration are primarily *cultural* rather than *structural* or *logistical*. In making this point, I am not arguing that different cultures need to be homogenized (even if that were possible, which I doubt) – excellent outcomes can flow from the creative diversity between the two worlds. But both academics and officials need to work to understand the values and incentives of others, changing some habitual practices and engrained assumptions in the process.

2.28 A recurring theme in the solutions identified by interviewees is that positive change will not emerge by forcing people to behave differently, but by creating conditions where personal relationships of trust can be established. This takes time and requires strategic momentum, recognising that significant benefits will accrue in the long-term.

2.29 The proposed solutions that are explored in the next chapter are all designed to address, to a greater or lesser degree, the challenges set out above.

[12] Aldrich, Richard (2010) *GCHQ: The Uncensored Story of Britain's Most Secret Intelligence Agency* London, Harper Press; Andrew, Christopher (2009) *The Defence of the Realm: The Authorized History of MI5* London, Allen Lane; Jeffery, Keith (2010) *MI6: The History of the Secret Intelligence Service (1909-1949)* London, Bloomsbury.

Chapter 3. Proposed Solutions

3.1 This chapter presents and analyses ideas for improving engagement that have emerged in the Inquiry Phase, based on proposals advanced by interviewees. These have been presented in two broad categories – Tactical (Processes) and Strategic (Structures) – although in reality they sit on a spectrum between tactical and strategic. A summary is provided in the table below.

Table 4. Summary of Proposed Solutions

Tactical/Processes	Strategic/Structures
• NS Knowledge Exchanges • Guidelines for IP/IPR • Information on Research-Base • NS Data Release Scheme	• NS Portal for Research Proposals • An Academic RISC • Accelerators & Incubators • NS Research Centre Strategic Study

3.2 The remainder of this chapter describes each of these proposals in greater detail, with one or more Case Studies and an assessment measured against the Evaluation Criteria (see Table 3 on page 7).

* * * * *

A. Tactical (Processes)

A.1 Knowledge Exchange Schemes

Background

3.3 The notion of establishing formal arrangements for exchanging knowledge between the realms of NS and academia goes back many decades. Reference has already been made to the contribution that mathematicians made to the work of the GC&CS after it moved to Bletchley Park in World War II. Indeed, the involvement of scientific advisers in the spheres of defence and security pre-dates the creation of a Government Chief Science Adviser (GCSA): for instance, Solly Zuckerman, the first GCSA (1964-71) had previously been the CSA at the Ministry of Defence (1960-66).

3.4 The GCSA is an established position in Government. The GCSA provides scientific advice to the Prime Minister and Cabinet (including advice on aspects of policy on science, engineering & technology) and ensures that effective systems are in place within government for managing and using science. All the main departments now have a CSA: they work with Ministers and senior teams to ensure robust evidence informs decision-making. CSAs also work together under the GCSA's leadership, with Research Councils and others, to address issues which cut across government. Their precise role and responsibilities varies from department to department, but in all cases they are senior officials who influence departmental thinking. Crucially, they retain a link to universities and a broader academic network.

3.5 A number of Departments, such as the Home Office and MoD, also have Scientific Advisory Committees that come together periodically to review scientific research within those departments and to provide *ad hoc* support. Beyond these formal structures, there are opportunities for knowledge to be exchanged between the domains. The findings from this inquiry, however, suggest that this avenue has been underexplored. A particular obstacle arises from the perceived sensitivities of NS work, often requiring academics to be security-cleared before they engage with Government Departments, and inhibiting Government officials and scientists from speaking openly about their work when visiting academic departments.

3.6 There are lessons that can be learned from other initiatives. In the private sector, many companies – often working with Learned Societies such as the Royal Academy of Engineering – will support the attachment of their scientists and technologists to universities as Visiting Professors; Thales UK, for instance, has more than

half a dozen such professorships, and the company also co-funds a chair at UCL with the RAE. A number of these initiatives were prompted by the Sainsbury Review[13], which proposed (Recommendation 4.2) embedding senior industry professionals into university departments, creating a cadre of "Professors of Practice". Meanwhile, a number of Government Departments have been sending senior officials on the Policy Fellowship scheme established in May 2010 by CSaP at Cambridge University; so far there have been 50 such Fellowships.

Case Studies

CSaP Policy Fellowships last for two years, providing an opportunity for decision makers from government and industry to forge useful and lasting connections with researchers. The Programme has been welcomed in academia as an effective pathway to impact, and in government and industry as an efficient form of executive education. At the earliest opportunity, the Policy Fellow spends 5 days at the University, meeting as many as 30 senior researchers and attending workshops/seminars. This period of immersion is tailored to the needs of each Fellow, with academics chosen for the relevance of their research to a list of questions drawn up by the Fellow. After just one week, as well as gaining fresh insight into how scientific research and evidence impact on public policy formation in relevant areas, the Policy Fellow will have established his or her own network of contacts within academia. Policy Fellows subsequently attend and/or initiate a range of CSaP events, and – perhaps more importantly – continue to interact with the network of academics that they have established, as well as having the opportunity to interact with other Policy Fellows.

The US National Intelligence Council has established an Associates Program designed to expand the global coverage of the Intelligence Community by drawing on the expertise of scholars outside Government, Associates – who are considered as national consulting resources - prepare periodic background reports within their area of specialization, meet with analysts at informal seminars, and participate in formal conferences with other experts. They are not security-cleared, nor are they exclusively US nationals; it is clearly stated that they make their expertise and knowledge available to help US leaders better understand the context and complexities of foreign trends and events, and they are not asked to collect information, nor do they take any action (official or unofficial) on behalf of the US Government.

Proposition

3.7 We establish a number of schemes designed to enhance knowledge exchange between academia and the NS domain. Options include:

- run a CSaP-style **NS Fellowship** scheme for – say – 6 HMG officials per annum, at a cost of c £3,300 per head (including establishing a week's board and lodging at university). *The GU Workshop recommended that any such scheme should consider deploying small teams rather than single Fellows, with visits to at least three universities in order to spread networks and benefits.*

- set up a programme of **Visiting Professorships** for HMG scientists and engineers, with the assumption that each would attend their chosen university department one day per month; *we should aim to have approximately 6 established within three years;*

- establish a cadre of **NS Associates** – academics with expertise in disciplines of interest and relevance to the NS community who are invited to visit HMG Departments four times a year;

Our attention has also been drawn to the **Security Studies Program** at Massachusetts Institute of Technology in the United States, where NS 'high flyers' spend 6-8 weeks at a key university studying as part of the student body attending lectures and becoming part of the community.

Benefits

3.8 These initiatives overcome concerns and perceptions about a secretive, disengaged NS community and help officials to understand the capabilities of the UK's research base. They help to build relationships of trust and enhance communications, undermining negative perceptions – on both sides - of cultural differences. This could also encourage HMG to develop strategic/portfolio approach to requirements, and academics to focus on pull-through from research to application.

[13] Lord Sainsbury of Turville (October 2007) *The Race to the Top: A Review of Government's Science & Innovation Policies* HM Treasury.

Caveats/Drawbacks

3.9 We should expect some discomfort, on both sides, in crossing the lines: officials may feel reticent about discussing requirements (and will need support here); academics may be concerned about applying restrictions to what they are told.

Evaluation. NS Knowledge Exchanges

SHORT-TERM	
Short-Term Deliverable	*We use CSaP to trial a NS Fellows scheme, but with one team of Fellows visiting up to three universities before the end of the year; we could also explore arrangements for a Visiting Professor Scheme.*
Scale of Short-Term Impact	*Based on visits already instigated, this will bring quick benefits leading to greater knowledge and understanding (on both sides) and new research projects.*
Resistance	*Not significant, but based on visits already instigated, we need to support HMG scientists in how to engage. We need to check that administrative resources are available.*
EVALUATION	**HIGH chance of delivering early benefits.**
LONGER-TERM	
Likelihood of Impact	*This looks to be a cost-effective & powerful way of bridging cultures and building relationships.*
Scale of Impact	*The impact is substantial, with ultimate benefits flowing from these exchanges.*
Resistance	*Some concerns – on both sides – need to be addressed but these can be overcome with guidance and advice.*
EVALUATION	**A promising & achievable option with HIGH prospect of success.**

A.2 Guidelines for IP & IPR

Background

3.10 The term "Intellectual Property" (IP) is a formalised/legal description of "a creation of the mind" that is owned by someone. This is a tradeable asset like other forms of property; it has a defensive value (owners can stop others using it, or demand payment for use); a commercial value (a third party who wishes to use IP must pay for the right to do so); and a relationship value (the skills & knowledge underpinning IP may be of interest to those owning related lP, leading to new productive partnerships being created). People speak of "IPR" to refer to the exclusive Intellectual Property Rights enjoyed by the owners of IP.

3.11 There is confusion about how IP/IPR is handled. Different HMG Departments apply different approaches when deciding whether to allow a researcher to retain IPR developed as a result of either a grant or contract. A number of factors lie behind this (over and above insufficient attention being paid to the subject). Firstly, there are challenges in defining IP, especially distinguishing between "background" and "foreground" or "arising" IP (the former being accumulated knowledge in a research establishment that contributes to IP developed in a project; the latter referring to the results of the project).

3.12 Secondly, there are competing principles at work: the individual researcher can feel vulnerable and protective of his/her IP, and certainly an attempt to raise or attract Venture Capital to commercialise IP will be doomed to failure if investors are not satisfied about clear ownership (preferably controlled by patents or a robust licensing structure); but Government officials feel obliged to use public funds prudently, and may be concerned about taxpayers getting a "raw deal" if IPR is given away too easily.

3.13 Further complications arise from arguments in favour of supporting and liberating SMEs in order to benefit "UK plc" versus those focussing on the narrower mission of a particular Government Agency or Department. It is often the case that "IP aggregation" by the funder leads to unnecessary restraint on innovation and the generation of new business. *One medical researcher and entrepreneur has spoken positively about the approach adopted by the Medical Research Council, which owns the IP deriving from MRC grants, but successfully incentivises inventors and institutes with some royalties flowing back to both.*

3.14 I have also been told of significant differences in the way in which universities handle IPR. It may or may not be a reasonable representation, but interviewees have distinguished between the centralised approach taken by some institutions (e.g. Imperial), where all IP developed in departments is owned by the university, and a more *laissez faire* approach taken by others (Cambridge is one, although the rules have tightened) with IP linked closely to individual academics. There appear to be strengths and weaknesses in both approaches.

Case Study

The *Lambert Review*[14] examined, knowledge transfer in business-university collaborations. Subsequently, in 2004 , the Lambert Working Group on Intellectual Property brought together key stakeholders from universities and business to draft model collaborative research agreements for voluntary use setting out options for the ownership & exploitation of IP including use of exclusive or non-exclusive licensing to the business. This led to the **Lambert Toolkit** – managed by the Intellectual Property Office – for universities & businesses wishing to undertake collaborative research projects, with an emphasis on innovation. The IPO notes that these agreements "do not represent an ideal position for any party; depending on the circumstances they are designed to represent a workable and reasonable compromise for both or all parties." But there appear to be reservations, at least on the part of business, and the level of take-up is uncertain.

Proposition

3.15 We should take steps to establish clarity in the way in which HMG officials – especially those working in the NS domain – address IPR issues when working with universities. Given the significant progress made by the Lambert Working Group on Intellectual Property, and the existence of the Lambert Toolkit, it is unlikely that we need to "re-invent the wheel", although we need to take note of objections. We should discuss, agree and circulate coherent arrangements in the form of guidelines.

Benefits

3.16 Efforts to clarify arrangements for handling IP/IPR will overcome, at minimal cost, an obstacle to effective collaboration and help to build relationships of trust. This in turn will create a benign climate for the pull-through and delivery of new capabilities. It appears to be an important enabler.

Caveats/Drawbacks

3.17 There are no obvious difficulties in seeking to address this issue, but streamlining IPR processes in both Government and academia will be difficult.

Evaluation. Guidelines for IP/IPR

SHORT-TERM	
Short-Term Delivery	*We could issue new guidance, having undertaken a small-scale inquiry into current working practices in different Departments (focused on Procurement Teams), culminating in a workshop bringing Government and academia together to develop guidance. Early benefits might be realised if participants began to apply best practice (e.g. Lambert Toolkit) more systematically.*
Scale of Short-Term Impact	*A small impact in the short-term, reflected in changes in behaviour of those involved in the work. But this could be an important step forward.*
Resistance	*Minimal, unless time-pressures prevented involvement of stakeholders in the work.*
EVALUATION	**HIGH benefit, given prospect of a quick win in bringing people together to change status quo.**
LONGER-TERM	
Likelihood of Impact	*High likelihood that this would have an impact on collaboration between HMG and academia, creating more opportunities for pull-through and delivery of know-how.*
Scale of Impact	*This could make a significant contribution to collaboration and ultimately to delivery.*
Resistance	*Minimal.*
EVALUATION	**HIGH value intervention, addressing at minimal cost confusion & frustration, leading to new behaviours and protocols.**

[14] *The Lambert Review on Business-University Collaborations* (December 2003), chaired by Richard Lambert, ex-editor of the Financial Times, former member of the Monetary Policy Committee at the Bank of England, and then Director General of the CBI until 2011.

A.3 Accessing Information on the Research-Base

Background

3.18 A common complaint voiced by Government officials is that they struggle to understand the quantity and quality of research being undertaken across the UK's 164 publicly-funded institutes of higher education. They need help to understand what research is going on, where. It cannot be assumed that the best research will always reside in the country's top universities – pockets of excellence are to be found across the nation. For instance, I have learnt that the University of Glamorgan, ranked 91st in the country, has a highly-regarded team working on forensics and security.

3.19 This problem is exacerbated if the challenge extends to the record of past research. Anecdotally, a number of NS stakeholders express the anxiety that they are commissioning work that duplicates research done previously, and they have no easy way to resolve this. This Knowledge Management challenge is not helped by the relatively rapid turnover of staff in Government posts, and the increasing levels of specialism in academic research: this means there is no certainty that one can find informed (or to use the Bletchley Park term-of-art, "enwised") sources to help resolve the problem either in a Government Department or in universities.

3.20 There are web-based databases that can help, including the University of Wolverhampton's map of UK institutes (http://www.scit.wlv.ac.uk/ukinfo/). Furthermore, Research Councils represent an impeccable source, but they are insufficiently consulted - possibly because the existence and scope of their databases are not well-understood. Case Officers in the Research Councils are available to provide guidance, and not only have the benefit of expertise in the RCUK systems but also personal (tacit) knowledge that is probably under-exploited.

Case Studies

The UK Research Councils maintain a number of databases that contain a record of current research, and there is a growing historical element to this. ROS, or the **Research Outcomes System**, was launched in November 2011; it is a web based system through which researchers and research organisations supply information about the outcomes of their research to Research Councils, which can then be searched; ROS is based on an existing ESRC collection system which has been developed on behalf of the AHRC, BBSRC, ESRC and EPSRC. The remaining three Research Councils use alternative systems (with MRC and STFC using **e-Val** and NERC using ROD, its **Research Outputs Database**). There are also databases such as EPSRC's "Grants on the Web", with searchable details such as title, abstract and key-words.

Another valuable source of information resides in the catalogue of projects funded by the Technology Strategy Board (including historical case-studies). They already publish a list of "Success Stories", such as Stratophase, a company spinning out of Southampton University, which has developed optical microchip sensors capable of detecting toxins, viruses and bacteria. Later this year, TSB plans to launch a searchable database covering all their projects.

ATHENA is the MOD's central library for storing scientific and technical reports, maintained by Dstl and available to registered users on the web. It provides a range of products and services which are available to organisations working in defence, including access to information from past and present research programmes and a portal for finding experts working in a particular field.

Proposition

3.21 We should take measures to help Whitehall understand what research is going on, where. This is not a challenge confined to the NS domain, and there would be merit in flagging this up to the Government Office of Science (GO Science), seeking their support and proposing some concerted action.

3.22 In the short term, however, we could develop a simple communication strategy in collaboration with RCUK and TSB, alerting colleagues in relevant Departments and Agencies to facilities such as ROS, *Grants on the Web*, and the new TSB database); we should also provide guidance on how best to make use of RCUK's Case Officers. We need to make sure that there are appropriate access rights to these databases, allowing them to be searched, and we may need to provide some training to allow officials to extract full value from these services. New habits need to be formed.

3.23 This may not be enough. Given the substantial amount of money being spent on research in the UK, it is reasonable to ask GO Science if a state-of-the-art, user-friendly, interface needs to be designed providing

access to databases with information about our research-base for stakeholders inside and outside Government. At our workshop in June, participants asked if we should adopt a "Big Data" paradigm, applying an "industrial-strength Google" to the Research Councils' portal and other databases (such as ATHENA). This should extend to cover the historical record.

Benefits

3.24 Significant value would flow from improving knowledge of current and past research activities. The information is available, to a greater or lesser extent, within RCUK and TSB databases and we need to ensure that end-users understand this. This should lead to better judgments about where to direct resources, as well as a more fruitful interaction between researchers and those who can derive benefit from their work.

Caveats/Drawbacks

3.25 No significant problems, other than overcoming reluctance to change the status quo. There would be costs associated with designing and developing a new interface.

Evaluation. Accessing Information on the Research-Base

SHORT-TERM	
Short-Term Delivery	*Early benefits, in the form of a communication and training strategy to ensure Civil Servants understand current systems and facilities and make better use of them, could be developed within months.*
Scale of Short-Term Impact	*Significant.*
Resistance	*None, other than winning support of those who "own" resources involved in drafting a communication and training strategy.*
EVALUATION	**This scores well (HIGH) with opportunities to achieve early beneficial changes.**
LONGER-TERM	
Likelihood of Impact	*High, providing clarity of understanding and opportunities for interaction that extend way beyond the NS arena. A quick win?*
Scale of Impact	*Potentially large.*
Resistance	*Negligible, unless there was concern in Government about the cost of a new interface.*
EVALUATION	**An attractive option, gaining HIGH score given benefits and low resistance.**

A.4 NS Data Release Scheme

Background

3.26 A chronic complaint from the research community is the unwillingness of NS stakeholders to make data available, for security reasons, undermining the quality of research projects.

3.27 This is not a problem that is confined to the NS domain. Substantial databases of great research interest exist, or can be compiled, in the health and transport sectors, for instance; but ethical and legal constraints arising from privacy concerns properly impose restrictions on how that data can be used. HMG is leading a major initiative in this area under the banner of the **data.gov.uk** initiative, with currently over 5,400 datasets available, from all central government departments and other public sector bodies and local authorities.

3.28 In June 2011, the Foundation for Science and Technology (FST) held a debate *Can better use be made of public data for example in health research?* Professor Paul Boyle, Chief Executive of the ESRC, said that the data routinely collected by different HMG departments and agencies constituted a resource of immense potential value for research across a wide range of social and economic subject areas. Acceptable ways needed to be found to improve accessibility and links between different datasets.

3.29 But there is an inherent tension between the desire to protect personal privacy and the desire to harness this resource of public data for the benefit of the public. A number of methods are being developed to increase access to sensitive data while safeguarding privacy, with the Office of National Statistics playing a leading role. The "**safe haven**" minimises the extent to which raw data is altered or redacted, but it is held in a controlled

facility with tight control over the access granted to researchers; examples include the Secure Data Facility established by the Metropolitan Police at the Jill Dando Institute, and the secure WHO Centre for analyzing flu data established at Cambridge's Infectious Disease Centre. Another option, favoured by those working with health data, is to **anonymise** the information, stripping out anything that breaches an individual's right to privacy; examples include the set of protocols by the Olympic Delivery Authority for anonymisation of its data; and the approach taken by Dr Foster Intelligence (working in collaboration with the Department of Health, to handle Health Service data. A third option, exemplified by i-LIDS, is to **simulate** data (although this can be costly and there is a risk that authenticity is lost in the process).

Case Studies

The Scottish Longitudinal Study (SLS) has brought together census data, population data, health data, education data and personal vital statistics, enabling that combined data resource to be accessible to researchers with viable measures to avoid compromising the personal privacy of the individuals covered by those data.

The Image library for intelligent detection systems (i-LIDS) is the government's benchmark for Video Analytics (VA) systems has been developed by the Home Office in partnership with CPNI. There are currently five scenarios within i-LIDS: sterile zone monitoring; parked vehicle detection; abandoned baggage detection; doorway surveillance; and multiple camera tracking. Publically available training and test datasets help researchers and manufacturers to develop new systems, with a privately held evaluation dataset used by HOCAST to benchmark the performance of VA systems in annual evaluations.

3.30 There are concerns that should not be underestimated. At the FST event, speakers warned about the increasing skills of those seeking to breach defences established to protect the identity of individuals in the datasets. The more data made publicly available, the greater the scope for making linkages which can reveal identity, disclosing sensitive data by means of inference. New techniques are being developed to address this, including methods to restrict queries (e.g. maximum order control or minimum query-set size) or add noise.[15]

Proposition

3.31 We should investigate ways to make NS data available to researchers, in order to enhance the quality and applicability of their work and to motivate and support research. One option would be to invite RCUK to sponsor a working group or seminar on data exchange, identifying ways to facilitate transfer of data from government to researchers, such as anonymisation techniques or safe havens; (a variant on the "safe haven" proposal – that emerged in the course of this inquiry – is that a mobile secure data facility could be developed to support researchers). This could draw on best practice measures being adopted in other sectors (e.g. health), and some thought should be given to credible and authentic analogues – in the NS sphere this might include the National Repository of Tweets and the Enron database of e-mail messages. However, Government representatives at the workshop in mid-June argued that we should **run a pilot study**: find a dataset to release; find someone to do the research; this will lead us to identify the criteria for assessing potential data sources to release, engaging in the process with relevant stakeholders. We would expect legal, political, ethical, commercial, and security issues to be considered and tested in the process. *The view was also expressed that we should not necessarily think of this data as being huge in size: there could be merit in looking at quite small amounts of historical and qualitative data.*

Benefits

3.32 This would address a major complaint from academia, providing a new incentive to work collaboratively with Government, and remove the perception that academics are excluded and untrusted. It also enhances communications; removes red-tape seen to inhibit effective and useful research; demonstrates a substantive input/contribution from HMG.

Caveats/Drawbacks

3.33 There will be concerns among those charged with safeguarding sensitive information that anonymisation processes are fallible. Government data doesn't always have an obvious owner or creator who can declassify it, and there would be cost implications. To solve this needs top level buy in again. *One interviewee has suggested there should be a "declassification czar"!*

[15] See, for instance Marcin Przybyłko (University of Warsaw) et al (2011): *Mathematical techniques for the protection of patients privacy in medical databases*. European Study Group Report: ESGI77.

Evaluation. Data Release Scheme

SHORT-TERM	
Short-Term Delivery	*An early benefit would come from running a trial that identified real data for release and research, exposing the challenges and looking for ways to address them. A quick win.*
Scale of Short-Term Impact	*Such a pilot would not only represent an important step towards sorting out this problem, but deliver impact through demonstrating willingness to engage. Mind-sets shift.*
Resistance	*There is likely to be resistance to making this first step, given costs and perceived risks. This will require champions at a senior level within the NS domain.*
EVALUATION	**A strong contender for receiving attention in the short-term, carrying HIGH value, reflecting scale of potential benefits but with some resistance to any efforts to trial a release of sensitive data rather than investigate the options.**
LONGER-TERM	
Likelihood of Impact	*Strong, making a direct & indirect contribution to the goal of greater & better collaboration. It would provide ground-truth for a number of projects where currently researchers struggle to satisfy requirements, with better evidence-based research.*
Scale of Impact	*Potentially large. Delivering better research and improved collaboration.*
Resistance	*Not insignificant. There will be concerns among NS officials about release of data, even if anonymised, and costs/red tape involved both in processing/maintaining such databases.*
EVALUATION	**Great benefits flow from this, but there are significant challenges. Given new techniques to protect sensitive data elsewhere, this is valued as VERY HIGH, but an intervention needing senior management attention in HMG to progress.**

B) Strategic/Structures

B.1 NS Portal for Research Proposals from Academia

Background

3.34 A common complaint voiced by academics is that they struggle to find a way of engaging with the NS domain, if and when – for instance - they have research proposals that they believe could be of value to end-users. It is difficult to penetrate the security shell surrounding decision makers who could benefit from their expertise and know-how. Hard-pressed Government officials are not entirely sympathetic: they express concern that any improvement in accessibility can only lead to distractions as they are bombarded by unsolicited and potentially poor-quality or ill-focused submissions. However, in recent years, the Ministry of Defence has started to transform the way in which researchers can reach it, through the Centre for Defence Enterprise (CDE).

Case Study

CDE aims to enhance innovation in defence and (following the recent White Paper *National Security through Technology*) security research and development by engaging the broadest possible audience of science and technology providers, proving innovative ideas by funding research proposals. It is the first point of contact for anyone with a disruptive technology, new process or innovation that has a potential defence or security application. It funds research into novel high-risk, high-potential-benefit innovations sourced from the broadest possible range of science and technology providers, including academia and small companies, to enable development of cost-effective capability advantage. It has developed an online submission process - 'The Portal' - designed to allow anyone to describe their innovation. In addition to themed calls, there is also an open call for any innovative research ideas that have a potential defence and security application.

Proposition

3.35 Explore with NS stakeholders the idea of establishing a web-based portal providing academics with access to potential customers for research and development proposals; one option would be to build on the existing CDE portal. Any progress in this area would need to be accompanied by a communications strategy.

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Benefits

3.36 This helps break down barriers that get in the way of effective communication and trust, with the potential for introducing important research to end-users in the NS domain which might otherwise go unnoticed.

Caveats/Drawbacks

3.37 There are likely to be concerns among Government officials about the cost of dealing with queries efficiently and effectively. For instance, what is the signal to noise ratio for unsolicited proposals with the CDE system? Could the CDE brand be adjusted to reach academics as well as SMEs and is the portal sufficiently useable for academics?

Evaluation. NS Portal for Research Proposals from Academia

SHORT-TERM	
Short-Term Delivery	*We could work with NS stakeholders, to explore feasibility of launching a gateway (e.g. using the CDE Portal) for academics to reach NS customers.*
Scale of Short-Term Impact	*Introduction of new arrangements could bring early benefits.*
Resistance	*Concerns about cost if a trial is run. Stakeholders may be reluctant to engage with the principles in the short-term.*
EVALUATION	**A MODERATE-HIGH evaluation.**
LONGER-TERM	
Likelihood of Impact	*This is likely to deliver a quick win in presentational terms, and could provide access to research of significance and substance.*
Scale of Impact	*This would help break down barriers, encourage interaction, and allow exploitation of relevant research that might otherwise be overlooked. Impact could be significant.*
Resistance	*Concerns about cost and risk of time-wasting are likely to surface.*
EVALUATION	**The promise of HIGH impact.**

B.2 Accelerators & Incubators

Background

3.38 Universities are developing knowledge and understanding of "Technology Transfer", with many of them establishing teams dedicated to commercialising the IP that is developed by research teams. The extent to which academics and institutions "buy into" this approach varies: Imperial has a well-established enterprise (with Imperial Innovations), and it has been said that a commitment to deliver applied research in the form of usable products is hard-wired into this university – part of its mission from the beginning. Other examples include Isis Innovation, Cambridge Enterprise, and Setsquared (serving Bath, Bristol, Exeter, Southampton and Surrey Universities). There are also examples of universities supporting "Accelerators" or "Incubators" designed to help small start-up companies gain the seed capital and the know-how to move "from the bathtub to warehouse" (to use the title of a talk given to entrepreneurs by Cambridge Consultants). The so-called "Cambridge Phenomenon" provides a particularly successful example, including IdeaSpace and Springboard (see Case Study, below), St John's Innovation Centre and the Babraham Incubator.[16]

Case Studies

IdeaSpace was established at Cambridge with East of England Development Agency funds and the support of the Hauser-Raspe Foundation to foster very early-stage companies. There is peer-mentoring, collaboration between ventures, access to advice and – of course – to Venture Capital. Currently 80 people from 65 small companies use *IdeaSpace*, including "hot-deskers" who have access to the place one day a week, and "co-workers" who are there five days a week. The attention that IdeaSpace pays to Concept Development and the early 'Start-up' phases of the enterprise lifecycle has led it to be described as a **pre**-incubator. Its alumni can go on to St John's Innovation Centre, or the nearby Babraham Incubator. *However, the Director of IdeaSpace tells me that no more than 30% of the companies at his facility are Cambridge University start-ups or spin-outs.*

Springboard is an accelerator that can mentor – say – 10 teams seeking to commercialise their IP, with a sponsor-investor providing £15,000-£20,000 to each over three months. The aim is to develop a business plan through a three-stage process (*Shape : Build : Sell*) to the point where presentations are made to angel investors and venture capital companies looking to many more substantial investments. The next stage would be to move to an incubator where they will implement a Business Plan – typically working on this over 1-2 years with a capital investment of £200,000 to £1 million.

[16] Kate Kirk and Charles Cotton (2012) *The Cambridge Phenomenon: 50 Years of Innovation and Enterprise* London, Third Millenium Publishing pp 182-189.

Proposition

3.39 The NS community should work with the Technology Strategy Board – HMG's Centre of Excellence for innovation – to engage with researchers and university ventures to encourage spin-outs delivering usable products and services for NS. The focus should be on supporting research teams get involved in university-based Accelerators or Incubators (and this could be a rational follow-through from NS Research Centres discussed above).

3.40 Participants at our workshop recognised that potential threats to national security meant that there was an urgency (in terms of turning research into applied products) that may not exist elsewhere; the suggestion was made that cooperation with TSB might provide a constructive and systematic way of taking this forward (encouraging TSB to work with university technology transfer teams to support spin-out initiatives). There need to be incentives to make it worthwhile for companies to accelerate, and HMG had to resolve how to fund work of this kind to encourage spin-out. Could this fit into an NS industry strategy that included arrangements for evaluating potential solutions and ensuring compliance with procurement rules?

3.41 This initiative could be supported by trialling a course along the lines of the 4-day *Enterprisers* or 2-day *Intrapreneurs* modules run at the Judge Business School in Cambridge. People from NS, business and academia could come together to develop innovation skills, building relationships of trust and understanding in the process. This could include training in *Open Innovation* and *Easy IP* ideas where collaborative relationships are built to deliver synergies through the fusing challenges and IP, and where universities give away low-value IP in order to encourage the generation of effective products. The aim would be to run an NS programme where HMG nominates public servants, academics and – where appropriate – private sector representatives who are involved in collaborative research aimed at delivering products and services.

Benefits

3.42 This would tackle the concern of many Civil Servants that academia is about research not delivery. It would also address the challenge of market failure (explored in my paper from December 2011 on a "NS Venture Catalyst"). There would be further holistic benefits if this linked into other initiatives proposed in this paper, where HMG is engaging more positively with academia in articulating requirements and sharing knowledge/data to help academics solve our challenges.

Caveats/Drawbacks

3.43 No significant problems, other than concern in some quarters of academia about Government attitudes to IP and IPR. This initiative could usefully be linked to that, below, arguing for a move to address these concerns by establishing clear and coherent ground-rules for IP and IPR.

Evaluation. Accelerators & Incubators

SHORT-TERM	
Short-Term Delivery	*Run a trial NS Enterprisers or Intrapreneurs course, bringing people in NS, business and academia together, to develop and apply innovation skills. This could include exposure to "Open Innovation" & "Easy IP" idea, and be build on existing research projects.*
Scale of Short-Term Impact	*Potentially useful, developing relationships of trust and supporting "pull-through". But given other demands on people's time, may be regarded as a "nice to have"not essential.*
Resistance	*Given commitments of busy people, this may be difficult to deliver in time available.*
EVALUATION	**MODERATE value could flow from laying foundations for this solution.**
LONGER-TERM	
Likelihood of Impact	*Potentially very high, providing a joined-up approach to the development of capabilities emerging from research projects of relevance to NS.*
Scale of Impact	*Potentially large, helping to address market failures constraining pull-through of IP.*
Resistance	*Some anxiety about HMG attitudes to IPR need to be addressed (see separate proposal below). But this is compatible with HMG thinking re trialling a Venture Catalyst.*
EVALUATION	**This could bring High or Very High value to NS stakeholders, and to national economic interests more broadly. This would be well-suited to incorporation into a plan to support SMEs (being relevant to industry as well as academia).**

B.3 Academic RISC: Partnering with Government and Industry.

Background

3.44 In 2007, an inclusive alliance of industry, trade associations and think tanks was established, under an umbrella organisation called RISC (the Security & Resilience Industry Suppliers Community), to help HMG and those managing the nation's critical infrastructure deliver a more secure and safe environment for the UK's citizens. A Strategy Group combining HMG and RISC representatives provides a link into the National Security domain through the Home Office, and HMG and RISC have set up five Industrial Advisory Groups to allow specific industrial advice on key areas for national security: Chemical, Biological, Radiological and Nuclear Protection; Information & Communications Technology; Protection of the Critical National Infrastructure; Police Capability Working Group; and Olympics & Paralympics.

3.45 There has been some involvement of academics with RISC – for instance, RUSI and Chatham House each hold a permanent seat on the governing Council, not only as representatives of the think tank community but also as gateways to the academic community. But in January 2012, a number of senior academics who have worked closely with RISC proposed an academic equivalent to this organisation, through the formation of a collaborative alliance of universities to support national security; it was argued that this would provide a strategic academic engagement whose benefits include access to a non-partisan long-term interdisciplinary approach to national security challenges; the introduction of thought leadership and risk-based advice on key elements of policy, process and technological strategy; opportunities for international collaboration and funding through academic networks; and the pull-through of laboratory S&T through spin-out activities.

3.46 It is not clear if this initiative, which is currently being considered by HMG, would become formally linked to RISC, but there have been a number of examples, in recent years, of collaborations between Government, academia and industry designed to achieve rapid pull-through of low-maturity research in order to deliver significant new capabilities (either to Government end-users, such as the Armed Forces, or to wider markets) or develop appropriate standards. At our workshop in mid-June, the view was expressed that these work best when there is significant benefit to all three parties; it was also noted that significant management overhead is required to make tripartite arrangements work – this is not a peripheral activity but an essential role requiring dedicated attention.

Case Studies

The Mobile Virtual Centre of Excellence was created in 1996 as a Government initiative to establish a collaborative partnership of leading mobile communications companies and UK universities, each having specialist expertise. Industry members pay a fee that is match-funded by EPSRC, to support long-term, research in Mobile & Personal Communications: Industry Steering Groups meet every 3 months to review progress. According to Professor Chris Firth, the Chief Scientist at Thales UK, the initiative has pioneered highly effective collaborative processes whereby our industrial members take a pro-active lead in defining and steering the research, which is undertaken by pan-university teams drawn from our academic members.

Defence Technology Centres (DTCs) were started in c 2005 by the MOD in an attempt to promote effective cooperation between industry and academia. Examples include such programmes as *Human Factors Integration*, *Electromagnetic Remote Sensing*, *Data & Information Fusion*, and *Systems for Semi-Autonomous Systems*. The last of these was led by BAE, and in addition to many industrial participants in this virtual organisation, there was input from such universities as Cranfield, Bath, York, Kings College London, and Bristol University; an analysis of the "Lessons Learned" from this DTC, written by BAE and Dstl, is found at Annex 3. More recently, the MoD has been establishing "Defence S&T Centres", such as one for *Armour and Protection* and *Materials and Structures.* There are question-marks about how successful DTCs have been, in terms of generating new capabilities deployed in the field.

A successful transatlantic collaboration is represented in the *International Technology Alliance* (or the Network & Information Sciences International Technology Alliance) - a collaborative research alliance between the UK MoD, the US Army Research Laboratory, and a consortium of leading academic and industry partners. The ITA program started in 2006 with the strategic goal of producing fundamental advances in information and network sciences that will enhance decision making for coalition operations and enable rapid, secure formation of *ad hoc* teams in coalition environments and enhance US and UK capabilities to conduct coalition warfare. The first phase ended in 2011 and appears to have been judged a success; a second five-year programme has now started.

3.47 Following the Hauser Report[17], BIS is embarking on a long-term programme to establish Technology Innovation, or "Catapult", Centres. The aim is to create a critical mass for innovation, focusing on technology with potentially a large global market and significant UK capability. Seven areas have been selected: high value manufacturing, cell therapy, offshore renewable energy, satellite applications, connected digital economy, future cities, and transport systems. With support from TSB, the new investment will bridge the gap between universities and businesses, helping to commercialise the outputs of Britain's world-class research base.

Proposition

3.48 We support efforts to establish a new framework – an "Academic RISC" or a "GU Alliance"- that will allow academia to engage with Government and industry on security issues in a more strategic manner. Ideally, there should be a close alignment with RISC in order to minimise management overheads and improve opportunities for pull-through; particular focus should be on support for tripartite partnerships where industry and academia work together to address NS challenges. An early output, supporting this initiative, would be to catalogue existing tripartite partnerships where there is either an existing NS agenda (such as the Centre for Secure Information Technology at Queens' Belfast) or where there are opportunities for NS stakeholders to shape research and gain early access to developments (e.g. Catapult Centres and the newly-formed Centre for Smart Infrastructure & Construction at Cambridge[18]). Another initiative could be an "NS Open Innovation Forum", where businesses and R&D organizations share knowledge and learn from each other, responding – for instance – to HMG's seven priority challenges (see Table 1 on page 6).

Benefits

3.49 An Academic RISC would provide greater coherence and strategic shape to the work of UK researchers addressing NS challenges. By involving industry in the mix, we can promote an emphasis on delivery, using business to help pull-through. It also enhances communications and addresses concerns over effective resourcing by HMG through partnership with private sector and links to longer-term investment initiatives (overcoming annuality issues). A commitment to communicating requirements and to engagement – already delivered through HMG links to RISC – will erode concern about secrecy and builds trust, with NS stakeholders demonstrating a strategic/portfolio approach to requirements.

Caveats/Drawbacks:

3.50 This is not suitable for all requirements or disciplines (there have been failed attempts at this). There could be significant management overheads.

Evaluation. Academic RISC: Partnering with Government & Industry

SHORT-TERM	
Short-Term Delivery	*Help designing the GU Alliance, and/or cataloguing relevant tripartite partnerships might be delivered within months if effective engagement is provided. But some risks here.*
Scale of Short-Term Impact	*Establishing rules of engagement for the GU Alliance could be fruitful. A catalogue of relevant industry-academia partnerships would help (if only to support recruitment of interested parties to the Alliance).*
Resistance	*No obvious problems in delivering this other than inertia and higher priorities.*
EVALUATION	**MODERATE. A small step that may not be achievable in time available.**
LONGER-TERM	
Likelihood of Impact	*Strong likelihood of impact through strategic cooperation, problem-based research and the development of road-maps.*
Scale of Impact	*The involvement of industry with academics and end-users increases the chance of innovative research being turned into end-products that deliver capabilities to the front-line.*
Resistance	*There will be concerns about bureaucracy trumping delivery, but these would be allayed if close alignment with RISC could be established. Funding could be an issue: will Trade Associations be willing to bank-roll academics? Could RCUK help here?*
EVALUATION	**Good prospects for success if a dynamic and engaged organisation is established. MODERATE-HIGH.**

[17] Dr Hermann Hauser: *The Current and Future Role of Technology and Innovation Centres in the UK* BIS, March 2010.
[18] Public sector organisations already involved include the Highways Agency, Transport for London, London Underground, and Crossrail.

B.4 NS Research Centre Strategic Study

Background.

3.51 In his recent report, *A Review of Business-University Collaboration*, Professor Sir Tim Wilson notes approvingly that "in recent years a model of strategic partnerships has evolved whereby a single university is able to meet the collaboration needs of a business in multiple domains. These are not exclusive partnerships, but explicitly cover more than one domain with possibility of extension into others. The potential efficiency of such partnerships is clear." He cites examples of links between Siemens and the University of Lincoln, Proctor & Gamble and Durham, and BAE and Bristol.[19] In discussion, Professor Anthony Cheetham referred to his own experience of a productive and creative research relationship with Mitsubishi Chemical at UC Santa Barbara, with a $15 million research alliance (initially running from 2001-06) on advanced materials, solid state lighting and displays: crucially, it took – by his estimate – three years to build effective relationships of trust, but it has been sufficiently successful that it has been renewed on two occasions and is currently running until 2014.

3.52 There are similar examples of units within universities that have an established relationship with policy makers and/or practitioners in Government. This supports an effective exchange between the two; close engagement can extend to regular interacts, including attachment of Government experts inside the Unit or Centre. The Case Studies in the box below are worthy of particular note.

Case Studies

The Behavioural Health Research Unit at Cambridge University is funded as part of the Department of Health Policy Research Programme (2010-2015). Its aim is to contribute evidence to national and international efforts, to achieve sustained behaviour change that improves health outcomes and reduces health inequalities, with outputs intended to inform policy-making. Specific objectives include providing timely and authoritative information (delivered in a matter of weeks) to support decisions on investing or disinvesting in interventions designed to change health-related behaviour. Its research draws upon recent developments from neuroscience, psychology and behavioural economics; its initial focus is on diet, physical activity, smoking and alcohol consumption – four behaviours which together are responsible for the majority of premature deaths worldwide.

The Heilbronn Institute for Mathematical Research (HIMR) is a partnership between Bristol University and the GCHQ, established in October 2005. HIMR brings together high-calibre mathematicians from various disciplines to conduct theoretical research into key areas of mathematics: it has about 30 members including both established researchers on secondment and some with recently awarded PhDs; their fields of expertise include topics in number theory, algebraic geometry, algebra, combinatorics, probability, quantum information and statistical data-mining. Each member of the Institute spends half their time pursuing research directed by the GCHQ, and the other half doing personal academic research.

The US National Consortium for the Study of Terrorism & Responses to Terrorism (START) at the University of Maryland is committed to the scientific study of the causes and consequences of terrorism. One of 12 Centers of Excellence funded by the Department of Homeland Security; it supports research efforts of leading social scientists at more than 50 academic and research institutions, each of whom conducts original investigations into fundamental questions about terrorism. Its experts apply a range of research methods in order to deliver findings based on the best available open-source evidence and data. Research must be scientifically rigorous and directly relevant to homeland security professionals. *Other Centers of Excellence include one for Zoonotic & Animal Disease Defense (CZAD); and one for Awareness & Location of Explosives-Related Threats (ALERT).*

GCHQ and EPSRC are launching two new Research Institutes (RIs) in strategically important areas of Cyber Security research that need to be strengthened. The first RI is in the area of 'Science of Cyber-Security' and will run from October 2012 to March 2016; the second will be in 'Automated Program Analysis & Verification' running from April 2013 to March 2016. These will be virtual centres, with each having a Host Institution responsible for organising meetings and providing a focus via a Research Director. Each RI will also support several research grants in the region of £700,000 - £900,000 which will be led by Principal Investigators from a number of different universities. Both research grants and Host Institution are chosen after an open competitive call, and within the funding available, the sponsors have adopted an inclusive model drawing on the best research available.

[19] *A Review of Business-University Collaboration*, Professor Sir Tim Wilson, February 2012, p 33

3.53 Given the promise of case studies like this, it is tempting to argue for the creation of more NS Research Centres: this is not a low-cost option, but given the quality of the UK's research-base, they can be said to represent good value-for-money. However, at our workshop, there was a weight of opinion against rushing to establish more Centres without giving careful consideration to the issue. Such Centres are not suitable for all requirements or disciplines, and they require commitment on both sides to succeed. There is a risk of failure, and there is a necessary management overhead that must not be overlooked. There is also the risk (especially in an institute centred in one university) that they create new gaps/barriers – with the chosen institute gaining exclusive rights that leave other universities "out in the cold" (unless we established a virtual centre), and with out-placed HMG personnel "out of sight, out of mind".

Proposition

3.54 Undertake a strategic study into merits of one or more new NS Research Centres: given HMG priorities (see Table 1 on page 6), such units might be formed to address: Protection from Improvised Explosive Threats; Protection from CBRN Threats; Horizon-Scanning Future Risks & Threats. This should be informed by an evaluation of different models for such Centres (drawing on experience in other sectors, whether involving Government or industry stakeholders), identifying factors behind success and failure; if appropriate, a Technology Road-Mapping exercise could be run to identify underlying capability gaps (see Annex 4 for a high-level description of the approach that could be taken). The aim should be to test the following vision:

> One or more Centres are established, funded for five years, with multi-disciplinary teams of academics committed to addressing both shorter- & longer-term challenges. These could be virtual organisations, involving more than one university, with access to people who understand NS requirements and who are authorised to explain them. Ideally, these NS specialists should be co-located with the unit.
>
> Include the option of **central research facilities** dedicated to supporting NS challenges: these could be fluid in terms of people – virtual and expert-led. If the need arises, there would be secure facilities to handle classified material. this should include centralised fast-track arrangements for security-clearing academics.

Benefits

3.55 This would provide firm foundations for policy decisions about the use of Research Centres, managing risks and increasing the likelihood that such initiatives deliver benefits (building trust, enhancing communication, establishing alliances and providing a forum for the in-depth analysis of challenges).

Caveats/Drawbacks

3.56 There may be concern about the cost and time spent in conducting such a study, although this should be allayed by the reassurance that risks are being managed in the process.

Evaluation. NS Research Centre Strategic Study

SHORT-TERM	
Short-Term Delivery	*In the time available, it would be difficult for the CSaP Fellow to make a significant contribution to this exercise, other than to support commissioning of the study.*
Scale of Short-Term Impact	*Limited.*
Resistance	*Limited.*
EVALUATION	**The Fellow could make small contribution to planning here. Moderate-Low.**
LONGER-TERM	
Likelihood of Impact	*Provided lessons are learned from past success and failure, with proper management, there is a strong likelihood of impact through strategic cooperation & problem-based research, especially if emphasis is placed on close engagement.*
Scale of Impact	*A well-conducted strategic study would provide a sound basis for introduction of Centres that could make a significant different to engagement (or avoid ill-judged expenditure).*
Resistance	*There is unlikely to be significant resistance to an exercise designed to support evidence-based judgments about deployment of resources,*
EVALUATION	**HIGH value intervention, requiring support and strategic investment.**

Chapter 4. Next Steps

4.1 This chapter brings this Inquiry stage of the CSaP Fellowship to a conclusion by proposing a set of short-term actions that could be taken forward in the next six months and by making a series of strategic recommendations for stakeholders (principally within the NS arena, but also elsewhere) to take forward.

The Short-Term. Next Steps for the Fellowship

4.2 Four of the solutions described in Chapter 3 gain a **high** score in our evaluation for short-term delivery, with a fifth rated **moderate-to-high**. These are *Knowledge Exchange*, *Accessing Information on the Research-Base*, a *Data Release Scheme*, *Guidelines for IP/IPR*, and the *NS Portal for Research Proposals.*

4.3 At least in terms of the Visiting Fellow's capacity, it is reasonable to argue that all of these could be pursued over the next six months. There is a potential risk that these projects, in aggregate, could overload resources in Government and/or academia, where staffing commitments in particular have already been made, so I recommend prioritising these tasks on the following basis.

Priority i. A National Security Data Release Scheme

4.4 **Recommended Action**. The CSaP Visiting Fellow **runs a pilot study**: finding a dataset to release and finding a group or community of academics to undertake research on it. This will lead us to identify the criteria for assessing potential data sources to release, engaging in the process with relevant stakeholders. We would expect legal, political, ethical, commercial, and security issues to be considered and tested in the process. In doing so, we should involve those who have developed and applied best practice in other spheres. The aim would be to report on issues and solutions by the end of November. [See para 3.31]

4.5 This deserves the highest priority because this intervention would deliver a **very high** long-term impact: it would tackle the most significant of the problem areas identified in the Inquiry Phase ("Trust and Communications"), breaking down barriers created by concerns over secrecy and security and helping academics understand important research challenges. It would also improve the likelihood that researchers deliver outcomes of substantive value to stakeholders in Government (overcoming the "Ivory Tower" stereotype). If we can resolve this problem, it allows Government to make a significant and highly-valued contribution to research collaboration.

4.6 This would represent an important innovation in the NS arena (even though important work has been done to address this issue in other sectors, notably healthcare). We should not underestimate the likely resistance to delivering a long-term solution to this problem, for both cultural and logistical reasons; but there should be support for a work-stream that explores the challenges in the short-term.

Priority ii. Accessing Information on the Research-Base

4.7 **Recommended Action**. The CSaP Fellow works with the Research Councils (and, if appropriate, GO Science and the TSB) to develop guidance by the end of September 2012 for stakeholders in Government on how to access and use sources on research, including engagement with RCUK Case Officers. He should also seek support of those stakeholders in delivering messages and/or training within Departments and Agencies in order to secure long-term benefit. If time allows before the end of the year, this work-stream should also consider scope for new initiatives, such as **mandatory reporting** of publically- and privately-funded research and development, and a **catalogue of expertise** to help answer the questions "who is doing what, and is it relevant?" [See para 3.21 - 3.22]

4.8 This could make an important contribution to communication and understanding, bringing efficiency gains that in turn address concerns over resources and red tape. But we are likely to find that current working practices go some way to addressing this challenge, so this does not deserve the highest priority. It adds value through an evolutionary approach, developing arrangements already in place.

Priority iii. Guidelines for IP & IPR.

4.9 **Recommended Action.** The Visiting Fellow issues guidance on the use of IP and IPR following a review of working practices in NS Departments, undertaking an inquiry into current working practices in different Departments (focused on Procurement Teams), culminating in a workshop in November 2012 that brings Government and academia together to develop guidance. The project should look at what is wrong with the current system: what are the problems and what do we need to get right? Early benefits might be realised if participants began to apply best practice (eg Lambert Toolkit) more systematically. *Caveat: success would be dependent on availability of senior procurement officers to participate, and their willingness to treat this as a priority.* [See para 3.15]

4.10 This option gained a **high** score for both short-term delivery and longer-term impact. It is worth noting, in its favour, that it would place demands on a different set of specialists within Government (ie the Procurement Teams) than the other work-streams, reducing the risk of overloading hard-pressed NS officials. Another important advantage is that much of the groundwork has been covered by the Lambert Working Group on Intellectual Property – we would be building on these foundations.

Priority iv. Knowledge Exchanges

4.11 **Recommended Action**. The Visiting Fellow trials a CSaP-style NS Fellowship scheme, with small teams (rather than single Fellows) **visiting a variety of universities (~3?)**. It is vital to establish arrangements for feeding back lessons learned and insights gained by Fellows into their HMG departments. The aim is for at least one team to have completed their rounds and fed back insights before the end of the year. *If time allows, we could also explore options for Visiting Professorships from the NS domain into academia.* [See para 3.7]

4.12 This is not an entirely novel proposal (the current Visiting Fellowship is an example of this model being put into practice). But it deserves a high priority because it tackles so many of the issues identified in Chapter 2: relationships of trust should build, and communication should be improved through more face-to-face encounters; cultural stereotypes will be eroded and sympathy and understanding of the two domains will develop; and a programme of Knowledge Exchanges from Government into academia addresses the complaint that insufficient investment is being made by the NS community.

Priority v. NS Portal for Research Proposals.

4.13 **Recommended Action**. The CSaP Fellow works with NS stakeholders to explore the options for a gateway giving academic researchers and experts access to NS end-users; one option worth considering is the CDE Portal, but there will be others. The aim should be to have produced a report on the way forward by the end of November 2012. [See para 3.35]

4.14 In examining the established process that has been operating at CDE for a number of years, key questions would include the quality of the brand, the focus (SME vs academia), the capacity of the NS community to cope with submissions, funding issues, and the communication strategy (including the question of whether or not to publicise specific requirements).

The Longer-Term: Strategic Recommendations.

4.15 This project has identified, and evaluated, five proposals for actions that will encourage effective engagement between the UK's National Security domain and academic research base. These are summarised as a set of strategic, longer-term recommendations that **decision makers and stakeholders** are **invited** to consider and progress. The following have been placed in priority order, based on the analysis and evaluation applied to our solutions in Chapter 3.

1. Research Centres: Senior NS stakeholders are invited to commission a strategic study into merits of one or more new NS Research Centres, identifying factors behind success and failure and testing the vision against an understanding of capability needs. [See para 3.54]

2. Accelerators & Incubators: NS officials are invited to work with the Technology Strategy Board on a programme of engagement with academic research partners and Technology Transfer teams to nurture the development of IP through SMEs supported by university-focused Accelerators & Incubators, etc. We have identified an option for developing entrepreneurial skills and a focus on innovation for cross-cutting teams where there is a need to help evolve research into applications. [See paras 3.39 – 3.41]
3. An Academic RISC: Strategic planners in universities and HMG are invited to support proposals for an academic "GU Alliance" – following the RISC model – providing strategic engagement between academia, industry and HMG. Ideally, there should be a close alignment with RISC in order to minimise management overheads and improve opportunities for pull-through. Our suggestions for early deliverables should be considered for action. [See para 3.48]
4. NSC Associates: The National Security Council is invited to establish a multi-disciplinary network of academics - *NSC Associates* - to respond to both strategic and operational requirements; this follows the model of the US National Intelligence Council's Associates Program. In order to maintain engagement and understanding, Associates should be brought together four times a year for briefings from Departments.[20] [See para 3.7]
5. Accessing Information on the Research-Base: GO Science is invited to consider the merit of a state-of-the-art, user-friendly, interface providing access to databases with information about our research-base for stakeholders inside and outside Government; this "big data paradigm" should extend to cover the historical record. [See para 3.23]

4.16 None of the above is sufficient, on its own, to effect the transformation that could lead to academic research making a more significant contribution to the safety and well-being of UK citizens than has hitherto been the case. But each proposed action will make a difference, and significant change can be achieved when combined with strategic direction from above and the commitment – at the working level - of well-intentioned individuals to build effective relationships of trust.

Engagement with Decision Makers and Opinion Formers

4.17 This report will be distributed to all those involved in the Phase 1 work, including interviewees, seeking their support in taking the work forward.

4.18 In order to provide some formal momentum and follow-through to the proposals set out in the report, the Executive Summary (together with the full paper if appropriate) will be sent to the NS Council (Officials) Science and Technology Sub-Committee, and to the Strategic Advisory Group of the Global Uncertainties Programme. These senior stakeholders are invited to **consider the longer-term strategic recommendations,** and to **support continuing work stemming from short-term workstreams** (beyond 2012).

4.19 We aim to bring representatives of Government and academia together in December 2012, at the end of the CSaP Fellowship, to review progress on the short-term actions and the response to strategic recommendations.

[20] Ideally, this should take place without the need for security clearances (or at least the highest-level clearance, which is expensive and time-consuming to administer), ensuring diversity and placing an onus on officials to communicate their challenges in unclassified fashion. Thought should be given to training and development: eg an annual briefing and/or conference. Models worth followin include Dstl's Fellowship Scheme and the Newton International Fellowship Scheme.

Annex 1. Interviewees

Academia

Behavioural and Social Science

- Debi Ashenden, Lecturer in Information Assurance at Cranfield University
- Stuart Croft, Professor of International Security, Warwick University
- David Good, Director of Education School of Biological Sciences, Cambridge University
- Frank Gregory, Emeritus Professor of European Security, Southampton University
- Professor Stefan Halper, Director of American Studies, Department of Politics & International Studies, Cambridge University
- Mark Levine, Professor of Social Psychology, Exeter University
- Paul Longley, Professor of Geographic Information Science, University College London
- John Preston, Professor of Education, University of East London

Bioscience

- Professor Chris Lowe, Director of Institute of Biotechnology, Cambridge University
- Dr Michael Neuberger, Deputy Director, MRC Laboratory of Molecular Biology
- Derek Smith, Professor of Infectious Disease Informatics, Cambridge University

Business

- Paul Findlay, Development Director, Knowledge Transfer, University of Hertfordshire
- Stewart McTavish, Director of IdeaSpace, Cambridge University
- Godfrey Gaston, Operations Director of the Institute of Electronics, Communications & Information Technology, Queen's University Belfast
- Jaideep Prabhu, Jawaharlal Nehru Professor of Indian Business & Enterprise, Judge Business School, Cambridge University
- Shailendra Vyakarnam, Head of Centre for Entrepreneurial Learning, Judge Business School, Cambridge University

Chemistry and Materials Science

- Tony Cheetham, Goldsmith's Professor of Materials Science, Cambridge University
- Stephen Elliott, Professor of Chemical Physics, Cambridge University
- Clare Grey, Professor of Inorganic Chemistry, Cambridge University
- Krzysztof Koziol, Royal Society University Research Fellow, Department of Materials Science & Metallurgy, Cambridge University

Computer Science

- Ross Anderson, Professor of Security Engineering, Cambridge University
- Jon Crowcroft, Marconi Professor of Communications Systems, Cambridge University
- John Daugman, Professor of Computer Vision & Pattern Recognition, Cambridge University
- Professor Chris Hankin, Director of Institute for Security Science and Technology, Imperial College London
- Ian Leslie, Professor of Computer Science, Cambridge University
- Professor Sakir Sezer, Director of Research, System-on-Chip Cluster, Queen's University Belfast

Engineering

- Alladin Ariyaeeinia, Professor of Signals Processing, University of Hertfordshire
- Roberto Cipolla, Professor of Information Engineering, Cambridge University
- Brian Collins, Professor of Engineering Policy, University College London
- Andrew Gill, Principal Industrial Fellow, Institute for Manufacturing, Cambridge University

- Philip Guildford, Director of Research, Cambridge University
- Jeremy Hilton, Principal Research Fellow, Centre for Systems Engineering, Defence Academy and Cranfield University
- Phil Sutton, Visiting Professor of Science, Engineering & Technology Strategy Department of Electrical & Electronic Engineering Imperial College London
- Peter Templeton, CEO, Institute for Manufacturing (Education & Consultancy Services Unit), Cambridge University
- Sir Mark Welland, Professor of Nanotechnology, Cambridge University

History

- Chris Andrew, Professor of Modern and Contemporary History, Cambridge University

Maths

- Peter Landshoff, *former* Professor of Mathematical Physics, Cambridge University
- David Spiegelhalter, Professor of Public Understanding of Risk, Cambridge University
- Dr Nick S. Jones, Lecturer in Biomathematics, Imperial College London

Industry

Behavioural and Social Science

- Dr Dimitris Potoglou, Analyst, Rand Europe
- Hans Pung, Vice-President, Defence & Security, Rand Europe
- Neil Robinson, Research Leader, Rand Europe

Computer Science

- Bob Hayes, Senior Fellow at Microsoft's Institute for Advanced Technology in Government.

Engineering

- Dr Hugh Burchett, Cambridge Consultants
- Professor Chris Firth, Chief Scientist, Thales Research and Technology
- Jeff Patmore, *former* Head of BT's Academic Outreach Programme;
- Dr Paul Zanelli, Chief Technology Officer, BAE's Advanced Technology Centre
- Colin Waugh, Business Development Manager, Thales Research and Technology

Maths

- Dr Andrew Coburn is Vice President of Catastrophe Research at Risk Management Solutions
- Dr Heather Tewkesbury, the Smith Institute.

Government

Government Office of Science

- Dr Miles Elsden, Defence and Security Portfolio

Home Office

- Dr Rob Coleman, Director, HOCAST
- Dr Brian Hampson, OSCT
- Alan Jenkinson, Industrial Liaison, OSCT
- Professor Dick Lacey, HOCAST
- Dr Mark Stroud, Assistant Director, Strategy & Plans, HOCAST
- Hywel Thomas, OSCT
- Seamus Tucker, Deputy Director for Science & Technology, OSCT

Ministry of Defence

- Andy Bell, Chief Technical Officer, Dstl
- Karen Bloy, Programme Leader, Knowledge Exploitation & Strategic Academic Outreach, Futures & Innovation Domain Programme Office, Dstl
- Stuart Brewer, MoD PhD scheme
- Professor David Oxenham, Senior Fellow, Dstl
- Dr Neil Stansfield, Deputy Director, Dstl
- Dr Jim Wilson, Principal Scientist, Academic & Industrial Relations, Dstl

Office of Cyber Security and Information Assurance

- Dr Jon Browning, Academic Outreach

Security & Intelligence Agencies

- 12 officials responsible for commissioning research and engaging with academia & industry.

Annex 2. Full List of Issues & Solutions

Complete List of Issues

1. *Yes Minister* and Ivory Towers. (25) Cultural blocks to delivery seem to exist in both academia and HMG: academics are perceived by NS stakeholders (by those in industry and even by some academics) to prefer research to application; HMG oscillate between being tied up with red-tape and wanting immediate solutions. This is reinforced by: incentives within academia; confusing practices over IPR (on both sides); and HMG procurement processes/mentality that are unhelpful, freezing out quality and small teams, or ignoring established relationships of trust.

2. 100 Years of Solitude. (21) NS agencies and departments within HMG are perceived by academics and researchers as over-secretive, a closed shop, impenetrable; it is difficult to reach relevant decision makers or experts, and there is more "take" than "give".

3. Resourcing Challenges. (20) HMG stakeholders lack the resource to make an effective contribution to projects with a culture of "fire and forget" (including no hospitality budget to network!), and annualised Government budgets fail to align to university/research time-scales; by extension, there is a ready assumption that academics will work for HMG *pro bono* and the change in universities to full-cost funding hasn't fully registered. There is also a tendency to try to pack too much into a project ("log-rolling").

4. Trust Dies, But Mistrust Blossoms. (20) There are problems building relationships of trust between stakeholders in Government and academia. HMG is perceived to be untrusting, ignoring what academia/best practice/evidence base has to offer; frequent changes in personnel, as Civil Servants are posted in and out of jobs every few years, does not help. HMG can expect scientists to rubber-stamp political decisions; and has a tendency to use established academics or consultants (comfort over quality). Denial of access to relevant but sensitive data is particularly frustrating and can lead to failures, but there are concerns that anonymized data can be unpicked.

5. Ships Passing in the Night. (19) Insufficient opportunities or mechanisms exist for communicating, and those that are in place are sub-optimal: there are language barriers, Civil Servants patronise academics and provide poor feedback, academics appear disconnected from concerns of policy makers and practitioners; it is difficult to know who does what (in both Government & academia - big Knowledge Management challenges), and there are poor structures for knowledge exchange; but language barriers exist between academic disciplines as well, requiring time to achieve effective translation.

6. The Coal-Face Syndrome. (16) HMG stakeholders are perceived by academics and researchers (and some of their own people) to lack strategic vision, tending to over-specify and over-circumscribe a set of short-term requirements; in a new sphere like cyber-security, academics perceive there to be a lack of any sort of strategic direction to help guide research; they are risk-averse, always expecting a result from research and failing to take a portfolio view.

7. Making the Possible Impossible. (10) There is too much bureaucracy - on both sides - when instigating research: university systems are cumbersome, HMG's procurement processes are counter-productive, RC funding methods and (for instance) CDE processes are slow, bureaucratic, inflexible and militate against the innovative.

8. Academics not great at team-working or multi-disciplinary collaboration. (9) There can be – as perceived by Civil Servants - a surprising lack of collegiality and competitiveness. They can lack discipline: they drift from aims of a project to what interests them.

9. HMG procurement processes. (7) These are seen to be unhelpful, freezing out quality and small teams, or ignoring established relationships of trust.

10. Post-Docs from Overseas (4) NS stakeholders see problems with commissioning research given the preponderance of foreign post-doc students, given requirements for managing protectively marked material.

11. Silos and Specialists. (4) There are too many silos and specialists inside and outside Government, including lack of multi-disciplinary journals.

12. Academics not well-versed or well-trained in handling classified material (3)

13. Different time-horizons in Government and academia when managing science (3)

14. Technology Strategy Board processes are flawed: narrow requirements, too many awards, over-conformist, discourage interaction between winners; (2)

15. The Civil Service generalist tradition leads to technophobia, an absence of "systems thinking" (1)

16. Too much attention on repeats of past threats, little or none to new ones. (1)

17. Using CDE to issue security calls could be unhelpful, given ethical concerns over defence. (1)

18. Academics can be constrained by fear of Freedom of Information requests. (1)

19. Indiscriminate cuts of RC budgets means important research themes under-resourced at expense of trivial. (1)

Complete List of Solutions

A. Interface Units. Establish one or more university units staffed by people who understand NS requirements (authorised to explain them), as well as by academics, providing a bridge between HMG and research domains, committed to servicing (addressing and delivering on) shorter- & longer-term challenges.

B. Tripartite Partnerships. Bring together a coalition of NS policy makers/practitioners, academics and industry, with the aim of producing innovative solutions to specific strategic challenges.

C. Pace and Delivery. Stream-line arrangements for commissioning and delivering academic research and development

D. Knowledge Exchange & Management Schemes. Develop and implement one or more schemes that exchange personnel between academia and the NS domain. Introduce better Knowledge Management schemes to help Whitehall understand what research is going on out there.

E. An Academic RISC. Follow the example of the Security & Resilience Industry Suppliers' Community (RISC) and Industry Advisory Groups, with universities forming an "Academic Security Research Council" to promote an open conversation with HMG on security issues, mobilizing its members to address key challenges such as those in the White Paper "NS through Technology".

F. Panels and Workshops. Establish (through a dedicated secretariat?) a programme of workshops, seminars, conferences, sandpits, "speed-dating" events and panels designed to enable NS stakeholders

to meet multi-disciplinary teams of academics to develop high-value applications in response to specific strategic challenges.

G. Enhanced Professional Development. Develop a pool of HMG scientists who demonstrate charismatic leadership, who have powerful communication skills, develop trust, and who care; meanwhile, lobby for universities to consider "impact" in promotion boards and reward schemes. Civil Servants involved in academia must have Job Objectives that commit time/resource to the exercise.

H. Data Release. Investigate ways to make HMG data available to researchers, in order to enhance the quality and applicability of their work and to motivate and support research (including the option of a mobile secure facility to support researchers). We could invite RCUK to sponsor a working group or seminar on data exchange, identifying ways to facilitate transfer of data from government to researchers

I. Strategic Planning. NS stakeholders should produce a strategy (or sub-strategy) for engagement with academia, coordinating fragmented approaches. This would include a clear statement of goals & values (eg "Risk, Responsibility and Reputation" and clarity over IPR arrangements); focus on building and maintaining networks and a network of networks; another aspect could be a NS Sector Plan (or Road-Map, covering technology, capabilities, people and infrastructure) embracing academia and industry, that identifies strategic requirements, national competences needed to support Security Sector development & growth over the next 15-20 years.

J. Research Funding. Take initiatives to expand/develop an enhanced programme of research, making greater effort to develop unclassified requirements and challenges that are addressed through a PhD programme, a DARPA/IARPA programme; open-ended programme of research through doctoral and post-doctoral activities, including one or more Doctoral Training Centres; more Ideas Factories and Sandpits.

K. More classified projects in universities. With universities building secure facilities.

L. Innovation Initiatives. Take action to stimulate and develop innovative solutions to HMG needs; eg –

   a. *Enterprisers* or *Intrapreneurs* courses, bringing people in NS, business and academia together, to develop and apply innovation skills, building relationships of trust and understanding in the process.

   b. Ensure a proportion of resources are ring-fenced for innovative ideas from non-establishment, unfavoured academics;

   c. sponsor more incubators and accelerators, and encourage spin-outs, with "Open Innovation" & "Easy IP" schemes where universities give away low-value IP;

   d. Study initiatives by the Obama administration in its innovation strategy: last year the president signed legislation granting all agencies broad authority to conduct prize competitions in an effort to engage large numbers of people outside government in problem solving aligned with governing objectives, and to identify and spread solutions already on the ground; to date, there have been 159 competitions from 40 agencies (see: Challenge.gov for examples).

M. Create a Royal Society of Applied Science & Technology. Change the culture to get academics to recognise the importance of this.

N. Create more multi-disciplinary journals. Break down academic stove-pipes and encourage applied approach; *are Oxford and De Montford working with OCSIA on this for cyber-security?*

O. Create Centres of Excellence. Identified through calls and application of objective criteria – to overcome knowledge deficit and help "kite-mark" talent. *Example – Cyber-Security Centres of Excellence established in 2012 by GCHQ and EPSRC.*

Annex 3. Lessons Learned from a DTC

Lessons Learned from the Systems Engineering for Autonomous Systems DTC

These notes were supplied by Professor David Oxenham of Dstl. The findings were reported at the 2009 SEAS DTC conference and are in the public domain, in PowerPoint form. Professor Oxenham has added a gloss, at the end.

1 The DTC benefits greatly from its short decision-making lines & minimal bureaucracy

1.1 Focused decision-making in the Management IPT, supporting an independent Technical Director with final decision authority devolved from the DTC Board, enables rapid decisions on allocation of funding to research work and provides freedom to curtail unpromising work.

1.2 The small size of the Management IPT supports effective discussion and a team approach.

2 The systems approach applied by the SEAS DTC to technology integration maximises the chance of successful application of low maturity research

2.1 The systems model is crucial in giving the greatest chance for focusing of innovative technology on real military needs; it encourages greater systems thinking amongst the research community, especially academia, who would not otherwise adopt this approach.

2.2 Use of vignettes/challenges to provide a relevant defence context for the research is effective; the creation of functional building blocks through building technology outcomes into 'mini-threads' & 'threads' is difficult but highly worthwhile.

2.3 Demonstrations and experiments at all levels of the work ground the research in reality and provide challenge to the technology outcomes.

3 The SEAS DTC has established an effective technical community within its area of interest, but this has taken consistent effort over a period of years

3.1 The DTC mechanism leads to creation of cross-sector knowledge and understanding of capabilities and skills (between industry, SMEs and academia); pre-existing relationships have been exploited and strengthened and links between disciplines and institutions that did not exist before have been created.

3.2 It takes time to establish relationships and build trust; full understanding of the federated research themes and directions was not present at the outset and has had to be developed through interaction and dialogue.

4 The approach to dealing with Contribution in Kind (CiK) requirements has maximised the value of the industrial consortium's contribution to the overall DTC programme

4.1 The establishment of mutually agreed principles and rules between MoD and industry for selection and valuation of DTC CiK was an essential and valuable step.

4.2 Integration of CiK to the greatest extent possible across all areas of the research programme is required, implying the need for access to and use of different types of contribution, including skilled manpower, previous research, complementary research, facilities and equipment as well as cash.

4.3 The DTC requirement on consortium partners to provide as much visibility as possible of their CiK offerings within the consortium has maximised mutual benefit.

4.4 The process for presentation and assessment of CiK was jointly run by industry and MoD, was rigidly applied and has worked well: it is auditable and assessable.

5 SEAS DTC outcomes can be exploited through many routes and at many levels

5.1 There are many potential routes to exploitation; some can be planned, but others emerge through ad-hoc contacts and synergistic identification of opportunities arising from programme activity.

5.2 Exploitation of emerging DTC concepts and ideas into MoD's wider programme through the DTC's advisory influence is important and complementary to the direct exploitation of more mature technology outcomes.

5.3 Early stakeholder engagement and ongoing communication of progress and outcomes is vital.

5.4 It is important not to assume that the initial DTC organisation structure, suited to programme start-up and maturation, will necessarily be suitable for the integration phase; there is now a need to revisit the organisation and add extra resource with appropriate systems engineering / integration skills.

6 The SEAS DTC's relationship with its Dstl advisory team has been a strength, but could now be beneficially extended

6.1 The structure of Dstl advice team, set up to mirror the DTC's internal organisation, has worked well, with valuable advice and guidance being provided, but with freedom of DTC decision-making retained.

6.2 More dynamic involvement from Dstl is now recommended to build on the good relationships created, but taking greater direct benefit of the military awareness of the advice team through more active involvement.

7 The SEAS DTC's approach to risky technology areas balances a willingness to attempt hard problems with a pragmatic approach to finding workable ways forward

7.1 The use of the Innovation Fund (IF) has been highly beneficial, with many IF studies yielding highly innovative outcomes and operating extremely productively, with participants awarded IF funding feeling strongly motivated to produce good results quickly to secure follow-on funding.

7.2 Taking parallel approaches to difficult areas, sometimes through two or three different routes, retains the ability to try something hard and risky, but increases the chances of overall success.

Comments from Professor David Oxenham

"Point 2 in the summary is a pretty obvious statement of the benefit I think was gained through using ***systems principles*** *to design the programme.*

It is also worth noting 5.2. One of the emergent features that pleasantly surprised me was how insights and conceptual thinking emerging from ***low TRL work could be rapidly exploited*** *in much more mature programmes. This is hard to explain without an example, but this is how I would expand the argument a little:*

- *The DTC generated a rich population of insights and ideas that were readily exploitable into current programmes, even into those that are relatively far advanced. Even work at, or close to, TRL 0 was capable of generating these insights.*
- *There are (at least) three exploitation routes.*
    - *into equipment (the "TRL/SRL technology maturation route"): this is at least medium term, possibly long term. Exploitation path is via demonstration.*
    - *into another Defence Line of Development, eg Concepts and Doctrine (the "ideas exploitation route"): this could be almost immediate. Exploitation path could be through operational experimentation (eg NITEworks).*
    - *into another research programme by influencing their research strategy or agenda: this could be short-term. The exploitation path could be through research road-mapping.*

A final point to note would be ***the importance of time*** *(point 3). This wasn't just about the normal time it takes to build relationships within a community, there was an important educational element in terms of raising shared knowledge and understanding within a multidisciplinary community: of military matters by academia and industry, of specialised knowledge and language between science and engineering disciplines. A key observation there is that, with hindsight, I think that if we'd deliberately planned to accelerate the exchange it have taken well under two years, rather than over three."*

Annex 4. Addressing Capability Needs

Peter Templeton CEO of the Institute for Manufacturing's Education & Consultancy Services Unit), has provided the following thoughts about a systematic approach to addressing the question "What needs to be delivered to respond effectively to the drivers? In what timescale?

The "What?" question could perhaps be addressed as what sets of Capabilities are required to respond effectively to specific individual or groups of drivers / threats. In this instance, Capabilities probably comprise a coherent, coordinated combination, within one or multiple public and / or private sector organisation(s), of:

- Strategy, as to how the desired outcome will be achieved
- Resources (technologies, facilities, money, people)
- Processes (business, technical, ICT)
- Teams' and key individuals' competences (knowledge, skills, traits)
- Coordination mechanism and / or agency
- Performance measures, targets

Building on recent work with the Technology Strategy Board (TSB), one approach might be to:

1. Identify the strategic, cross cutting themes for National Security necessary to ensure appropriate responses to the external drivers and threats
2. Identify the 'National Competences' needed to respond to the strategic cross-cutting themes. These 'National Competences' might comprise:
    - Industrial and public sector capability
    - UK science and technology research
    - Opportunities to exploit the research and industrial capability in related sectors, thus making industry investment more attractive. An example of a NS-relevant National Competence could be Design and Manufacture for Small Scale and Miniaturisation, which is also applicable in Aerospace and Medical Technology sectors.
3. Identify the Gaps between Required State and Current State, and prioritise the need for closure
4. Develop plans to close the Gaps through:
    - Strategy development and action planning
    - Science & Technology Research (TRLs 1-3) and Development (TRLs 4-7), taking account of:
        - a balanced portfolio of technologies to manage risk
        - Key steps in commercialisation, esp. managing progression between the Science, Technology, Application and Market stages of the technology lifecycle
        - Commercialisation routes, e.g.
            - Spin-outs to create new ventures; how to scale
            - Licensing to SMEs, Mid-caps or Multinationals, etc
    - Engagement of Research Council, University and TSB stakeholders
    - Investment in resources
    - Development of key teams, and their skills
    - Enhanced coordination mechanisms

Technology Roadmapping provides a mechanism to support this process, whereby:

- Diverse stakeholders are engaged to identify current & desired future states, considering context & drivers, government/business aims, technology development plans, resources, etc.
- A viable path from the current state to future state(s) is developed, and
- The resulting plans re described in a structured, time-based and visual representation.

Annex 5. Acronyms and Glossary

AHRC - the Arts and Humanities Research Council.

BBSRC – the Biotechnology and Biologicial Sciences Research Council.

BIS - the Department for Business, Innovation and Skills.

CBRN - chemical, biological, radiological and nuclear (a term used to refer to weapons and/or threats).

CDE - see Centre for Defence Enterprise.

Centre for Defence Enterprise - a "gateway" established by the MOD to provide access to all organisations that may have a disruptive technology, new process or innovation that has a potential defence application. It is aligned with TSB's Small Business Research Initiative.

CPNI – Centre for the Protection of National Infrastructure.

CSaP – the Centre for Science and Policy, Judge Business School, University of Cambridge,

CST – the Council for Science and Technology

DHS – US Department of Homeland Security.

Dstl- Defence Science and Technology Laboratory; a part of MOD.

DTC – Defence Technology Centre.

EMRS DTC - MOD's Electro-Magnetic Remote Sensing Defence Technology Centre

EPSRC - Engineering and Physical Sciences Research Council.

ESRC – Economic and Social Research Council.

FST – the Foundation for Science and Technology.

GC&CS – the Government Communication & Cypher School, Bletchley Park; precursor to GCHQ.

GCSA – the Government Chief Scientific Advisor: the current incumbent is Sir John Beddington.

GSC – the Global Security Challenge (qv).

Global Security Challenge - an annual competition established in 2006 by London Business School students to empower start-ups in the homeland security technology space. It offered entrepreneurs with security ideas the opportunity to showcase their IP and compete for over $500,000 in cash-grants sponsored by the DHS.

Global Uncertainties Programme – RCUK Programme addressing the cross-cutting, interdisciplinary and international nature of security challenges.. It focuses on six themes: Terrorism; Cyber-security; Threats to Infrastructures; Countering the Proliferation of CBRN Weapons & Technologies; Transnational Organised Crime; and Ideologies & Beliefs.

GO Science – the Government Office of Science, overseen by GCSA, in BIS.

GU – Global Uncertainties Programme.

HHS – US Department of Health and Human Services.

HMG - Her Majesty's Government.

HOCAST – the Home Office Centre for Applied Science and Technology; formerly HOSDB.

HOSDB – the Home Office Science and Development Branch (now HOCAST).

IfM – the Institute for Manufacturing (qv)

i-LIDS - Image library for intelligent detection systems, maintained by HOCAST (qv).

Institute for Manufacturing - a division within the Department of Engineering at Cambridge University; it is multi-disciplinary: experts cover such diverse subjects as management, design, routes to market, technology, maintenance, strategic planning, performance measurement, production, supply networks, Industrial Policy, Industrial Innovation, etc. The aim is to achieve a joined-up approach from research to applied service delivery.

Intellectual Property (IP) - formalised/legal description of "a creation of the mind" that is owned by someone.

IP - see Intellectual Property.

IPR - Intellectual Property Rights: exclusive rights enjoyed by the owners of IP.

ITA – the International Technology Alliance (also known as the Network & Information Sciences International Technology Alliance) - a collaborative research alliance begun in 2006, between the UK MoD, the US Army Research Laboratory, and a consortium of leading academic and industry partners.

LEA – Law Enforcement Agencies: HM Revenue & Customs, Police Forces, UK Border Agency, Serious & Organised Crime Agency, etc.

MOD - Ministry of Defence.

MRC – the Medical Research Council.

NERC – the Natural Environment Research Council.

NSC – National Security Council.

ONA – the Office of Net Assessment, within the US Department of Defense.

ONS – Office of National Statistics.

OSCT – Office of Security and Counter-Terrorism, in the Home Office.

RAE – The Royal Academy of Engineering.

RCUK - Research Councils of the United Kingdom.

RISC –Security & Resilience Industry Suppliers Community.

SEAS DTC - Systems Engineering for Autonomous Systems Defence Technology Centre

SIA – Security and Intelligence Agencies: GCHQ, MI5 (or Security Service), MI6 (or Secret Intelligence Service).

SLS- the Scottish Longitudinal Survey.

SMEs - Small and Medium-Sized Enterprises.

STFC- the Science and Technology Facilities Council.

Technology Readiness Level (TRL) - A measure developed in the USA to describe the maturity of evolving technologies: 1-2 = Basic Research; 2-4 = Research to Prove Feasibility; 3-5 = Technology Development; 5-6 = Technology Demonstration; 6-8 = System/Product Development; 8-9 = System Test, Launch & Operations.

Technology Strategy Board (TSB) - the UK's national innovation agency: an executive non-departmental public body established by HMG in 2007 and sponsored by the BIS.

TRL 1-9 - see Technology Readiness Level.

TSB - see Technology Strategy Board.